Oceanic Birds of South America

OCEANIC BIRDS
OF SOUTH AMERICA

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A STUDY OF SPECIES OF THE RELATED COASTS AND SEAS, INCLUDING THE AMERICAN QUADRANT OF ANTARCTICA BASED UPON THE BREWSTER-SANFORD COLLECTION IN THE AMERICAN MUSEUM OF NATURAL HISTORY

BY

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To

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OCEANIC BIRDS OF SOUTH AMERICA

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ERRATA

Page

236, Fig. 37. For "Ishuaia," read Ushuaia.

296, bottom line. For "gues," read longues.

572, first word of bottom line should read "southern."

599, fifth and sixth lines of second paragraph. Kerguelen Island probably does not fall within the breeding range of the species.

Third and fourth lines of third paragraph. For "Cape Roquemaurel, Kerguelen," read Cape Roquemaurel, Louis Philippe Peninsula, West Antarctica.

1101, in page heading. For "Common Tern," read Arctic Tern.

1201, The second reference under Reinhardt is apparently an incorrect citation of the preceding paper.

OCEANIC BIRDS OF SOUTH AMERICA

PART I

THE PHYSICAL ENVIRONMENT

INTRODUCTION

Collections of South American birds are among the oldest still preserved in natural history museums. Without exception, however, such historic series are chiefly made up of species inhabiting the land areas or the inland waters of the continent. Systematic field work devoted to sea birds, particularly to such as are truly pelagic, has been undertaken only within the modern era of ornithology, and never in South America as a whole until the time of the Brewster-Sanford Expedition of the American Museum of Natural History.

Most of the earlier collections of South American oceanic birds were gathered together sporadically. They were obtained in a haphazard manner on voyages having other aims; they came from chance localities along the coast, at disjointed dates covering long periods of years. They formed, therefore, random, often puzzling aggregations of specimens, rather than adequate series such as in themselves go far toward solving some of the very problems that they raise. Moreover, the early collections were widely scattered, so that it was usually impracticable to bring together representative series which would illustrate individual and seasonal variations, and the immature plumages, of many forms. Finally, relatively few specimens had been taken at the breeding grounds of the respective species, and the key to numberless difficulties lies in the possession of accurately labelled nesting birds.

A somewhat extreme example of the slight and casual data upon which knowledge of South American marine ornithology has been based is offered by Hornby's Petrel. The type of this distinctive sea bird was supposedly captured on "the north-west coast of America" some time previous to 1853. No second specimen was seen until 1895, and the species remained all but unknown until 1913. Mainly as a result of the Brewster-Sanford Expedition, *Oceanodroma hornbyi* is now recognized as a common petrel along the west coast of South America between the latitudes of central Chile and the Gulf of Guayaquil (Murphy, 1922, 60). With our increased information, the bird has at length acquired significance. What was formerly little more than a meaningless name has become an item of zoögeographic importance, for the range of Hornby's Petrel fits well, as we shall see, into a special faunal zone of the eastern South Pacific.

Oceanic birds of several groups still belong in greater or lesser degree within a similar category of uncertainty, but perhaps none so much as other members of the Procellariiformes, the order comprising the albatrosses, fulmars, shearwaters, and petrels. Spending most of their lives on the high sea, usually at a distance from the land, these birds are even more essentially pelagic than the penguins. Certain species may abound off any coast, but, unless they are blown ashore by severe storms, or attracred to the littoral waters by peculiar concentration of food, we may be unaware of their existence. While the Procellariiformes are distributed over the salt waters of the globe, they are more numerous in the southern oceans than elsewhere. Here they breed in part at islands so remote or inaccessible that the nesting places of certain species are yet to be discovered.

It is, therefore, apparent that in order to secure specimens of such sea birds an aggressive program is necessary. The collector must cruise in remote and tempestuous waters, and must face difficulties, hardship, and danger of a sort that does not confront the collector of terrestrial birds. In the same statement is expressed the reason why these birds, which exist in incalculable numbers, have been until recently so rare in collections.

It was this rarity, coupled with our ignorance regarding the habits of the winged wanderers of the ocean, that influenced Dr. Leonard C. Sanford and Mr. Frederick F. Brewster to make a special effort to fill a great gap in ornithological collections and ornithological biography. Both gentlemen, who are residents of New Haven, Connecticut, have been for periods of years trustees of the American Museum of Natural History, and ardent supporters of its objects.

Dr. Sanford has been the promoter of innumerable enterprises that have enriched the ornithological and other collections of the Museum through field work, purchase, and exchange. Himself possessed of wide knowledge of birds, especially of oceanic species and of land birds that are rare or of extraordinary historic interest, Dr. Sanford has been the spirit behind expeditions more comprehensive than any others in the annals of ornithological exploration. He has been unsparing of his own resources, and has enlisted the aid and kindled the enthusiasm of his friends. He has worked in the field with his own gun and hands, and has coöperated, whenever favorable opportunity offered, with many other institutions and with patrons of ornithology, in both the United States and the Old World. The new building of the Department of Birds, a joint gift of the late Mr. Harry Payne Whitney and the City of New York to the American Museum of Natural History, is recognized by friends of Dr. Sanford as a symbol of his devoted service.

Mr. Brewster, on his part, not only supported the South American field investigations throughout their course of nearly five years, but has ever since sustained an interest and a pride in the collection and the scientific reports. His latest contribution to this branch of the Museum's research is a gift to cover the costs of publishing the present volumes. Those of us who are old enough to look back upon more than two decades of ornithological work in the American Museum now realize that Mr. Brewster's enthusiasm and munificence first injected the leaven which has been responsible for the phenomenal growth of our world-wide collection of birds.

THE FIELD-WORKER

As the first step in launching the South American marine work, Dr. Sanford and Mr. Brewster fortunately obtained the coöperation of Mr. Rollo Howard

Beck. At that date (1912), Mr. Beck had not only had an extended experience in collecting petrels in the northern Pacific Ocean, at the Galápagos Islands, and elsewhere, but had established a record for field work among sea birds in general which had placed him in a class by himself. Subsequent activities during the Brewster-Sanford Expedition, a later voyage to Alaska, and, finally, the ten-years' campaign of the Whitney South Sea Expedition, have served only to enhance his effectiveness and his reputation. He stands today as the most successful worker in this branch of ornithology that the world has known.

At my urgent request, Mr. Beck has written the following brief biographical notes, which eminently deserve a place in a record based in so large a measure upon his skill in the field.

The light of day first greeted me in Los Gatos, Santa Clara County, California, on August 26, 1870. My parents, six years after that, took me with them when they moved across the valley to Berryessa, the home of the remaining members of the Berryessa family, who still retained a few hundred acres of the many thousands their forbears had received from the Spanish Governor of California. My school days did not last quite long enough for me to graduate from the eighth grade in the Berryessa grammar school.

In the Santa Clara Valley fruit was beginning to replace the wheat farms of the first settlers, and early in life I began to work in the apricot and prune orchards of neighbors. Some of my first work, which was before and after school hours, was the trapping of gophers. These pests, when the grain fields were planted to fruit trees, caused much loss to the orchardists by eating the bark and roots of the trees. One neighbor, whose parents bought property in Berryessa soon after my father did, was Frank H. Holmes, who had been a close friend of T. S. Palmer, now well known to all American bird students. These two, with Charles A. Keeler, another western ornithologist, had become familiar with the bird life of the San Francisco Bay Region, and Frank retained his interest on the farm at Berryessa, while Dr. Palmer left for Washington, D. C., to work in a more scientific branch of the study.

Sharing with Frank the love of quail hunting, we two often went out together, and I began to take an interest in the other birds of the hills. From him I learned to prepare bird skins, and from his copy of Coues' 'Key' to get the proper names of the many species we collected on various trips. From boyhood I had been keenly interested in birds' eggs, but had not put much serious study into the work. When, however, I had learned to make scientific specimens and to mount birds, my real interest in ornithology began. Becoming an associate of the American Ornithologists' Union in 1894, I was encouraged by Dr. Robert Ridgway and Captain Charles Bendire, of the Smithsonian Institution, with whom I occasionally corresponded regarding some of the rarer birds and eggs of California.

Shortly after the Cooper Ornithological Club was formed at San Jose I became acquainted with the local members, and joined that organization also in 1894, enjoying the companionship with all the enthusiasm of youth.

About the same year Frank Holmes proposed a trip to the Sierra Nevada Mountains and we spent six weeks or so there, visiting Lake Tahoe and the Yosemite Valley. In 1896, with a companion, W. H. Osgood, who now occupies a prominent chair in the Field Museum, Chicago, I returned to the Sierras and became acquainted with some of the bird residents of the pine forests. There I had the pleasure of taking the first authentic sets of eggs, I believe, of the western evening grosbeak and the hermit warbler, the nests being discovered within an hour of each other.

The following spring I hitched up the old horse to my spring-wagon and drove down three hundred miles to Santa Barbara, where I made friends with Captain Sam Burtis, who was master of a schooner trading between the coast and the Santa Barbara Islands.

Taking passage with him, I visited Santa Cruz, Santa Rosa, and San Miguel Islands, collecting bird specimens as well as eggs. One of the desirable "takes" of that trip was several sets of the island jay eggs, which had not been previously discovered.

Getting back from the islands and stopping at home a few days, I wrote a cousin to join me, and, hitching up the trusty horse once more, started to spend the summer in the vicinity of Lake Tahoe on the far side of the Sierras. As I drove slowly past the last stage station before crossing the crest of the Sierras to drop down into the Lake Tahoe district, my cousin ran in to see if any mail had been sent to us. He came out with a telegram for me, asking if I would join an expedition to the Galápagos Islands which Frank Blake Webster was organizing. I wired back "Yes," and turned old Tom around to head homeward.

The Honorable Walter Rothschild, interested in the giant tortoises and the land birds of the Galápagos, was financing the expedition, and I had a chance on the trip to learn something about collecting sea birds as well as land birds. Though little collecting was actually done on the ocean during this voyage, we had unlimited opportunities to study and collect sea birds in their rookeries. Boobies of several species, frigate and tropic birds, gulls, terns, shearwaters and albatrosses, were all observed at close range.

Captain Lindbridge, the master of the schooner, heard from an old sailor at Chatham Island an intriguing tale of treasure on Tower Island. The story, however, was not revealed until after we had finished work at Tower. Our chief, C. M. Harris, took little stock in the treasure story, so the Captain nursed his plans in secret. On returning to San Francisco, the Captain got confirmatory evidence of the treasure, and interested the owner of a thirty-ton schooner. Then he suggested to the mate, the cook, and to me that we go down on shares and visit Tower Island, as the owner of the vessel was willing to take his charter money out of the pirates' loot, when and if found. The plan suited us, and I induced a couple of friends to come in on the excursion.

During the interval between the return of the Rothschild expedition and the treasure hunt, I had spent a few days at sea with A. W. Anthony, an ocean-loving ornithologist, who was sailing his own vessel into tropical waters on a collecting trip, with a cargo of dynamite for Central America as an expense-reducer. Off the coast of Lower California, running before a strong northwest wind, the vessel was set ashore at two o'clock in the morning by a heavy northerly current, and we got to land with nothing but the clothing on our backs.

When the vessel struck, with thirty tons of dynamite in the hold, I presumed my earthly career was finished, and I remember saying to nobody in particular, as we rose on the crest of a huge breaker, "Good-bye everybody!" But the excellent stowing of the Captain prevented any shifting, and the sandy beach on which we struck did not jar one of the boxes sufficiently to set it off. Returning to California as a shipwrecked sailor, at Uncle Sam's expense, the Galápagos offer was proposed, and in the fall of 1900 I went treasure-hunting.

We caught sight of Tower Island one evening just before dark, but drifted off during the night and did not succeed in getting near it again before it was time to turn homeward. The next winter we started out once more. I had in the meantime received orders for several tortoises and a lot of birds from the Honorable Walter Rothschild, and so we stopped at several other islands of the group before making for Tower. When we arrived at the spot and commenced to search for the treasure, we found only a square hole in the ground, from which, no doubt, some earlier seeker had abstracted the contents, said to be valued at a third of a million dollars. The Captain and cook were sorely distressed but the rest of us, being young, took it easily.

We returned to San Francisco with some five dozen tortoises, alive and dead, and an interesting lot of bird skins, so Lord Rothschild—as he had now become—cabled me to bring the entire lot to London, which I did. A young barn owl, taken at one of the Galápagos Islands, was carried alive to the London Zoölogical Garden and left there with several of the tortoises and a half-dozen land iguanas. After receiving for the specimens a sum of money sufficient to pay us for the five-months' trip—better wages than we could have earned in California—I returned to Washington, D. C., intending to get a passport for Colombia in South America, where I expected to collect further for Lord Rothschild. In Washington I was told that it would be necessary to get also a special permit from Colombia before being allowed to take a gun there. I then requested my congressman from California to ask the State Department to attend to the red tape, and went home by way of San Francisco.

In San Francisco I got into conversation with Leverett Mills Loomis, who was at that time Director of the California Academy of Sciences. He was greatly interested in Tubinares and asked me to collect some sea birds at Monterey, California, while waiting for the Colombian permit. This I did, and getting interested in the prolific bird life of Monterey Bay, continued with the Academy of Sciences, letting the Colombian project lapse when the permit finally reached me.

Mr. Loomis kept me in the field for several years, during which time I made three offshore trips: one to the Santa Barbara Islands, one to the Revilla Gigedos, and one to the Galápagos. The last trip was of a year and a half duration, and the material obtained comprised the principal part of the Academy's collections, for the fire of 1906 had completely destroyed the old collections. The voyage was made in the yacht 'Academy,' bought for the purpose. Collecting was undertaken at several Mexican islands, and at Cocos Island, Costa Rica, as well as at all islands of the Galápagos Archipelago. There were expert collectors for botanical, herpetological, entomological, conchological, and ornithological specimens, and I was placed in command.

After spending some months at Monterey in 1907, getting series of birds to replace in part the burned ones, Mr. Loomis suggested a Hawaiian trip. This sounded good to me and I decided I would ask a young lady to join me in seeing the home of the ukulele players. I asked Miss Ida Menzies, of Berryessa, my home town, to be my partner in this expedition and any future ones that might eventuate, and she finally consented.

We promptly got married, but before proceeding with the Hawaiian preparations, I mentioned to Mr. Loomis, that, having worked for the Academy for some time, it seemed to me that an increase in my salary would not be out of place. As I had been in charge of the three offshore expeditions, and had returned with everybody alive and apparently with satisfactory collections each time, I figured that the rise in salary should not be too slight. Mr. Loomis quite agreed that this was correct, but unfortunately, as is always the case in Museum finances, in whatever part of the world they may be calculated, the demands from at least seventeen departments of the institution for absolutely necessary supplies to keep them functioning the remainder of the year, prohibited him from allotting to me the increased percentage which, undoubtedly, but for the departmental requirements, he would have liked to allot. The monthly increase which he suggested did not seem quite commensurate with my ideas and I quit, with regrets on both sides that the Museum had to lose my services.

Under Dr. Joseph Grinnell, the bird department of the University of California was in need of water bird material in the spring of 1908, and I wrote him that I was at liberty, and that in return for a salary a trifle larger than the California Academy of Sciences could afford to pay, would endeavor to secure some very rare birds from Monterey Bay. He fell in with the idea and, after I had been a few months at Monterey, sent me to the San Joaquin Valley to collect water birds, where I had collected previously for the Academy. While busy at Los Baños, getting ducks and geese which later were to cause extended arguments between ornithological experts, I had a letter from Dr. Leonard C. Sanford, of New Haven, Connecticut, offering a considerably better salary than the increased one which Dr. Grinnell had proffered, if I would collect for him. The enlarged remuneration for the identical amount of labor made me decide in his favor, and after a few months collecting at Monterey, I went to Alaska in company with Mr. A. C. Bent, who was collecting material for his 'Life Histories of North American Birds.' Dr. Alexander Wetmore, recently from college, was my companion in collecting and skinning the northern fauna. On this trip we started out as guests on a Revenue Cutter, visiting several of the Aleutian Islands the first month. We found it necessary to change our collecting itinerary on returning to Unalaska, principally, I have always surmised, because the sick-bay or hospital quarters of the craft, used by Dr. Wetmore and myself as a storage room for unskinned birds, was invariably in such a congested condition whenever the Commander of the steamer was making his daily inspection that he could no longer let the discipline of the ship be endangered by such disregard of maritime regulations. For me the change to the 'Polar Bear,' which conveyed us to Nome, was much appreciated. It enabled me to see interesting northern birds on their breeding grounds. Several of them I was to see again later at the southern end of their ranges, the bristle-thighed curlew, particularly, on many islands of the South Seas.

In 1912 Dr. Sanford proposed a trip to South America for two years. This undertaking, which was financed by Mr. F. F. Brewster, lengthened to nearly five years and enabled Mrs. Beck and me to see bird life in the Andes, where we collected on lakes, and highlands up to 16,000 feet;

the island of Juan Fernández, of Robinson Crusoe fame; and to enjoy the penguin rookeries of the Falkland Islands where three species of penguins nest in colonies but two hours' ride or sail from Port Stanley, where steamers regularly call. It also enabled us to make a record passage around Cape Horn, which was done in a twelve-ton cutter. Ultimately we worked at a number of the West Indian Islands.

Returning to the United States in 1917, we purchased a small property near my boyhood home and enjoyed a period of home-making for two and a half years, although during that time I visited Kodiak Island and the Seward Peninsula, in Alaska, for the American Museum.

In 1920 Dr. Sanford asked how a South Sea trip would appeal to us. We had enjoyed the blessings of regular American food and had learned to handle our own motor car, but we thought a visit to the South Seas for a couple of years would not be too hard to bear, though the better half of the family declared firmly against the period of five years for which Dr. Sanford had made provision by interesting Mr. Harry Payne Whitney, of horse-racing and other fame. Selecting an eager Stanford University student, E. H Quayle, as assistant, we proceeded to Tahiti in the Society Islands. After a year's time, becoming acquainted with the necessities of the work, we bought a schooner, the 'France,' in which we visited the Marquesas, Austral, and many of the Tuamotuan Islands. The conditions on the 'France' were not the most conducive to keeping a college graduate in good health, and Quayle after a two years' stretch of work returned to California.

The Museum then sent out J. G. Correia, a Portuguese-American collector, and his wife. After four years working through the Samoan, Fijian, and Tongan Archipelagoes, we entered the New Hebrides and were all attacked by malaria which finally, together with other causes, impelled Correia to return to a more healthful country.

Dr. F. P. Drowne, a physician, who in youthful days had been one of my companions on the first Galápagos trip, decided to try the schooner life once more, and came out to join us. Malignant sores, which afflict nearly everyone in the Solomon Islands, bothered him greatly for months after he had joined us, and the Museum sent out Messrs. Hannibal Hamlin and Guy Richards to help in the work, which had been prolonged three years beyond the original five.

With the three others aboard, Mrs. Beck and I decided we would definitely quit ocean life, and we turned the ship over to the newcomers at the Solomon Islands. We had not yet reached Sydney, Australia, on our way homeward, however, before a wireless caught us, proposing an examination of bird life on the mainland of New Guinea. Birds of paradise were among the tempting forms mentioned, so we outfitted in Sydney and headed again northward to the coast of New Guinea. Nearly a year was spent in collecting in the Mandated Territory and then, California interests demanding our attention, we once more sailed for the U. S. A.

Looking back at the various expeditions which I have headed, it appears remarkably strange to me that every one of the principal directors for whom I have labored had the magnetic qualities that kept me eternally striving with utmost endeavor to get the best material at whatever locality I happened to be working.

Mr. Loomis in the beginning urged me to improve my technique and methods of preparation, which was gradually done. Dr. Grinnell pointed out improvements that would be beneficial from a Museum standpoint, and in the last twenty years Dr. Chapman and Dr. Murphy, of the American Museum, have continually been to the fore whenever any question arose that they, with their fuller experience, could clarify to the satisfaction of all concerned. Dr. Sanford, with his understanding knowledge of human nature, has revived my flagging energies and rejuvenated my spirits on repeated occasions by his timely letters.

Last but not least, the presence of Mrs. Beck with me in the field has been a source of inspiration, and it is undoubtedly due to her attendance to my physical well-being in the last few years, that I am as well as I am today. Vivid recollections have I yet of the gentle care with which she bathed a poisoned back from which the skin was scaling off in great flakes. It was out in the Torres Islands, north of the New Hebrides, where I had unconcernedly lain down in a shallow mountain stream to bathe, under an extremely poisonous tree which had dropped a multitude of inoffensive looking leaves and twigs into the water. The skin of my back, wherever the flesh had touched the macerated leaves, turned perfectly black and within a few days scaled off in great slabs. Another time, in the high mountains of New Guinea, pneumonia threatened, after malaria had taken a hand in slowing up the work in that section, but the ministrations of the lady who had been journeying with me for better or for worse quickly overcame the threatened malady and we continued on our way rejoicing

Here in the civilized atmosphere of New York we wonder if some time in the near future we may not hanker to sniff the odor of tropical soil once again.

October 1, 1929.

These autobiographical notes reflect only a faint shadow of the energy, conscientiousness, and fearlessness with which Mr. and Mrs. Beck have faced long years of trying toil in the field. Only those who have worked in the cramped and stuffy quarters of small schooners, and who have felt the heat and swelter of the tropics, can vaguely imagine more than two decades of such life.

Mr. Beck's words touch but lightly, moreover, the technique of marine collecting, which he has placed upon a totally new basis. His specimens of sea birds are noted for their faultless preparation, and even more for their standardization. A tray of Beck specimens presents as uniform an appearance as so many cigarettes in a box. The fact that he has himself made up within a single day as many as forty petrels of the size of a pigeon is proof enough that his fine workmanship has not been developed at the expense of a plentiful return in specimens. On the contrary, Beck collections are no less notable for their richness than for their perfection.

Speaking as one who has watched him at work and who has learned his methods, I may say that it would be impossible to imagine anyone preparing specimens of sea birds with more rapidity, vigor, and precision. There is not a lost motion. Mr. Beck makes the incision under the left wing of the specimen, from shoulder to hip, and employs heated corn (maize) meal as an absorbent. His method of removing the fleshy parts of the skull, including the brain, with two snips of the shears, is a great time-saver. To scrape away the dermal fat from sea birds he uses a spoon into which notches have been filed. The next step is the preparation of a hard, thread-wrapped body of "excelsior," through which is thrust a pointed stick that projects into the throat of the finished specimen. With the body as a model, this procedure assures a skin of approximately the same size as the bird in the flesh. After the wings have been sewed against the excelsior body with an upholsterer's needle, and tied in place, one of Mr. Beck's specimens is practically in final form, and is so rigid that it may be laid away to dry without wrapping.

In addition to the preparation of skins, which are often accompanied by measurements, notes on the stomach contents, careful descriptions of the flesh colors, etc., Mr. Beck has never failed to preserve a proportion of his specimens in formalin and still others in the form of roughed-out skeletons. He is equally careful in the selection of series illustrating the growth and development of a species from the youngest stages, and in the preservation of nests and eggs with full and well-chosen data. Finally, by no means the least important part of any collection made by Beck is the superb series of photographs which invariably accompany it. In view of the large number of such records serving to illustrate this book, no further comment is necessary.

The methods of a good collector go far beyond the mere preparation of specimens, however, and even more remarkable is the procedure Mr. Beck has long since developed for discovering the feeding grounds of rare sea birds, and for luring them within range through the use of bait. So far as I know, Beck was the first to follow the latter custom, with results that made his success seem at times almost mysterious. His unparalleled experience has given him an eye for favorable waters and meteorological conditions, and on many occasions he has lowered a boat to make rich hauls of specimens when, to ordinary observers, there was nothing to indicate the presence of birds. The following quotation from my own experience will illustrate the point.

> When Mr. Rollo H. Beck, a veteran student of marine birds, was collecting for The American Museum of Natural History in Peru, he chartered a coasting sloop under command of an experienced native skipper and sailed several days' journey off shore. The subsequent enlightenment of the Peruvian sailors was related to me by my friend of the Chinchas, Captain Charles Niehorster, who was a member of the crew.
>
> One quiet gray morning early in the course of the voyage, Beck remarked that he would like to lower a boat for birds.
>
> "But there are no birds here, señor," said the skipper, waving an arm around the circle of blank water.
>
> Nevertheless, a skiff was sent down, and Captain Charlie manned the oars. For two miles or more he pulled straight ahead, while Beck methodically tossed flecks of oil and grease and scraps of meat in the boat's track. Then they doubled on their course, and to Charlie's amazement the long food-line was soon dotted with unfamiliar, dainty sea-sprites, which skipped and danced like butterflies along a blossoming hedge-row. A series of many birds, including specimens of Hornby's Petrel, was brought back to the sloop, and displayed before the doubting crew.
>
> "But we have never before had such birds as these in Peru, señor," insisted the captain. And his men unanimously agreed (Murphy, 1925, 270).

NARRATIVE OF THE BREWSTER-SANFORD EXPEDITION

On December 4, 1912, Mr. and Mrs. Beck departed from San Francisco on the journey from which they were not to return to the United States for nearly five years. Mr. Beck began his actual collecting in Peru, engaging small craft of various types to take him far enough from shore to find the ocean-ranging birds that were the special object of his search. Subsequently he extended the explorations southward, working from many stations on the Peruvian and Chilean coasts, visiting the Juan Fernández Islands, and passing a year in the Magellanic region. Still later he cruised among the Falkland Islands, along the coast of Patagonia, and northward to Brazil. Finally, he visited certain West Indian localities, and in Hispaniola and Cuba ascended to the summits of mountains previously unscaled by an ornithologist. Throughout much of the field work, particularly on the cruises in sailing craft, Mrs. Beck was with her husband, and under all other circumstances she made her headquarters as close as possible to the base of operations.

The following itinerary is drawn largely from Mr. Beck's all too laconic journal. It is intended to indicate merely the period, route, and conditions of oceanic and littoral collecting during the long trip around South America.

Details of the inland expeditions are omitted, while observations referring to the habits and distribution of birds are reserved for later sections of the book.

1912

December 31. Reached Balboa, Panama Canal Zone, *en route* from San Francisco.

1913

January 3. Paita, the first Peruvian port.

4, 5, and 6. Touched at Eten and Salaverry, and arrived at Callao about noon of January 6.

The journal is sketchy and interrupted for some time after this date, but the following quotation from one of Mr. Beck's reports in 'Natural History' elucidates one of his primary, but unrealized, aims.

> Armed with letters of introduction, I started out the morning after my arrival in Lima, early in January, 1913, with the hope of obtaining a government permit to collect a dozen or so of the innumerable shags or cormorants that had formed one of the sights of the day before as we sailed southward along the shores of Peru. As the Peruvian government derives a yearly revenue of many thousands of dollars from the sale of guano, the birds are carefully protected,—how carefully protected I did not learn for more than five months, at the end of which time permission to collect the birds was finally refused. Although I was introduced to the Government Minister by a leading official of the Peruvian corporation which had the concession for gathering the guano, and although the American Minister to Peru added the weight of his office to my plea, the weeks and months of waiting were in vain so far as government sanction was concerned. Between my semiweekly, weekly, biweekly, and finally monthly visits to the government offices to learn the progress of my petition, I spent my efforts collecting birds which were not government-protected (Beck, 1919, 183).

During January and February, Mr. Beck collected chiefly in inland regions, such as the valley of the Rimac and the mountains behind Lima. Not until February 15, apparently, did he visit the seashore, at Chorillos, and even here his prospecting was mainly in the irrigated country behind the beaches.

Shortly thereafter he went into the Andes *via* the Cerro de Pasco railway, and his notes between March 1 and April 3 all relate to field work about Oroya, Lake Junín, and other places in the highlands.

April 14. The entry for this date marks the real beginning of the maritime work of the Brewster-Sanford Expedition, for Beck states that he went in a fishing-boat five miles out to sea from Chorillos, and got in among the Peruvian boobies, pelicans, cormorants, gulls, terns, and petrels which are such characteristic elements of the Humboldt Current avifauna.

After travelling up and down the coast for several days thereafter, chiefly for the purpose of reconnaissance, Mr. Beck established headquarters at Ancón on April 24, and began a month of offshore collecting with the use of such fishing-boats as he could hire. On certain occasions, as noted in the journal for May 1, he put forth absolutely alone, manning his own oars, and remaining at sea from early morning until dusk. On at least one day he went out 20 kilometers from shore, so that the return required six hours of steady pulling.

During this period Beck also visited the Pescadores Islands, which lie off Ancón and just north of the Bay of Callao. Here he found breeding the small form of Mother Carey's chicken, which Dr. Percy R. Lowe subsequently named *Oceanites gracilis kelsalli*. On May 19 Beck entered in his notes that he had collected 240 sea birds during his month at Ancón.

June 3. On this date Beck visited San Lorenzo Island, off Callao, and in the evening set sail in a chartered "balandra" for the Hormigas de Afuera Islets, some 70 kilometers to westward. These are probably the smallest rocks projecting above the surface of any of the world's oceans at a considerable distance from land. At noon of June 4 he was off the Hormigas, where he saw several Hornby's Petrels and other sea birds which are less common nearer the mainland, as well as numbers of boobies, Kelp Gulls and other species familiar in the cool inshore waters of the Humboldt Current. Sea and wind proved too boisterous to permit landing at the Hormigas, and the voyage was continued westward. By June 6 the vessel had reached a point about 320 kilometers off Callao, and more and more time, until June 14, was spent in pelagic collecting, Mr. Beck lowering a dinghy whenever possible and laying a line of bait, as described previously in the section devoted to his career and methods.

On June 14 he once again made the Peruvian coast, landed at the island of Mazorca, off Huacho, and during the following week beat southward against wind and current to Callao, which he reached on June 21.

June 23. After only one day ashore, Beck put to sea again, quartering the coastal waters between Callao and Chilca to a distance of about 65 kilometers from the land. He continued southward, dividing his time between lowering for birds during favorable weather, and spending long and arduous hours below decks making up specimens, and on June 29 he stood into Pisco Bay. During the next few days he worked along the bars and beaches of this district, as far as the inner cove of Paracas, and also spent a day ashore at San Gailán Island, before travelling by coasting steamer back to Callao during the night of July 3.

After this period of work with Callao as a base, Mr. and Mrs. Beck went by steamer to Mollendo, thence by rail to Arequipa, and finally to Puno on Lake Titicaca. Then followed another month in the high Andes, between July 26 and August 25, before they were once again back at sea level at Arica, bound for Iquique, Antofagasta, Taltal, Valparaiso, Talcaguano, Coronel and Corral. At the last-named port Mr. Beck established himself on September 10, and worked in the vicinity, both offshore and in the estuaries and littoral waters, until October 22. He makes no mention of the kind of boats he engaged to take him out to sea, beyond the whaling station at San Carlos, but I judge that they were always small fishing craft, for apparently he never had more than one man to assist him. His collecting in this region was highly profitable, and for the first time he encountered two different species of the large southern albatrosses, and the Magellanic Penguin, as well as migrant shearwaters which he had known of old near the other end of their long range, off the Pacific coast of the United States.

November 8, 1913, found him farther north on the Chilean coast, at Valparaiso, where he worked uninterruptedly in the same manner until the end of the month.

On December 1 he set forth once more in a chartered sailing vessel, this time headed for the Juan Fernández Islands. Collecting at sea was, of course, carried out whenever weather conditions made it possible. Thus the entry for December 4 states that Beck was down in a boat all day, from eight o'clock in the morning until five in the afternoon, obtaining examples of the petrels that nest at Juan Fernández, as well as of migrants from farther southward and of the jaegers, Arctic Terns, and phalaropes that hail from the northern hemisphere. On December 12 he landed for the first time at Mas Atierra, the main island of the group, and continued a thorough investigation, obtaining both land birds and sea fowl, for the next week. Leaving Mas Atierra on December 18, he made for the outer island of Mas Afuera but, after collecting extensively in the waters to northward, he failed to get within landing distance because of constantly adverse winds. The vessel finally returned to Mas Atierra late in the evening of December 24, with only a gallon and a half of water remaining in her casks for seven men.

Between December 30, 1913, and February 9, 1914, Beck continued work on and about Mas Atierra, the period including a visit to Santa Clara Island, 18 kilometers to southward.

1914

February 24. This date found Mr. Beck again in Valparaiso, where he resumed his coastal collecting until some time after March 16. On March 28 the journal entry was made at Corral, the seaport of Valdivia, from where Mr. and Mrs. Beck evidently departed afrer only three or four days' additional work, for by March 31 they had reached Ancúd, at the northern end of the island of Chiloé.

From the first of April until the middle of May, Beck carried on in the vicinity of Ancúd, including the lagoons, estuaries, and streams as well as the offshore waters, within his field. Between May 18 and 21 he went by train and steamer to Quellón, at the southwest end of Chiloé, and then hired four men to row him some 26 kilometers to an abandoned whaling station on San Pedro Island. After collecting steamer ducks and other birds here, he returned to Ancúd, concerning which the latest entry in his journal is dared June 10.

On July 4 he arrived by passenger steamer at Port Sleight, in the Gulf of Peñas, hoping that the atrocious weather encountered, with squalls and heavy fog, might force a useful delay at this point. He reports, however, that the captain forged righr ahead through the night, and the next entry in the journal was made at Punta Arenas (now Magallanes) several days later (date unrecorded). From here Mr. Beck accepred an invitation to accompany a Chilean Government vessel to Puerto Delgado, where he landed on July 21, and subsequently, back in Magallanes, "spent about a week skinning the birds collecred on this side trip!"

At Magallanes he was able to hire a launch for reconnoitering through various neighboring channels until, without warning, the outbreak of the European war put him into serious difficulties with regard to drawing money. He notes that he paid double fare for steamship accommodations, and then waited five days for the vessel, before getting away on August 15 to the Falkland Islands, and from there to Montevideo, Uruguay. On August 21 he and Mrs. Beck sailed into the Río de la Plata. They subsequently crossed over from Montevideo to Buenos Aires, where they arrived on September 8. After making an examination of game birds for sale in the city markets, and purchasing and preserving a series of selected specimens from this source, Mr. Beck proceeded to Mar del Plata on the outer coast where, owing to strong southwest winds and a terrific surf, he carried on only land collecting in the neighboring countryside for some days following September 18.

On September 28, after acquiring the local prefect's launch, with a crew of four sailors, he went offshore some six miles. Subsequently his time was apportioned between the sea and the land, depending upon the condition of the weather, until the end of October. During this period he speaks of the use of various small craft, including fishing launches, sailboats, etc. On several occasions he writes of being as far as 29 kilometers offshore, while baiting and collecting many species of sea birds.

The sojourn at Mar del Plata was in large part a campaign of "waiting for the summer to begin at Cape Horn." Early in November the Becks started southward, going first to the Falklands. Perturbed conditions, owing to fear of the German high seas fleet, and evident even before they attempted to land from the steamer at Port Stanley, made Mr. and Mrs. Beck realize that collecting in the archipelago would be difficult. They therefore remained on board, and continued to Magallanes, to return to the Falklands only after a memorable sea battle had reduced the German fleet to one man-of-war, for which the oceans were being scoured far and wide.

Late in November Mr. and Mrs. Beck began a momentous voyage in the 'Leguri,' a small sloop which was to be their home for a much longer period than originally anticipated. Heading in the general direction of Cape Horn through the inland passages, the indefatigable leader landed at many ports and islands, constantly collecting both afloat and ashore. Of this period of the Brewster-Sanford Expedition he writes in 'Natural History':

> By the middle of November, when Punta Arenas had begun to put on spring garments, I readily obtained the best sealing cutter Magellan Strait boasted, as the war had made sealing unprofitable. This was a small twelve-ton boat manned by three men and a cook. It had a small cabin that accommodated the collector and his wife, while the four sailors bunked forward close by the stove, which was fed with wood chopped as we went along. Having been accustomed to drying wood thoroughly in California before burning it, I imagined we should need coal about Cape Horn, where rain or snow thoroughly soak all wood lying on the ground. The captain, however, took but a sack or two for emergencies, relying on freshly chopped wood most of the time, and I was greatly surprised to see how readily the newly-felled trees burned.
>
> We left Punta Arenas on November 25. . . . We headed for Point Isidro some fifty miles down the strait [southward], reaching it about four o'clock, and anchored for the night. An old Norwegian, whom we dubbed "Quién sabe" owing to his frequent repetition of that questioning

phrase, was the sole warder of the defunct whaling station located in the cove. In former years whaling from this point had been a profitable occupation, many whales being taken in Magellan Strait. But they have become scarce lately, and in our two-months' trip only three whales were seen, these being in Beagle Channel. . . .

We anticipated a couple of hours of rough weather crossing the strait, as the prevailing westerly winds sweep strongly up the channel from the western entrance to near Point Isidro where the strait bends northward. We enjoyed good weather, however, and after crossing, worked with a light wind and the tide as far as King Island in Cockburn Channel. The close view of Mount Sarmiento [2300 meters], the snow-covered peak visible in clear weather from Punta Arenas, was enjoyed for three hours as we passed it, the usual foggy covering being absent in the morning.

After spending a day at King Island until a head wind subsided, we started out again and succeeded in getting into the protected waters just beyond Brecknock Pass. This was a dreaded spot, for the ocean swells roll up into the channel, and some years before, the captain had been capsized here and all his companions drowned. . . . We anchored in a small harbor in the lee of London Island, working close in to the edge of a kelp patch so that the sudden williwaws or gusty gales sweeping down off the rocky heights could not disturb us. . . .

Leaving this inhospitable anchorage the morning of December 2, we sailed out into Whaleboat Sound with a fair wind, and through rain and snow squalls reached the eastern end of Grand Island where we anchored again. The next morning at half past five we got under way and spent the forenoon sailing slowly along until an inviting cove at Timbales Island, with a snowy white kelp goose standing on the outermost point of rocks, induced us again to drop anchor and go ashore. This part of the sound was studded with little islands. . . . Shortly before anchoring, we saw the wreck of an Argentine steamer, the captain of which had selected the wrong channel between two . . . and had come to grief on an uncharted reef. . . .

After leaving Timbales Island we sailed nearly south for twenty-five miles and swung around into Christmas Sound, an island-dotted channel which separates Hoste Island from several small islands bordering the southern ocean. We anchored for the night halfway down the sound, and when we sailed again a day later [December 7], we headed for Ildefonso Island which lies about twenty miles out in the open ocean to southward. After getting outside the sound four or five miles, the breeze began to increase, and the captain turned back to anchor in a secluded cove in Trefius [Trefusis] Bay, which forms the southern entrance to Christmas Sound.

Ildefonso Island has no anchorage, being merely a long narrow rock sticking up a few hundred feet above the water, and as its shore line is swept continually by the heavy seas that roll up from the westward, landing is possible only on calm days, and these are of rare occurrence. The island was plainly visible from Trefius [Trefusis] Bay, but although we anchored on the seventh, it was not until the seventeenth that the rain and snow squalls gave place to a sunny day (Beck, 1918, 5–10).

While stormbound, Beck made the most of his time by rowing from islet to islet in the bay. Thorough collecting and photography was undertaken on Caroline Island where, in the path of the gales, all the surface boulders and rocky outcrops are buried in soil and moss on the leeward or easterly sides, leaving the windward aspects bare and scoured.

Soon after midnight of December 16, the sky began to brighten and the weather moderated enough so that the 'Leguri' could be towed out of the cove. A dead calm prevailed throughout the forenoon, of which Beck took advantage by lowering the tender and rowing along the eastern shore of the bay, where high, perpendicular cliffs of Hoste Island, toward Black Point, furnished nesting sites for white-breasted shags.

A light breeze sprang up at noon and we stood out toward Ildefonso where I hoped to find the yellow-nosed albatross nesting. That was the particular desideratum of our trip. In Punta Arenas the captain had assured me Diego Ramírez Island, seventy-five miles to the southward, where the birds were supposed to nest, could be reached in our small boat, but after seeing the sudden storms that sprang up without an hour's warning, we decided Ildefonso was quite far enough from shelter to satisfy us, and we thought it probable some of the birds nested there. Our light breeze died down toward evening and we stood back in the direction of land, heading out again at midnight.

At three in the morning the captain roused me out in foggy, drizzly weather, announcing the nearness of land. As he expected a change in the wind he wanted me to hasten ashore, but I held off until five o'clock when, with camera loaded, three of us dropped the whaleboat overboard and pulled in along the rocks. Being oldtime sealers, the two sailors carried rifles, expecting to find fur seals on the rocks. We did see a dozen or so at the entrance to a cave and shot a couple, but the expected herd was not there. Black-browed albatrosses . . . sat on the steep sides and on top of the island, or sailed over us. . . . We rowed a mile or two until a little ledge gave us a footing to climb the slippery penguin trail to where some of the albatrosses were nesting . . . I was busy with the cameras for an hour or two, tramping through the mud and slush searching for the best spots . . . A drizzly fog hanging low over the island gave promise of a change in wind, and after taking photographs and deciding that the yellow-nosed albatrosses were not present, we returned to the sloop which was standing on and off near shore.

We ran back toward Hoste Island, passing in between Morton and Henderson Islands and close to a little island where a copper mine had been worked some years before, then up through a tortuous channel, finally anchoring under the Diadem Mountain, which stretches up about three thousand feet. Mrs. Beck and I climbed the mountain-side from the thick grass and mossy tundra along the beach to a small lake where great cakes of ice were floating in the cold water. This was probably two thousand feet up and was surrounded by snow-covered mountains. . . .

The next day [December 20], soon after lunch, we were surprised to see a small sailboat appear around a headland, and as it approached, our cook recognized the steersman as a former friend from Ushuaia. The sloop contained but two individuals, the young man acting as captain and an Indian boy as helper. They had three dogs with them and about fifty otter skins which they were taking to Punta Arenas to sell. After making some inquiries about the course and telling us they intended to try for fur seals on an outer rock some miles south, they vanished around a point—and have never been heard from since . . . .

We moved a few miles down toward False Cape Horn the next day and from a rocky point where a colony of terns was nesting we secured a bucketful of eggs to eat. December 22 began with a light breeze and, as False Cape Horn was only twenty-five miles away, we hoisted anchor at four in the morning and headed for it. Getting away from the protection of the small islands, we could see the dark heavy clouds piling up over the top of Hoste Island behind us. This was a sure presage of storm, but our breeze freshening, we hoped to get around the cape before it struck us. Just before reaching the cape a rain squall hit us and with it wind. The sea roughened suddenly, and as we ran before the squall the boom hammered the waves as they swept past. Fortunately we were a few miles to windward, and it took but a short time to swing round the cape and haul up on the lee side where the fine anchorage at Lort Bay protected us from the bad weather (Beck, 1918, 11-16).

Despite high winds and squalls, Mr. Beck collected during the next few days both from his boat and ashore on the Hardy Peninsula, which forms the western extension of Hoste Island. The sole entry in his journal for Christmas Day states that he was busy all day preparing specimens.

Writing for 'Natural History' he several times reveals an evidently long-cherished hankering to "round the Horn." When he and Mrs. Beck were leaving San Francisco in 1912, he remarks, for what was scheduled to be a mere two-years' jaunt, circling Cape Horn was regarded as a rather remote possibility; but when in 1914 they enjoyed their Christmas dinner only thirty miles away from the southern tip of the continent, the same possibility loomed large before them. Again, Beck writes that on December 26 he and his wife made consolation photographs of Cape Horn from the top of Hermite Island—"in case our attempt at rounding the Horn proved futile." But his published record continues as follows:

> On the twenty-eighth of December, 1914, we hoisted anchor at five thirty o'clock in the morning and started south from Hermite Island for the Horn. Before an hour had passed fog was pouring over Hermite Island, and the wind increased to a strong breeze. We headed in behind Jerdan Island and dropped anchor once more. The wind died down in the evening, and on the twenty-ninth we turned out again at five o'clock and got under way. A light northeast wind carried us down to Horn Island, and we rounded the Horn in flying style as the wind freshened on nearing the Cape. Being in a small boat and the wind offshore, we passed close along the southern side of the island, taking photographs of the Cape from different angles and, although at times sailing with the rail under water in the sudden fierce gusts that swooped down off the high cliffs of the promontory, we enjoyed to the full this pleasant passage of the Horn—a trip I had many years longed to make. Shearwaters and albatrosses swung high and low around us, and the rapacious skuas hurried from one flock of fishing birds to another in search of food, while the timber-strewn beach reminded us that the stories of wrecks credited to this point were not all fables.
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> We sailed to the southward about ten miles, but the breeze freshening, we turned back, and by the time Herschel Island was gained a heavy wind hurried us up the South Sea Pass to an anchorage at the southernmost point of Wollaston Island. We were held at Wollaston Island a week by prolonged gales, but found much of interest there, discovering and photographing sooty shearwaters' nests being the most important work (Beck, 1918, 111).

1915

January 5. The wind subsided somewhat, and the 'Leguri' transferred her berth to the northerly side of Wollaston Island, from where Beck landed on Grévy Island. Next morning the cutter moved across Nassau Bay to Bertrand Island, which lies just south of the large island of Navarino, and which at that date probably supported the southernmost sheep ranch on the globe. Some years previously a few sheep had been kept for a while on Wollaston Island, but the Indians had gradually killed them off. Bertrand Island was owned by a Captain Grande, with whom Beck subsequently made two cruises in Fuegia. At the time of this first visit to the "Hacienda Grande," he and Mrs. Beck were regaled with a piano recital by the daughter of the house, while the Señora produced cakes and tea. The guests therefore felt quite within the pale of civilization again, even at the back door of the Horn. During the same afternoon Beck found an opportunity to go ashore at the tiny islet of Vauverland.

Next day operations were continued on Bertrand, after which the sloop proceeded to the Yahgan Indian mission at Río Douglas, Navarino Island, before anchoring for the night. Beck has already published his impressions of the remnant of the Yahgans, and of the conscientious efforts being made for them here (Beck, 1916, 116). He notes in his journal that vast numbers of Cassin's Terns' eggs were stored as food in the Indians' cabins.

January 8. The Yahgans, some of whom had a fair smattering of English, lent a hand in towing the 'Leguri' out of the river against the tide, and about noon the party set forth northward through the Murray Narrows toward Beagle Channel, and headed on the roundabout homeward route. Progress was slow, going against the wind to westward. For 65 kilometers from its eastern end the channel nowhere exceeds six and a half in width, and at one spot it narrows down to a quarter of that. Mountains rise abruptly from the shore, and French Peak, on the Tierra del Fuego side, has an altitude of 2150 meters. Several glaciers crawl down and drop their loads of ice into the frigid waters.

Unfavorable weather retarded the voyage to such an extent that Brecknock Pass, about 240 kilometers from Murray Narrows, was not reached until January 19. On the 12th collecting was undertaken at Timbales Island, and on succeeding days at Londonderry, O'Brien, Smoke, and Caroline. As Brecknock Pass was approached, the squalls increased, and the sloop had to seek shelter and drop anchor. Rain, sleet, hail, or snow would sweep over the heights and channels, perhaps to be followed by fitful sunshine that would be promptly blotted out by another tempest. During the wait for sailor's weather, Beck climbed to the highest slopes of Brecknock to collect seed snipe and other birds of the uplands.

Three times head winds and pounding seas drove the little vessel back as it essayed to round the point into the open Cockburn Channel, and on the third occasion it drifted on to a sunken rock. Although the skipper ran out the kedge anchor, it was only the great rise of the tide that enabled the cutter to slip off its precarious perch. The fourth trial at a start was successful, and the 'Leguri' scudded out into Cockburn Channel at five o'clock in the morning of January 22. She received an answer to her salute to two British men-of-war in Shoal Bay, and, heading northward before a fair wind, made the run to Magallanes by seven o'clock of that evening. Thus ended a most interesting two-months' voyage in a region where, unless the wanderer has both experienced and fortunate guidance, he is likely to be reported missing, as were the two ill-fated otter-hunters met during the cruise.

Between February 1 and an unstated date in March, Beck made headquarters at Magallanes, travelling about by small boat, on foot, and on horseback, to various desirable collecting stations and carrying back his specimens for skinning and making up. Trips by launch sometimes took him 30 or more kilometers away from his base. His adventures included the experience of having rifle shots sent whizzing over his head by guards in charge of the wireless station at Sandy Point, who refused even to look at his permits and other documents from Santiago.

His failure to track down the Yellow-nosed Albatross still irked him and, meeting Captain Grande, who contemplated transporting a cargo of firewood from Beagle Channel to Río Gallegos on the Patagonian coast, Beck bargained with him to run out to the Diego Ramírez Islands, far south of Cape Horn, as soon as he had discharged a small load of food supplies at Ushuaia, the Argentine penal settlement just across Beagle Channel from the Murray Narrows. It was more than a month, however, before they got away from Magallanes. April 1 found them at Ushuaia, and the next day at Hacienda Grande, on Bertrand Island. On April 7 they set out southward, but after going 13 kilometers beyond False Cape Horn a thick snowstorm compelled them to put back into Lort Bay. The sea was far too rough to permit of landing on Diego Ramírez, even if the sky had cleared. Furthermore, Captain Grande had no stomach for the ocean outside in such weather, for shortly before that time his son had been knocked overboard and drowned when the boom of the stout power-schooner 'Antarctica' had jibed during a sudden and unexpected squall.

Thereafter they had to remain in Lort Bay until April 20, with both anchors down much of the time, and the howling gales and driving snow compelling Beck to view his birds from the deck, except on rare occasions when he could lower a boat for brief periods, with three stalwart men at the oars. The barometer alternately rose and fell, with no prospect of steady weather of any sort. By the 16th, the meat supply, comprising two sheep and a guanaco, had been consumed, and when clear weather appeared on the 20th it was necessary to run for food and water to Bertrand Island, which was buried in snow to the water's edge. By this date, Beck concluded that his elusive albatrosses would have left their nesting ground in any case, so he gave up this particular quest for the season but decided, nevertheless, to continue on the 'Antarctica' to Río Gallegos.

April 21. At Bertrand Island, after obtaining provisions from the ranch, Beck took an eight-foot skiff and went for some distance up among the channels. As far as can be told from the journal, several following days were spent at the same task. April 27 found him back at Ushuaia, from where on the 30th the 'Antarctica' left for Gable Island to take on its cargo of firewood for the treeless coast of Patagonia. On May 1 Beck obtained a small boat from the sawmill at Almirante Brown Bay, Gable Island, and collected in all directions from this center during the next few days.

Daybreak of May 6 found the 'Antarctica' 25 kilometers southeast of Cape Good Success, near the eastern tip of Tierra del Fuego. As the schooner turned northward into the Strait of Le Maire, Beck could see guanacos along the shore. Small flocks of land birds were flying close to the water across the strait from Staten Island, in the face of a strong wind from the west-northwest.

Following a night at anchor in Good Success Bay, four days were apparently spent at sea in rainy and squally weather. During lulls in the wind, Beck took the opportunity to continue his devoted collecting, despite the fact, noted on May 9, that the schooner had to be bailed with buckets during the greater part of the day, since the pump wells were clogged with sand and gravel. May 10 found the vessel far off San Sebastián Bay at noon. Early next morning Cape Fairweather, which marks the entrance to the Río Gallegos, was mistaken at a distance of 24 kilometers for Cape Vírjenes, north of the entrance to the Strait of Magellan. The error was not discovered until the captain had passed by his landfall before a strong south wind, after which he decided to run northward to Santa Cruz. Entering the latter estuary under power, the schooner ran aground on a soft sand bar, but the tide, which rises 12 meters here at times of full and new moon, soon floated her off. Two members of the crew, attempting to go ashore from the schooner during the ebb, could make no headway with four oars against the strong current.

The entry of May 17, after a six-days' break in the journal, indicates that Mr. Beck had devoted the intervening time to intensive collecting ashore. This he continued until May 23, both along the beaches and river banks, as well as on the continental table-land, where birds proved very scarce. On May 24 he left Santa Cruz, at the customary hour of dawn, for Río Gallegos. The schooner ran first to southeastward, then turned southward, being some 65 kilometers off Coy Inlet at evening. Very large flocks of fishing birds, including penguins, terns, shags, gulls, petrels, and albatrosses, were encountered on the voyage. Next afternoon, in dirty weather, land was made dead ahead. This landfall was quite unexpected, and was evidently caused by currents which had carried the schooner off course, so the motor was started and the vessel headed southeastward until she had cleared Cape Vírjenes. The wind and rain decreased into the evening, but not until after the mainsail had blown to pieces.

On the morning of May 26 it was calm enough for Beck to lower again and to spend several hours pulling ahead of the schooner, baiting and collecting sea birds. A new mainsail was bent on, and in the afternoon the vessel headed westward toward the coast, which it made, midway between the Cape Vírjenes and Point Dungeness lights, about four o'clock next morning. It then turned north toward the Río Gallegos, and at nightfall dropped anchor a short distance south of Cape Fairweather, where it became stormbound and had to lie with two anchors down, and 125 fathoms of chain out, until the southwest gale had spent itself by the morning of May 29. The schooner then chugged up the estuary against the tide, and anchored near Point Loyola. In the Río Gallegos region Beck collected from May 30 until June 9 or thereabouts.

On June 10 he left again for Magallanes, arriving at Punta Delgada late in the evening of the following day, after many hours of bucking westerly winds. Proceeding early on June 12, the 'Antarctica' passed through the first narrows, and at midnight anchored just beyond the second narrows, reaching Magallanes on the afternoon of June 13.

There follows another of the recurrent breaks in the record, but labels of specimens indicate that Mr. Beck was making the usual good use of his time while awaiting the loading of his means of conveyance with cargo for Ushuaia. On July 5 his entry states, "I hope to get away tomorrow for another round of Tierra del Fuego," and on July 15 he records at Ushuaia that the schooner had anchored there at evening, after being delayed three or four days *en route* by engine trouble. A week was spent at Ushuaia, and on July 23 they sailed out of Beagle Channel through the Murray Narrows and anchored off Bertrand Island from where, after small boat work along the coasts of Bertrand and Navarino, the party set sail again for Cape Horn on July 25.

Out past False Cape Horn in the morning, and straight to sea until noon, the schooner proceeded. Beck seems to have been thinking once more of the Diego Ramírez, but it was now the season of midwinter, and the captain of the 'Antarctica' assured him that the Yellow-nosed Albatrosses would not be found at their nesting site before September at the earliest. Beck therefore made arrangements to be allowed two full days for sea-collecting during the return voyage to Río Gallegos. At evening of July 25 the vessel laid up for the night at Sea Gull anchorage of Baily Island, just westward of Wollaston.

July 26. Southward and around through Washington Channel, in search of a mast which was to have been cached at an anchorage for the 'Antarctica' to pick up. It was not found, however. Beck here notes with surprise that the house of Halsichas, the otter-hunter, now had a long-deserted look. Not until several months later did he learn at Ushuaia that the hunter and his Indian had waved their final farewell on the 20th of the preceding December.

July 27 found Beck again in Ushuaia, from where he worked alone in small boats along the coasts of Gable Island, and inland into the guanaco-tracked forest of the opposite shore, until the end of the month.

On August 2 the 'Antarctica' left Almirante Brown Bay, again laden with Fuegian firewood for Río Gallegos, and carrying as passengers two discharged convicts who had served, respectively, 10 and 15 years in the prison at Ushuaia. They stopped at Harberton Harbor, but no sheep were near at hand so they proceeded and anchored a few kilometers to eastward, with the hope of taking a number of the wild sheep that ranged in that vicinity. On the following morning this object was accomplished, the party securing two very fat feral sheep with exceedingly long wool, estimated to have a weight of from 7 to 8 kilos in the two animals. The anchor was then raised and the vessel passed north of New Island at dark. Daylight of August 4 found them south of Cape Good Success, from where they beat against fresh northerly winds until afternoon, and then anchored in Good Success Bay.

August 5 was spent at anchor, but on the following morning the vessel set to sea and ran out to northward of Staten Island and up the coast toward Cape San Vicente. Late on August 8 anchor was dropped in the Río Gallegos, but heavy westerly winds prevented landing until the evening of August 9.

Between August 10 and September 9 Beck resumed work ashore, often with snow on the ground and ponds frozen. The ice of the latter he sometimes had to break with his bare feet, while wading for specimens. He observed, collected, and photographed many kinds of birds, including seed snipe and sheathbills, in addition to sea fowl. Whenever he proceeded inland, he found much of the fauna in a relatively undisturbed condition, with flocks of from 30 to 40 guanacos frequently running past him at a distance of a few hundred meters.

On September 9 the vessel hauled into the stream and set sail, and next morning, when some 70 kilometers northeast of Río Gallegos, Beck was able to lower in a light wind and lay out a line of bait. After remaining alone on the face of the ocean for about six hours, he had made one of the most notable collections of sea birds of the entire Brewster-Sanford Expedition, including a number of species new to the American Museum of Natural History. By September 11 the vessel was 145 kilometers from the coast, and on the 12th she continued to head northward before fresh southwest winds. September 13 found her 65 kilometers east of Puerto Deseado, with few birds about, and Beck working furiously to make up the overwhelming booty of the last few days. Thereafter the vessel stood again offshore until she was 130 kilometers or so off Cape

Blanco, after which she headed westward with the hope of making Cape Deseado lighthouse by dark of September 14, the captain wishing to check his bearings before setting forth on a still longer voyage.

During the next few days the 'Antarctica' was held to a southerly and easterly course, and at noon of September 17 it was reckoned that they were some 130 kilometers north-northwest of the Jason Islands of the Falklands. Next day, with a gale and heavy sea from the north, they were within 65 kilometers of Port Stanley, and the skipper lowered mainsail and jibs, to run southeastward under foresail only. On the following day they believed themselves off the east coast of the Falklands, though nothing could be made out in the rain and fog. At six o'clock in the morning of September 20 Beck was down once more in a boat, collecting until the rising wind forced him back on board. On this day an example of *Halobaena caerulea*, the only petrel of the species taken during the course of the expedition, was secured. On September 21, sailing north-northwestward in slightly quieter weather, they picked up the Falklands at 4.30 P.M., at a distance of 32 kilometers, whereupon the schooner once more stood offshore toward the southeast and remained at sea, with only an occasional glimpse to be had of the partly snow-covered hills of the islands, until September 25, when she pointed her bowsprit toward the Strait of Magellan. Beck had by this time begun to consider his days unprofitable, in comparison with the memorable collecting of the earlier part of the month. He remarks that between September 15 and 25 he had been able to spend but two hours down in a boat, and those in water too choppy for comfort or safety.

Without meeting much improvement in weather, the vessel headed westward during September 26, 27, 28, and 29. No opportunity was lost for picking up birds, but on the evening of September 29, when an effort was made to tack ship in a strong tide-rip somewhere to northward of Cape San Diego, the attempt failed and the jib blew to ribbons. It became necessary to lower the mainsail and wear around, after which the 'Antarctica' ran in a northwesterly direction all night under foresail and staysail. The weather was better on the morning of September 30, and presently it fell calm. The noon observation of October 1 gave the latitude of Río Gallegos, a point at least 113 kilometers north of the position which had previously been assigned through dead reckoning. As it turned out later, both computations were wrong! After noon Beck lowered again, but the wind arose and the water quickly became so rough that it took the schooner more than an hour to pick him up. October 2 was foggy and rainy until the sky cleared in late forenoon, when land, which proved to be in the vicinity of San Sebastián Bay, was sighted dead ahead. The course was set to northward, and on the following day they entered the Strait of Magellan, scarcely making headway under sails and motor against the wind, and having to drop anchor about 25 kilometers from Punta Delgada when the tide turned outward.

By an early start on October 4, they progressed well into the first narrows before noon, and after numerous difficulties due to the west wind, including the discomfiture of the mate, who was knocked overboard while gybing, the narrows were passed by seven in the evening. The heavy sea and strong southwest wind had been dead ahead all day, and Beck remarks that while making this entry in his journal the schooner was rolling and pitching in the supposed shelter of the Strait of Magellan quite as actively as though she had been on the open ocean. On October 5, after thirteen hours of continued patience, they arrived at Magallanes. Here Beck was put to the task of drying a very large collection of bird skins by such means as he could devise in a hotel bedroom. Many of the specimens had been lying unwrapped on shelves in the schooner's cabin during the long period at sea. Not only had they failed to dry, but many had begun to turn mouldy.

On October 12, Mr. and Mrs. Beck left Magallanes by steamer for the Falkland Islands and arrived at Port Stanley next day. Mr. Beck applied to the Governor for the privilege of taking protected species of birds for scientific use, which was in due course courteously granted, and during most of the remainder of October he collected in the vicinity of Port Stanley, being out in all kinds of weather on saunterings that took him weary distances from his headquarters. After reaching his hotel in the teeth of a gale on the evening of October 2, he observed in his journal that "nine steamer ducks and three oyster-catchers make none too light a load for one man to carry on his back on a three-mile tramp!"

On October 28 he went to Sparrow Cove, on the west side of Port William, in a cutter dispatched to gather Gentoo Penguin eggs for food. This brief trip yielded many experiences of interest. Contrasting his difficulties in reaching the breeding sites of penguins at Ildefonso Island, and elsewhere, with the facilities of this new field, Beck has written in 'Natural History':

> In the Falklands one lands by launch at the wharf from the Royal Mail steamers; and it is possible to mount a horse, visit the three species of penguins on their nesting grounds, and return the same day to the steamer (Beck, 1917, 431).

On November 4 he set out on a voyage toward Port Louis and Johnson Harbor, at the head of Berkeley Sound. Eggers were dropped at Kidney Island to collect Rockhopper eggs, and Beck went on to Cochon Island where he encountered his first large congregation of these crested penguins at the very beginning of their laying season. Geese were also abundant, for he remarks, "I found 18 geese a heavy load for a mile and a half walk back to the boat." On November 5 he called at Johnson Harbor, from where he returned again to Cochon Island next morning, finding his first nest and egg of *Garrodia nereis*, as well as nests of the Falkland Diving Petrel. Proceeding to Kidney Island, Beck made photographs of the egg-gatherers, who had already brought together some 13,000 eggs from the Rockhopper Penguin colony extending along the cliff of the island.

During the remainder of November, Mr. and Mrs. Beck divided their time between the territory about Stanley and the stations such as Kidney Island, which could readily be reached by accompanying egg-gathering expeditions. Throughout this period Beck was awaiting the completion of a required survey of a cutter which he had chartered to take him on a tour of more distant members of the archipelago. Action on this being delayed, he hired a small sloop for a preliminary trip. The first stop of the voyage was at East Island, reached on December 10, and found to be teeming with birds as well as rabbits. The second was the larger island of Bleaker, south of Adventure Sound, where the owner, Mr. F. A. Cobb, himself a bird-lover, extended all possible aid in furthering Mr. Beck's work. On this island, which is about 20 kilometers in length, 3000 sheep were pasturing and mingling freely with such birds as penguins, Upland Geese, and shags.

On December 15 Beck set sail from Bleaker, and anchored for the night in a cove of Adventure Sound. After a few hours in this part of the East Falkland mainland, he proceeded to Sea Lion Island offshore, a place occupied by only three human beings but by several thousand nesting Gentoo Penguins and numbers of Giant Fulmars, as well as by Short-eared Owls and many small land birds. Bad weather drove the sloop back to Bleaker on the 18th, after which they were stormbound for several days, but, as Beck reports in 'Natural History,' one of these gusty days yielded the finest series of bird photographs it had ever been his privilege to make.

1916

At Stanley, action regarding the cutter 'Exe' was still held in abeyance. Government officials insisted that owing to her small size (about ten tons) she was not safe for a West Falkland voyage. To this her captain replied that the East Falkland waters were more hazardous for a sailing vessel than the West. During the period of uncertainty, Beck kept at work at Kidney, Tussac, and other near-by islands, and on the commons or grasslands back of Stanley. On January 5, 1916, however, he most regretfully had to give up hope of being permitted to charter the one suitable craft for his purposes. Thereafter he had to content himself with inadequate travel along steamship routes to the western islands of the archipelago.

His first objective was New Island, off the southerly part of West Falkland, where the blue petrels or prions were said to nest. This aim, however, was frustrated by a war-time order, and the next best seemed to be West Point Island, outside of Byron Sound, where Yellow-nosed Albatrosses were reported to be nesting among the common Black-browed species.

The voyage was interrupted by gales which impeded even the progress of a steamer and compelled the captain to hold her at anchor behind the shelter of Bleaker Island all day on January 26. Next morning she put to sea again, and passed through Eagle Passage into Falkland Sound, unloading a cargo of coal at Fox Bay. On January 18, after traversing the length of the Sound, which splits the Colony into two main parts, the steamer turned westward north of West Falkland, passed Pebble Island, and next day landed Beck at West Point Island. The weather continued inclement but, under the hospitable guidance of Mr. Felton, owner of West Point, Beck worked in the vicinity during the rest of January. On the steamer trip back to Stanley, he stopped briefly at Saunders Island.

At evening of February 2, Mr. and Mrs. Beck set sail on the S. S. 'Oronsa' for Montevideo, Uruguay. The voyage was, of course, marked by no collecting, and the next journal entry, dated February 14, states that Beck had spent more than a week at the capital trying vainly to obtain a permit. His few notes relate only to observations on the birds at Carrasco and other places along the Uruguayan water front.

February 18 found the Becks at Santos, Brazil, on their way north by steamer, and on February 21 they put in at Rio de Janeiro. The notes report that no petrels of any kind had been seen since leaving Montevideo. Sea birds of all sorts were so scarce as to be practically absent on the subsequent leg of the voyage from Rio to Bahia, where Beck made headquarters for some time, with the hope of chartering a schooner or a small fishing steamer for a voyage to South Trinidad Island. This promised to be an expensive undertaking but, after negotiations lasting several months, Beck finally obtained Government permission to make collections at South Trinidad, and also located a vessel available for his purpose. Toward the end of June, however, he learned that the craft was in no shape to put to sea until she had undergone extensive repairs. Since this would have required not less than three months' additional time, and since he could persuade no other owner-captain to fall in with his plan, he necessarily abandoned the proposed offshore work in the tropical Atlantic.

According to his custom, Mr. Beck allowed neither the delay nor the disappointment to interfere with the best use of his time, and the few and scattered entries in his journal for the months of March, April, May, and June, 1916, tell of work afoot and by canoe in the country around Bahia, as well as of trips offshore in small fishing-boats for the purpose of obtaining specimens of noddies and other terns, boobies, and Wilson's Petrels. The last-named birds reached this part of the coast in April on the long northward migration from their antarctic breeding grounds.

The journal is a blank between June 30 and August 10, and by the latter date Mr. and Mrs. Beck had come by steamer from Brazil to the island of St. Thomas, in the Lesser Antilles. Even during brief steamer stops *en route*, however, Beck had occasionally found opportunity to make profitable use of the moment, as when he persuaded a black man to swim out to the only rock or islet off the coast of Barbados, and there to collect four examples of Audubon's Shearwaters in their burrows. On August 10 we find Beck once again in a sailboat, making landings at Cockroach and Cricket Islets off St. Thomas, and obtaining a considerable variety of both land birds and sea fowl.

After a period of a month at St. Thomas, which gave opportunity for visits to the more distant outlying islets of Sail Rock, Little Saba, and Tobago, Mr. and Mrs. Beck sailed for Santo Domingo, where from September 23, 1916, until the end of March, 1917, work was undertaken in both the lowlands and the mountains of that country and of Haiti, resulting in the acquisition of a representative collection of Hispaniolan land birds. The period was one of disturbance and even peril in Haiti but, surmounting all obstacles, Beck cut trails to the higher zone where the resident crossbill lives, and, incidentally, collected the type of the curious goatsucker which Dr. Chapman has named *Microsiphonorhis brewsteri*.

1917

This part of Beck's journal is kept with more detail than most of the remainder, but since the field work does not come within the scope of this book, the fuller publication it deserves must await another occasion.

At the end of March, 1917, Beck returned to St. Thomas, and, on April 15, proceeded southward to Dominica, where he continued his collecting and chartered a small sloop for work around the coasts of the island as well as those of Martinique. On April 26, led by a negro guide whose parents had fed upon the "Diablotin" half a century before, he made a search among the higher ridges of Dominica for the present breeding grounds of *Pterodroma hasitata*. The hunt was, in fact, continued without result throughout the remainder of April. Every current legend purporting to relate to rediscovery of the Diablotin proved, upon critical examination, to have originated many years ago. In fact, Beck mentions an argument between two aged residents as to whether a mutually remembered incident had occurred 25 years or 60 years before! On May 2 he gave up his fruitless quest, returned to Roseau, and three days later set out for St. Thomas in the S. S. 'Guayana.' On May 9 he once more ran a sailboat to Little Saba Island, where he found Audubon's Shearwaters with young in their burrows.

Later in this month Mr. and Mrs. Beck returned to Haiti, where Beck put in another period of collecting, purchasing horses and making a number of pack-train journeys until July 7, when he took passage in the schooner 'Express' bound from Aux Cayes, Haiti, to Santiago, Cuba, with a cargo of Haitian laborers. Beck had made arrangements with the captain to be dropped at Navassa Island. He went ashore at Navassa through a rough sea on July 13, and collected there until the 19th, when he departed for Guantanamo, Cuba, in another schooner.

At the end of July he began an expedition from Santiago, Cuba, into the mountains, and accomplished, on August 18, the ascent of Pico Turquino, the highest peak of the island. At the summit he found a bottle containing a record left by Dr. E. L. Ekman, the Swedish botanist, during April, 1915. Information obtained by Beck at Santiago led him to believe that he had made the second climb to this summit during a term of 40 years. Most of the remainder of August was spent working in various parts of the Sierra Maestre. When Beck returned to Santiago, on August 27, 1917, he found a letter from the American Museum recalling him to New York. He and his wife therefore set sail on the following day, reached Key West on September 1, and reported at headquarters with the last of the collections a few days later.

The specimens of birds obtained during the course of the Brewster-Sanford Expedition number 7,853. Those that may be broadly classed as water birds comprise upwards of a hundred species. The collection is, naturally, more notable for its full representation of the South American sea bird fauna, including hitherto little known rarities, than it is for forms new to science.

When one considers the faultless character of the skins, and the great body of associated data, such as nests, eggs, notes, and photographs—and when one balances all of these tangible credits against the obstacles, disappointments, and discomforts of the journey briefly retold above—then it becomes clear that the treasure obtained by Mr. Beck and his courageous helpmeet is a monument to rare skill and indomitable persistence. Up to date, it is safe to say, no other ornithological collector has carried through a similar campaign, or matched such scientific spoils.

OTHER FIELD WORK CONCERNED WITH THE PRODUCTION OF THIS REPORT

1. South Georgia Expedition, R. C. Murphy

My expedition to the island of South Georgia was carried out during 1912–1913 through a contract between the American Museum of Natural History and the owners of the whaling brig 'Daisy' of New Bedford, Massachusetts. I was at the time a member of the staff of the Brooklyn Museum, which institution entered jointly into the undertaking. The arrangement was that I was to reside on board the vessel during a cruise for sperm whale and sea-elephant oil in the South Atlantic Ocean, and that I was to have an opportunity to spend three or four months at South Georgia and also to collect birds at sea whenever favorable opportunity offered. Various accounts of the expedition are cited under my name in the bibliography of this volume.

I left New York on May 25, 1912, and joined the 'Daisy' at Barbados, although the actual departure from the West Indies was delayed until July 31. During the whole month of July, however, the 'Daisy' cruised in the vicinity of Guadeloupe, Dominica, and Martinique, after which we sailed northward to the latitude of Bermuda and thence eastward across the Sargasso Sea. On September 18, 1912, we anchored in Porto Grande, St. Vincent, Cape Verde Islands, where for two days I had an opportunity to collect ashore. On October 16 we visited the Brazilian island of Fernando Noronha where I spent one successful day afield, obtaining examples of most of the resident birds as well as considerable other material. Fernando Noronha was the last land sighted on the outward voyage.

The South Atlantic, with its abundant bird life, offered favorable opportunity for observation but little for collecting. However, on a few occasions during quiet weather I was enabled to lower a dory and shoot good bags of sea birds, in addition to which a few were caught from time to time on fish lines from the stern of the vessel.

South Georgia was sighted on November 23, 1912, and for a time thereafter the 'Daisy' lay at anchor in King Edward Cove, Cumberland Bay. Here, through the courtesy of the Norwegian explorer and whaleman, Captain C. A.

Larsen, I enjoyed the opportunity to make an offshore voyage in the whale-chaser 'Fortuna.' On December 13 the 'Daisy' proceeded to the Bay of Isles near the northwestern end of South Georgia, a region then isolated from the whaling stations, and one in which Captain Benjamin D. Cleveland, master of the brig, had hunted sea-elephants during earlier voyages. Here we remained at one anchorage until the latter part of February. Wild life proved abundant on this part of the coast, and study in the albatross and penguin colonies, together with the collection and preparation of specimens, which included seals, fish, invertebrates, and plants, as well as birds, occupied all available time during the long hours of daylight. From the end of February until March 15, 1913, the 'Daisy' lay in Possession Bay, where my labors continued without much variation.

The homeward voyage was marked by a great deal of stormy weather, and I was able to lower only twice for collecting birds on the open Atlantic. On April 8 we stopped for one day at the Brazilian island of South Trinidad and, although no landing could be effected because of heavy surf, I obtained, nevertheless, a collection of both sea birds and fishes. After delays occasioned by a successful sperm whale hunt or two, and a week of calms in the doldrums, we arrived at Barbados on May 8, from where I took the S. S. 'Vestris' for New York, disbarking on May 24, 1913, after an absence of exactly one year.

The ornithological part of the collections comprised about 500 specimens of 55 species, together with more than 100 sets of eggs, many photographs, and other useful data (Murphy, 1914, 43).

2. Correia's Work at South Georgia

During the voyage of the brig 'Daisy,' Mr. José G. Correia of New Bedford, Massachusetts, a member of the crew, learned from me the technique of collecting and preparing birds. While the 'Daisy' was in Cumberland Bay, Mr. Correia talked with Captain C. A. Larsen, founder and resident manager of the oldest South Georgia whaling company, and made a tentative arrangement to return for work at the station after his discharge from the 'Daisy.'

Late in 1913, Correia therefore travelled by passenger steamer from New York to Buenos Aires, and from the latter port continued his voyage on one of the oil-carriers to South Georgia. For several months he devoted all of his holiday time to bird collecting, and succeeded in obtaining beautiful series of specimens, including particularly the smaller nesting petrels of South Georgia, with special reference to species or stages of growth that I had failed to procure during the earlier field work.

3. Cape Verde Island Expedition, J. G. Correia

During the spring and summer of 1922, Mr. Correia spent several months at the Cape Verde Islands where he obtained a characteristically excellent series of the waterfowl, including six species of petrels, as well as a smaller representation of the land birds inhabiting the archipelago. This collection was the principal basis of my paper entitled 'The Marine Ornithology of the Cape Verde Islands, with a List of all the Birds of the Archipelago' (Murphy, 1924, 211).

While the Cape Verde Islands do not come within the scope of the present work, the collections made in that region by Correia have been of utmost importance for comparison with South American and Antillean material. Only a short distance to southward of the Cape Verdes, the distance across the Atlantic between the Old and New World is least. Furthermore, the source of tropical storms responsible for American records of many sea birds from the equatorial Atlantic, the eastern Atlantic, and even from the southern edge of the tropics, lies close to the Cape Verde Islands. Finally, some of the early European naturalists, such as Linnaeus, Gmelin, and Lesson, based their original descriptions of marine species upon specimens from the eastern side of the tropical Atlantic. The Cape Verde resident forms are in certain instances practically topotypical, and their possession greatly facilitates the identification of sea birds from other parts of the world. For many reasons, therefore, Correia's visit to the Cape Verdes has had a place in the preparation of the present work.

4. Peruvian Littoral Expedition, R. C. Murphy

On August 23, 1919, I sailed for Peru, arriving at Callao on September 11. Thereafter, through the courtesy of the National Guano Administration and of the American firm of W. R. Grace & Company, I was privileged to visit most of the islands along the coast between Independencia Bay (latitude 14° 16′ S.) and Lobos de Tierra (6° 30′ S.). I also skirted the greater part of the Peruvian shore line between the same limits, and found opportunity to become thoroughly acquainted with the bird life of the region.

The specific objects of the expedition, which was under the auspices of the Brooklyn Museum, the American Museum of Natural History, and the American Geographical Society, were to investigate the oceanic conditions responsible for the abundance of life in Peruvia ncoastal waters, as well as the interrelationships and distribution of this life; to make collections for use in zoölogical studies and in the preparation of Museum exhibits; and to obtain motion pictures of the bird life of the coast and of the reorganized Peruvian guano industry. The expedition was in the field until February, 1920. Its accomplishments are summarized in my book, 'Bird Islands of Peru,' published in 1925.

5. The Visit of Francis L. Jaques to Peru

After completing work on Barro Colorado Island, Canal Zone, during 1925, Mr. Jaques, with the aid of a fund supplied by Mr. Frederick F. Brewster, proceeded to Callao, Peru, to make field sketches of coastal birds and their haunts on which to base colored illustrations for the report on the Brewster-Sanford Collection. The convincing authenticity of the resulting paintings is sufficient proof, if any be required, of the importance of giving an artist opportunity to base his product upon original observation. Facilities for field work were extended, as previously, by Mr. Francisco Ballén, then head of the Peruvian Guano Administration, and a life member of the American Museum.

6. Ecuador and Northern Peru, Murphy and Heilner

In November 1924, I again set sail for Callao, first to attend the Pan-American Scientific Congress at Lima, and later to meet Mr. Van Campen Heilner in northern Peru, with the object of continuing the field work I had left off in January, 1920. At that time the shores of northernmost Peru, and the adjacent coasts of Ecuador, had been touched only slightly by ornithological expeditions of the American Museum, since Mr. Beck had begun his collecting farther south, while Dr. Chapman and his associates had worked chiefly to northward and to southward.

I reached Lima on December 8, and for a full month was engaged in duties not related to field investigation.

Between January 8 and 16, 1925, I journeyed by steamer southward to Mollendo and then back to Talara, near the northern end of the Republic. Here Mr. Heilner, who generously served as a volunteer collaborator, met me, and we began our work at once with the aid of launches and other facilities supplied by the International Petroleum Company. To Mr. Bruce Dunlop, Resident Manager, and Mr. Leon M. Stone, at that time Mayor of Talara, I am particularly indebted for assistance of many sorts and for the hospitality of the guest house.

According to plan, Mr. Heilner and I had arrived at the season of the year during which the northward flow of the Humboldt Current is normally interrupted, to be replaced by the warm Niño Current from the north. The phenomenon is always accompanied by marked changes in the fauna of the sea, including the disappearance of the typical cool-water birds, and the invasion of the region by equatorial species. In the commodious sea-going launch 'Chiralite' we were able to run out 35 kilometers or more from the coast, making hydrographic cross-sections of water which differed in composition from day to day, and collecting plankton, fish, and sea birds. Smaller launches were used for numerous coastwise voyages, and we were also supplied by the officials of the International Petroleum Company with Ford motor cars for trips to the mouth of the River Chira and other points of great interest.

On January 27, just after the momentous rains of 1925 had begun in northern Peru, Mr. Heilner and I set sail for Guayaquil in the launch 'Silver Spray.' We were the guests of an American, Captain M. P. Skorlich, who had built the little vessel in San Pedro, California, and had brought her to Ecuador, where he subsequently sold her to the Guayaquil-Quito Railroad Company. Early in the morning of January 29 we reached Puná Island, took on board our customs officer, and proceeded up the river to the port of Guayaquil.

On February 10, 1925, after a journey to Quito for obtaining the necessary permission from the Government to collect along the seacoast of Ecuador, Mr. Heilner and I once more left Guayaquil, this time in the launch 'Cypress' bound for the peninsula of Santa Elena. Off the Puerto Rico anchorage, on February 11, we were met by the launch 'Mantalite,' and subsequently landed in a bongo, or dugout canoe, on the beach in front of the local station of the International Petroleum Company, where we made our headquarters as the guests of the manager, Mr. William Light.

For several days Mr. Heilner and I collected in the neighborhood of Santa Elena, both up and down the coast and offshore. On February 14 we visited Pelado Island in Santa Elena Bay. Before dawn of the 17th we started northward for La Plata Island, where we remained until a northwesterly squall during the night of February 19 drove us away from our shelterless anchorage and back to the peninsula, whence we returned to Guayaquil on February 23.

Next day we once more set forth, this time as the guests of Mr. E. Hope Norton, on a launch trip to the island of Amortajada, El Muerto, or Santa Clara, in the Gulf of Guayaquil. We anchored for the first night off the southern tip of Puná Island, and before daybreak went on to El Muerto, where for two days we carried out a reconnaissance and obtained examples of most of the 13 species of birds observed at the island. The specimens, through the courtesy of Mr. Norton, were subsequently stored in the refrigerating room of the National Brewery at Guayaquil until they could be skinned and made up at our leisure.

On March 3 Mr. Heilner and I separated, he returning to the United States and I going southward in the 'Silver Spray' to Talara. From there I proceeded on March 6 to Paita, joined Mrs. Murphy and our children, who had just come up the coast from Chile, and returned to New York, where we arrived on March 24.

Aside from the interest of studies and collections from such little-known localities as La Plata and El Muerto, the region I had the good fortune to visit during this expedition proved at the time to be of exceptional geographic importance. The early months of 1925 were characterized by extraordinary if not unprecedented weather conditions along most of the western coast of South America, and the phenomena pertinent to the scope of this book had their incipience in the district centering about the Gulf of Guayaquil (Murphy, 1926, 26).

7. The Explorations of Chapman and His Associates

Beginning in the early 'nineties of the last century, Dr. Frank M. Chapman has conducted very extensive field work in the West Indies and in Central and South America. Since 1911 the consummation of his plans has involved also the labors of numerous associates. The aim of Dr. Chapman's research has related chiefly to the delimitation of the Andean life zones, and to a precise tabulation of the birds that mark them, as realized in the monographs on the bird life of Colombia and Ecuador and in numerous shorter studies. However, Dr. Chapman's personal journeys have likewise included two almost complete circumnavigations of the South American continent, while various parties of his representatives have done much travelling and collecting along diverse sections of the coast. Brief reference to some of this exploration will point to the source of part of the material used in the preparation of this report.

In 1893 and 1894 Dr. Chapman collected at Trinidad, obtaining a few sea birds even though his interests were concerned mainly with the relationships between the land birds of the island and those of the Venezuelan mainland.

During August and part of September, 1912, Mr. W. B. Richardson worked at Tumaco Island, and along adjacent parts of the Pacific coast of Colombia. A year later he continued ornithological investigations on the coast of Ecuador, visiting Puná Island in the Gulf of Guayaquil, and La Plata Island in the Pacific. At La Plata, during the month of October, Mr. Richardson apparently did not encounter the sea birds which Mr. Heilner and I found breeding at the same locality in February, 1925.

In June, 1921, Mr. George K. Cherrie began one of his several periods of field work in Ecuador for the American Museum of Natural History, this time with Mr. Geoffrey Gill as his assistant. Their work was chiefly inland, in the arid tropical zone near Guayaquil, but in October Mr. Gill collected on Jambelí Island in the Gulf of Guayaquil, and in December on the peninsula of Santa Elena.

In July, 1922, Dr. Chapman, accompanied by Mr. Cherrie and Captain Geoffrey O'Connell, made a reconnaissance of both shores of the Gulf of Guayaquil, southward to Tembleque Island. On this trip they obtained a series of waterfowl, made interesting records regarding the great numbers of birds which had washed ashore dead, and also discovered that non-breeding northern hemisphere shore birds (Limicolae) are present in large flocks in the Gulf of Guayaquil at a season during which all members of the several species might be expected only nearer their boreal breeding grounds.

Returning toward Panama during the following September, Dr. Chapman also succeeded in collecting certain petrels which flew aboard his steamer at night, and which proved to represent the first records for the coast of that country of at least three species.

Between November, 1923, and January, 1924, Dr. Chapman visited the maritime parts of southern Chile and the Fuegian region. With Senator Frederic C. Walcott and Lord William Percy, he chartered at Puerto Montt a small wood-burning steamer, having a speed of nearly seven knots, and set out for the Guaitecas group, to southward of Chiloé Island. The course lay down the eastern side of Chiloé, and on December 31 the vessel anchored off Malinka, the only human settlement at the Guaitecas. On January 6, 1924, the party crossed the Gulf of Corcovado to the mouth of the Río Rodriguez, and continued thence to the Bay of Pumalín, a land-locked body of water filled with aquatic fowl.

By the middle of the month, the vessel was back in Puerto Montt, but Dr. Chapman thereafter accompanied United States Ambassador William Miller Collier on a voyage to Punta Arenas, following the inland passages through Darwin, Messier, Sarmiento, and Smyth channels to the Strait of Magellan. From Punta Arenas, or Magallanes as it is now named, he had the privilege of travelling by gunboat and motor car to various accessible parts of Tierra del Fuego, as well as northward over the mainland to Puerto Natales on the inland sound of Última Esperanza.

Returning to Puerto Montt once more, Dr. Chapman subsequently followed the coast as far as Temuco before crossing the continent to obtain material for an American Museum exhibit of water birds from Lake Chascomús, south of Buenos Aires.

8 Tate's Work on the Coast of Venezuela

During May, 1925, Mr. G. H. H. Tate of the American Museum's Department of Mammals, spent a short time in the area about Cumaná, on the Venezuelan coast, while awaiting transportation homeward after his expedition to Mt. Turumiquire. Collecting was undertaken along the beaches and among the mangrove growths a few kilometers to eastward of the port. Birds of more than 25 species were collected, these including pelicans, frigate-birds, cormorants, skimmers, and terns, as well as many marsh birds and Limicolae.

9. Chapin's Visit to the Galápagos

During the spring of 1930, Dr. James P. Chapin accompanied Mr. Vincent Astor in the motor yacht 'Nourmahal' to the Galápagos Islands, where he remained about three weeks, obtaining a small but useful collection of water birds among a larger representation of land birds inhabiting the group.

10. The Cruise of the 'Zaca'

In 1934, Mr. Templeton Crocker, of San Francisco, invited several members of the American Museum staff to accompany him on a Pacific cruise. Dr. James P. Chapin and Mr. Francis L. Jaques were members of this party, which sailed from San Francisco on the yacht 'Zaca' on September 15, and returned to Panama on April 1, 1935. The Polynesian part of the voyage falls outside the scope of this account, but on January 30, 1935, Dr. Chapin and Mr. Jaques landed at Mas Afuera, of the Juan Fernández group, and spent nine hours ashore. On the following day a landing was effected at Mas Atierra, after which the schooner proceeded to Valparaiso.

On February 18 the expedition called at the island of San Felix, on which Dr. Chapin was ashore from 7:30 to 11:30 A.M. Birds were obtained on the island as well as around the yacht. In mid-afternoon the 'Zaca' moved over toward the adjacent and nearly inaccessible island of San Ambrosio, where no landing was attempted but around which birds were observed and collected from about 5 P.M. until dark. The resident avifauna of the two islands appeared to number seven species, concerning which I shall have more to say later.

The next port of call of the yacht was Pisco, Peru, reached on February 23. Through the courtesy of Mr. Francisco Ballén, chief of the Peruvian Guano Administration and a life member of the American Museum, arrangements had been made for the party to obtain at the neighboring Chincha Islands all necessary material for a museum exhibit of guano birds. The 'Zaca' accordingly anchored between two of the islands until Messrs. Crocker, Chapin, and Jaques had completed their field work on the afternoon of February 26, after which they departed for Callao.

On the morning of March 3 the schooner was headed toward the islets of Hormigas de Afuera, upon which Mr. Beck had attempted unsuccessfully to make a landing on June 4, 1913. The 'Zaca' party had no better fortune, for the surf seemed to be piling high from every direction, occasionally reaching the brinks of the cliffs which rise seven or eight meters above mean sea level. Dr. Chapin reports that a short distance away from the island the sea was no more than moderate, and a dozen or more open fishing-boats, as well as one small sloop, were riding at anchor off the northern side. The 'Zaca' cruised around the islets and remained in the vicinity from the middle of the afternoon until 8 P.M. before setting her course toward the Galápagos. A summary of what is known about the birds of Hormigas de Afuera will be found in the section devoted to a circumnavigation of the continent.

No further landfalls were made until daybreak of March 9, when the 'Zaca' made the southern end of Albemarle Island. The yacht subsequently cruised along the western shore to Tagus Cove, and on the following day rounded the northern end of Albemarle and came to anchor for the night at James Island. On March 12 another shift was made to Conway Bay, Indefatigable Island, where 13 days were occupied in making studies and obtaining specimens and accessories for a museum group of Galápagos birds. After a brief visit to Academy Bay of the same island, the 'Zaca' sailed for Tower Island, making a brief stay in Darwin Bay before departing for Panama.

11. Miscellaneous Sources of Material

Scattering examples of marine birds from many parts of the South American region are plentiful in the collection of the American Museum of Natural History. Some of these have been taken by members of our own expeditions bound, as indicated above, to or from various parts of the interior but making use of their time during the accidental or enforced sojourns on the coast. Others have been obtained through exchange, or have been presented or purchased in small lots, and their respective sources are too numerous to note in detail.

Worthy of record, however, are the collections made by Mr. Thomas Hallinan, in Panama and Chile; those of Mr. Carlos T. Reed, from Chile; those of Mr. Gerald H. Thayer, from Grenada and neighboring islands of the Lesser Antilles; and those of Mr. D. S. Bullock, from several parts of the Chilean coast. Of particular interest was Mr. Bullock's visit, during November and December, 1932, to the little-known island of Mocha, where he obtained much new information, as well as a representative collection of both the land and sea birds. Of the older material, the birds brought from Gough Island in the South Atlantic by Captain George Comer are worthy of note.

Finally, three expeditions by other organizations have served to enrich the sea bird collections of the American Museum of Natural History, and to supply us with specimens which have proved particularly valuable during the preparation of this book. These are respectively, the South Atlantic Expedition of the Cleveland Museum of Natural History, in the schooner 'Blossom,' under the command of Mr. George Finlay Simmons; the first Byrd Antarctic Expedition; and Mr. Lincoln Ellsworth's projected Transantarctic Expedition of 1934–1935.

The 'Blossom' party collected extensively at sea over much of the tropical and sub-tropical Atlantic, and visited not only the islands of Fernando Noronha and South Trinidad, but also the very important oceanic stations of St. Helena and Ascension. The last-named island is of special significance because it is the type locality of a number of Linnaean species of sea birds which are found along various South American coasts, both in the Atlantic and in the Pacific. Without topotypes of these, obtained in exchange from the Cleveland Museum, many taxonomic comparisons and conclusions would have been impossible.

Small collections generously turned over to the American Museum by Admiral Richard E. Byrd have given me needed data on penguins, the Antarctic Skua, and several species of petrels. The extent of the debt is made clear in the biography of the Emperor Penguin and elsewhere.

Mr. Ellsworth's contribution comprises about a score of birds collected and prepared by Mr. Christian Braathen of his party at Deception and Snow Hill Islands, in West Antarctica.

ACKNOWLEDGMENTS

During the period of investigation, I have, of course, examined specimens of oceanic birds in many museums, both within the United States and abroad. To the custodians of the ornithological collections at the following institutions I owe thanks for innumerable facilities and courtesies:

Museum of Comparative Zoölogy, Cambridge.
Boston Society of Natural History, Boston.
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Academy of Natural Sciences, Philadelphia.
United States National Museum, Washington.
Carnegie Museum, Pittsburgh.
Cleveland Museum of Natural History, Cleveland.
Field Museum of Natural History, Chicago.
California Academy of Sciences, San Francisco.
Museum of Vertebrate Zoölogy, Berkeley.
Museum of the University of San Marcos, Lima.
British Museum (Natural History), London.
Royal Scottish Museum, Edinburgh.
Zoölogical Museum, Tring.
Zoölogical Museum of the University, Berlin.
Senckenberg Museum, Frankfurt-am-Main.
Royal Natural History Museum, Stockholm.

To all of my colleagues in the Department of Birds, but especially to our Chief, Dr. Frank M. Chapman, I owe an endless debt. The precept, aid, and encouragement of Dr. Chapman is squarely behind whatever any of his immediate disciples accomplish in our common field. In my own case, I believe that his patience and faith have had fully as great a share as any efforts of my own in bringing this report to completion. Furthermore, he has assumed much of the burden of putting the book through the press.

To several young ladies I am obligated for assistance during a term of years. First, Miss Dorothy Taylor aided in the organization of data, took down considerable text by dictation, and typed a proportion of first-draft copy. Subsequently Miss Kathryn Johns not only continued the same work through a longer period, but also assisted in a less tangible but even more important manner by constantly keeping the progress of the book first among her many secretarial duties. After Miss Johns's untimely death, in August, 1934, Miss Ruth M. Campbell coöperated as earnestly and capably as the most exacting author could wish until the manuscript had been converted into a finished volume.

For many months Miss Paula Wätjen gave me expert and essential collaboration by combing a great bulk of scientific literature in several languages, and preparing digests of material which proved to have a bearing upon subjects discussed in this book. Later, after her marriage to Mr. J. Sterling Rockefeller, she continued from time to time to help in the same way, and never lost a keen and generous interest in my task. After losing the regular services of Miss Wätjen, I felt that they could not be replaced, but Miss Helen F. Witte stepped into the breach and carried on in a manner altogether praiseworthy, and during four final months Miss Dorothea Dreier concluded this phase of the work, besides making herself helpful in all other ways. Mrs. Murphy, always my foremost collaborator, has assisted and inspired me at every stage, and has read the entire proof of the work.

All members of the staff of the American Museum Library have given every indication of pleasure in meeting my wants. Certainly they have spared no effort to obtain with eagerness and dispatch any rare or obscure publication for which I asked. Fellow workers, whatsoever their field, will appreciate what such facilities have meant, and how thankful I am to have enjoyed them.

The plates and other illustrations by Mr. Francis L. Jaques speak for themselves, but I should add my appreciation for the cheerfulness with which he has always striven to combine such points as I wished to emphasize with a faithful depiction of Nature as seen through his own eyes. Through the courtesy of Dr. Isaiah Bowman, I was enabled to draw upon the expert cartographic facilities of the American Geographical Society for the preparation of maps, which were drawn by Messrs. Gustav Schweizer and John Forsyth.

To many ornithologists and other scientific men in the United States and abroad I am grateful for counsel and assistance frequently requested. So numerous, in fact, are those who have helped at least in small measure that it would be impossible to list all of their names. Several to whom I owe most are no longer living. Below are those who come strongly to mind as I look backward toward the distant days when the Brewster-Sanford Expedition was still in the field, and when the always exciting cases of specimens were arriving at intervals in the Museum:

In the United States—Mr. Outram Bangs, Prof. Robert E. Coker, Dr. Joseph Grinnell, Dr. Charles E. Hellmayr, Dr. Harry C. Oberholser, Mr. James L. Peters, Dr. Charles W. Richmond, Dr. Witmer Stone, Mr. W. E. Clyde Todd, and Dr. Alexander Wetmore.

In Argentina—Dr. Roberto Dabbene.

In Great Britain—Mr. W. B. Alexander, Dr. Ernst Hartert, Dr. Percy R. Lowe, and Lord Rothschild.

In Germany—Dr. Erwin Stresemann.

In Sweden—Dr. Einar Lönnberg.

Furthermore, Dr. A. C. Stephen has recently sent me certain specimens of critical interest from Edinburgh; Dr. George Gaylord Simpson, of the American Museum, has opened to me his rich record of observation relating to the coast of Patagonia; and Dr. George E. R. Deacon, of the British 'Discovery' Investigations, has supplied me with unpublished information relating to the zones of surface water in the southern hemisphere.

THE GEOGRAPHIC BACKGROUND

1. The Continent

From a geographer's point of view, South America is a model continent for the reason that no other is so simple in shape and construction and no other equally large region is so isolated. In relation to area the coast line is exceptionally short, about one linear kilometer to 700 square kilometers of surface (1 mile to 435 square miles). In latitudinal extent South America is one of the longest of the continents, but still more notable is the fact that it comprises large areas on both sides of the equator and at the same time extends into a zone where sub-antarctic conditions prevail.

Furthermore, there are natural geographic and zoögeographic relationships between South America and the truly antarctic lands across Drake Strait to southward. Similar connections hold also for the numerous oceanic islands to eastward and westward, and for the archipelagoes of the Antillean and Scotia arcs, respectively to northward and southeastward. All of these regions fall within the scope of the present study.

Owing to the pronouncedly triangular outline of the continent, and the projection of its acute apex into the open southern oceans (the zone of westerly winds, which are otherwise practically unimpeded on their course around the globe), the oceanographic conditions along most of the shore line express themselves in a relatively simple, almost diagrammatic, way. For such reasons, the operations of nature, including the interplay of the great forces of land and sea, may be observed in South America on a scale at once colossal and readily intelligible.

Such circumstances could not fail to be reflected in the distribution of the birds which live along the coasts and which derive their sustenance either from the open sea or from estuaries, channels, or beaches affected by salt water. In wealth and variety of oceanic birds, including on the one hand such inter-tropical forms as frigate-birds and noddy terns, and on the other such essentially sub-antarctic species as skuas and certain of the albatrosses, petrels, and penguins, South America is without a peer. It is to a study and interpretation of the factors controlling the distribution of the oceanic and littoral birds that this work is especially dedicated.

Let us preface and mingle our account of the bird life with notes upon the structure of the South American coast, and also upon drainage, meteorology, ocean currents, and other phenomena that help to make the littoral and pelagic environments what they are. Let us include, furthermore, a running description of salient coastal features, seeking the impressions that circumnavigators of the continent would gain if their craft might hug the bends of the highly varying shore throughout the whole voyage of some 27,000 kilometers. Only by such attempts to correlate life and its physical background can we hope to comprehend the place of the native sea birds in the scheme of nature.

We shall draw our information from any available source—manuscript note-book, periodical, work of travel, geographic text, mariners' pilot book, or even fiction if the descriptions seem warranted. Curiously, we shall have to learn more through the eyes of visitors than through those of South Americans for, as Shanahan has pointed out, the

> Spanish and the Portuguese, both in Europe and in the New World, have been more interested in describing characters and events than in studying the physical milieu. . . . Individual authors and learned societies in the Iberian Peninsula and in South America have had a great deal to say about what people did and said but are mainly silent about places (Shanahan, 1927).

The South American continent consists, fundamentally, of a great system of folded mountains in the west and northwest, together with a lunette of three plateaus to eastward, the latter almost meeting the mountain ranges in the north and south. Between each plateau and the next, and between all of them and the mountains, are extensive tracts of detrital deposits.

The western edge of the continent contrasts with the Caribbean and the greater part of the Atlantic margins in that coastal plains are absent on the Pacific slope throughout most of its length. Wherever they do exist, as in Peru and Ecuador, they are narrow. Extensive trough-faulting along the western coast, accompanying the upward movement of the Andes, has caused the descent to great oceanic depths to be very abrupt.

Except in a few restricted localities, notably off Arauco, Chile, the great downward flexure of the earth's crust known as the geosyncline lies close to the Pacific shore all the way from the Magellanic district to the Gulf of Panama. Under such circumstances, the recent elevations of the shore in Peru and Chile have been of little avail to extend the coast line westward. Relative absence of indentations is a marked character along the north Chilean and Peruvian coasts, where progressive uplift has effaced most previously existing erosion features.

The streams, for example, are without estuaries. Even to northward and southward of the desert zone, where denudation has been heavy along the western slope of the Andes, the coastal plains are still narrow or non-existent.

On the northern continental coast, on the other hand, from the mouth of the Amazon to Panama, the slope of the land toward the sea, and of the floor of the sea itself, is generally gentle, and little of the region is close to deep soundings. There the coastal plains become more pronounced; the Orinoco and the Magdalena rivers have been able to establish deltas, such features furnishing evidence that the land is now gaining upon the sea after a period of subsidence that caused Trinidad and other islands off the Venezuelan coast to be separated from the mainland.

Between Trinidad and the Lesser Antillean chain, the sill over which the equatorial current flows into the Caribbean is less than a thousand meters in depth. West of Tortuga Island and Cape Codera, Venezuela, however, the coastal shelf narrows sharply, and the contours of 200, 500, 1000, and 2000 meters lie nearly parallel and close to the main trend of the shore all the way to the Mosquito Bank, off Nicaragua.

Turning again to the eastern sea front of South America, the coast along the Brazilian scarp is steep-to from Cape São Roque to about 16° south latitude. From here southward the continental shelf and slope widen, becoming even broader than along the Atlantic coast of North America and reaching a maximum extension at a point southeastward of the Falkland Islands. From the Falklands the 200-meter contour loops just south of Staten Island and Cape Horn, to continue close to the mainland shore along the west coast.

There are several reasons why the depth of the littoral waters has an important bearing upon bird life. Deep coastal currents, for one matter, are usually cool currents, while shallow currents are relatively warm. The relation of low ocean temperatures to faunal abundance will be illustrated by many examples during our coastwise survey and in subsequent parts of the text.

In one respect the eastern margin of South America resembles the western, for except in the pampa region of Argentina the coastal plain is narrow from Cape São Roque to the Strait of Magellan. In central and southern Brazil it practically disappears. Here subsidence, as evidenced by the numerous rock-basin harbors of Brazil and the estuaries of many rivers, has permitted the ocean to invade a former coastal plain, and has brought the present shore up under the eastern scarps of the two southern plateaus. The geographic relation between the sea and the pampa of Argentina has led Professor Denis to liken Buenos Aires to a Chicago with the Atlantic seaboard submerged and the Appalachian Mountains breached.

In Patagonia, the terraces along the coast, and the hills and mesas at no great distance inland, indicate that there is no true coastal plain except about the mouths of the larger, northerly streams. A striking feature of the topography is the succession of long, thoroughly mature, groove-like valleys opening upon the beaches. In southern Patagonia the plateau lowers by easy stages. Just north of the Strait it consists of plains of moderate elevation, while in eastern

Tierra del Fuego there are wide stretches of lowlands sloping gently toward the Atlantic.

West of the Patagonian Plateau, the mountain axis correspondingly lowers southward. Beyond latitude 51° S., the Andes disappear as a distinct watershed and, degenerating into a marshy table-land penetrated by the sea in Última Esperanza Inlet, Skyring Bay, and Otway Water, finally come to an end at the Strait of Magellan. Along the western border of this region extensive glacial and river erosion, combined with subsidence, has broken the seaward mountains into a complicated system of islands. To northward the Chilean coastal range is continuous, attaining a maximum elevation of nearly 2500 meters in latitude 25° S. Near the northern border of the country it breaks down, and in Peru this range is recognizable only as a few isolated blocks.

It remains to emphasize the important fact that, in general, the margins of the South American continent are high, the interior low. Along the whole of the west coast, the greater part of the east coast, and in middle Venezuela on the northern coast, the lines of maximum elevation are at no great distance from the ocean. From these crests the terrain slopes toward the interior, so that the trend of drainage is largely away from the periphery of the continent and toward the low levels of the central river systems. The Amazon, throughout its long course from Iquitos to the Atlantic, has a fall of less than 4 centimeters per kilometer (2½ inches per mile). Independent rivers of any size have little chance of coming into existence because the coasts throughout the well-watered parts of the continent are almost everywhere guarded by ranges and plateaus, the high ridges of which overlook the sea and force the bulk of the drainage to find its ultimate outlet at a few well-marked gaps where the relief falls to sea level.

Notwithstanding these facts, South America has more running water than any other continent, and less desert area than any continent except Europe. Even the dry coasts have rivers of some sort. Except in northern Chile, where the River Loa stands practically alone in a long stretch of desert seaboard, the seemingly interminable arid zone of the west is crossed by extraordinarily numerous short streams that proceed from the maritime cordillera. Sight should not be lost of the fact that the water of such small, intermittent or irregular rivers may be seasonally important to life within the ocean, however slight its apparent effect upon the aspect of the land. From such sources come supplies of silica and other minimal nutritional substances upon which, by way of ecologic sequences, the existence of even sea birds may depend.

2. Meteorology

Behind the range, migration, and breeding season of sea fowl lies the local climatic cycle. It imposes the régime of existence. The control is to some extent direct, but is exerted rather more through a chain of phenomena beginning with the light and heat of the sun, continuing through atmospheric movement, oceanic circulation and the resulting physical characteristics of the water, the latter determining in turn the nature and abundance of a series of marine organisms which, at one plane or another, constitute the food of the birds. Certain meteorological circumsrances lead to a poor result and others to bounteousness; the sea has its deserts as well as its rich pastures. The temperature of the upper layers of water, more than any other single factor, furnishes the best index of what we may expect to find.

The direct physical force of wind also has a selective influence upon sea birds, some types being fitted for life in zones where others would be literally blown out of their bailiwick. It has been suggested that mere barometric pressure exerts a similar determining influence (Jones, 1926, 36), a subject discussed hereafter in the biography of the Galápagos Albatross. Still more, wind in its effect upon the surface of the ocean is more potent than latitude in the creation of certain special climatic environments and in decreeing what types of sea birds may occupy them. Ocean currents in contact with continental shores provide many seeming anomalies of distribution. However, no part of the ocean is, zoölogically speaking, of the traditional "boundless" character. On the contrary, both the ranges and the barriers of oceanic creatures are as definitely laid out as are those of continental organisms. For interpreting many striking and even unparalleled attributes of the sea bird fauna of South America, a continent with the greatest known climatic range at sea level, an understanding of the meteorology and hydrology, in their broader aspects, is essential.

The continent as a whole falls into several well-marked climatic regions, the limits of which are determined largely by the position, height, and direction of the chief mountain ranges. These regions stand out with singular clearness, and the major controlling factors for each are not difficult to assign. In briefly reviewing them, we may draw freely upon the excellent summaries of Shanahan (1927), Denis (1927), and others, and the more detailed rainfall studies of Franze (1927).

Generalized planetary conditions in variation of barometric pressure and of winds are less affected by the expanse of South America than is the case with most continents. In the tropical zone, where the territory is largest, the greater part is occupied by low, humid plains and forests in which the evaporation is almost as copious and the temperatures nearly as uniform as over the surface of the sea. In the extra-tropical zone to southward the width of the continent is too slight for it to show the sharp shifts from winter highs to summer lows that are so characteristic of the northern hemisphere. In other words, alternating anticyclones and cyclones do not form on a vast continental scale in South America. Sea winds rule the coast at most places and seasons, and extend their influences even far into the interior.

Since the Andes lie across the tracks of both the westerly winds and the trades, there tends to be a marked difference in the amount of precipitation on opposite sides of the chain in any given latitude. There are thus two types of rainfall, and consequently of climate, east and west across the continent in both of the great wind belts of the southern hemisphere. Neighboring oceanic islands of sufficient altitude also show the same phenomenon on a small scale. Thus Fitz Roy (1839, 502) writes:

> Striking instances of the manner in which high land deprives air of its moisture may be seen at the Galápagos. Situated in a wind nearly perennial, those sides only which are exposed to it (the southern) are covered with verdure and have water: all else is dry and barren, excepting such high ground as the passing clouds hang upon indolently as they move northward.

On the continent itself, the difference holds for all sections except that of northern Ecuador and western Colombia, where both flanks of the mountains are humid all the time, and where precipitation reaches its maximum. In regions characterized by two or more seasons of marked difference in rainfall, the drier part of the year is generally known as "verano" (summer), the rainy part as "invierno" (winter). In Brazil, the Portuguese equivalents, "verão" and "inverno," are used in the same senses. The terms may prove convenient for avoiding confusion with the calendar summer and winter of the northern hemisphere.

Rainfall is, therefore, determined by the position of the sun, the winds, and the topography. The three fundamental factors concerned with its distribution in South America are, (1) the permanent areas of high pressure over the South Atlantic and South Pacific Oceans between the 20th and 40th parallels of latitude; (2) the equatorial region of low pressure in upper Amazonia, which moves to and fro with the sun so that it is mainly north of the equator during the northern summer and mainly south of it during the southern summer; (3) the ocean currents that bathe the shores of the continent, particularly the warm equatorial current that divides at the northeastern corner and so washes both easterly coasts, and the cool Peruvian or Humboldt Current that flows northward along the Pacific coast. Ocean currents profoundly affect the relative humidity of air reaching continents from the sea. Moreover, in conjunction with the source and direction of the prevailing winds, they cause the heat equator in South America to lie approximately along the line from Panama to Cape São Roque, close to the northeastern coast line.

a. Trade-Wind Régimes.

In considering the climatic conditions of a continent so much subject to trade winds, it is important to note that these winds are not necessarily bearers of rainfall. If they proceed from high-pressure areas extending over wide ocean spaces to the neighborhood of moderately low shores, the winds upon reaching the land will tend to absorb rather than to deposit moisture. An abrupt slope, sufficiently high to effect sharp adiabatic cooling, may cause precipitation, but in most places the tropical beaches and the adjacent country are warmer than the sea winds coming from higher latitudes. An outstanding feature of the annual distribution of rainfall in Franze's illuminating study is the ineffectiveness of the trade winds as rain-bearers except where relief and exposure aid precipitation. Along the northernmost extension of the Venezuelan coast, for example, the dryness seems almost phenomenal, a subject to be reverted to below. Wherever the trade wind shows a marked annual rhythm, the windy season is the drier season (verano), the season of relative calm is winter (invierno).

For such reasons both the east and west coasts of South America, within the limits of the trade winds, have scant rainfall during the northern-hemisphere late summer and autumn period. Much of the west coast remains dry during the remainder of the year as well, but, since there is no cold current along the east coast north of Patagonia, the Atlantic center of high pressure contracts during the northern-hemisphere winter and spring. Then the winds, being neither as strong nor as drying as at other seasons, are accompanied by rain. The correspondence between trade-wind period and dry season is very pronounced all along the northerly coast from Cape São Roque to Panama.

South of the Amazon the winds die away and the rains increase from January until May or June. When the easterly winds augment in force in July, and the area of tropical calm retreats inland, a relatively dry season sets in over all territory affected by the sea winds. Farther southward, along the coast between Bahia and Cape Frio, the easterly winds of the southern summer are likewise associated with fine weather.

b. Maritime Climatic Control on the Central East Coast.

Still southward, from Rio de Janeiro to Bahia Blanca, Argentina, there is a strip that receives fairly abundant rains throughout the year, with a tendency toward an austral-summer maximum in the north, a spring maximum in southern Brazil, and spring and autumn maxima on the Argentine pampa. The coast seems to be under the influence of a strictly maritime régime, and to southward of latitude 18° the winter rains are determined by the passage of barometric lows across the zone of westerlies, which produce the storms known as pamperos. Regarding the south temperate part of the continent as a whole, we may say, therefore, that the regular rains are summer rains, but that there is also liberal rainfall in winter due to the passage of cyclones across Argentina. This leads to an even and adequate rainfall throughout the year.

From Cape Frio to Bahia Blanca the coastal zone is mainly outside the influence of the southeast trades, and the winds are accordingly very variable at all seasons except during summer when the low-pressure system over the Chaco leads to an indraught from the Atlantic. Farther northward the winter rains are brought by the southwest monsoon winds, which become more and more regular as they approach Cape São Roque.

c. Modification of the Double Equatorial Rainy Season.

Theoretically there should be a double annual rainy period throughout the equatorial zone, between about 10° N. and 10° S., corresponding with the swing of the sun. Actually, however, such a condition is obliterated or obscured except in the cordilleran region and in parts of Guiana. Elsewhere a single rainy season peak has replaced the double régime; precipitation shows a strong monsoonal tendency, and an austral-summer maximum south of the equator.

Toward the southeast in the equatorial belt, this passes through an autumnal to an early winter (May, June) maximum in the region of marked rainfall anomaly between Cape São Roque and Bahia. Even here, however, as Franze fails to make clear, the rapid dwindling of precipitation begins with the waxing strength of the southeast trade wind during July.

d. The Northern-Summer Rainfall Region.

On the other hand, the greater part of the tropics north of the equator lies within the northern-summer rainfall region. During the northern winter the high-pressure belt of the northern hemisphere expands and pushes southward until it just reaches the Caribbean seaboard, and so deprives most of northern South America of any considerable amount of rainfall during that season. Only the northward projection on the west side of the Gulf of Maracaibo, and the opposite Coro region of Venezuela, have an Antillean régime, with winter rains. Here one reaches a sufficiently high latitude so that the trade wind is not interrupted during the summer, while in winter the whole belt moves farther southward when the winds approach or reach the southern hemisphere. Coro, in other words, is at times actually north of the zone of northeast trade winds. Its feeble invierno or rainy season comes between October and March, more pronouncedly in the eastern part of the coast where there are large inundated savannahs. At Maracaibo the rains come from August to November, and also during the month of May. Throughout the dry season (December to April) the northeast trade wind is very regular.

The zone of the northeast trade wind shifts poleward and equatorward, with the declination of the sun, to the extent of about three degrees of latitude at its northern margin and about ten degrees at its equatorial margin. The southern limits range between 13° 30′ N. in August and 2° 30′ N. in February. Sometimes it reaches even farther southward, though not on the coast. The southeast trade, on the other hand, often attains 10° N. latitude in mid-Atlantic during the northern summer.

The boundaries of the northern-summer rainfall region, with the exception noted, cut the coast a little north of the Gulf of Guayaquil on the Pacific side and a little north of the mouth of the Amazon on the Atlantic. The winter drought that characterizes much of this region is most pronounced in the Orinoco lowlands, from west of the delta to the mountain-locked basin in which Lake Maracaibo lies. On the seaward slope of the Guiana highlands the rainfall is heavier and more evenly distributed.

e. The Northwestern Coastal Area of Perpetual Rains.

The northern part of the Pacific coastal strip receives rain not only during the northern summer, when there is a strong inflow of moist air from the northeast, but again during the northern winter, when the continental low-pressure system south of the equator tends to pull in equatorial air from westerly and northwesterly points. In other words, the southeast trade is deflected inshore

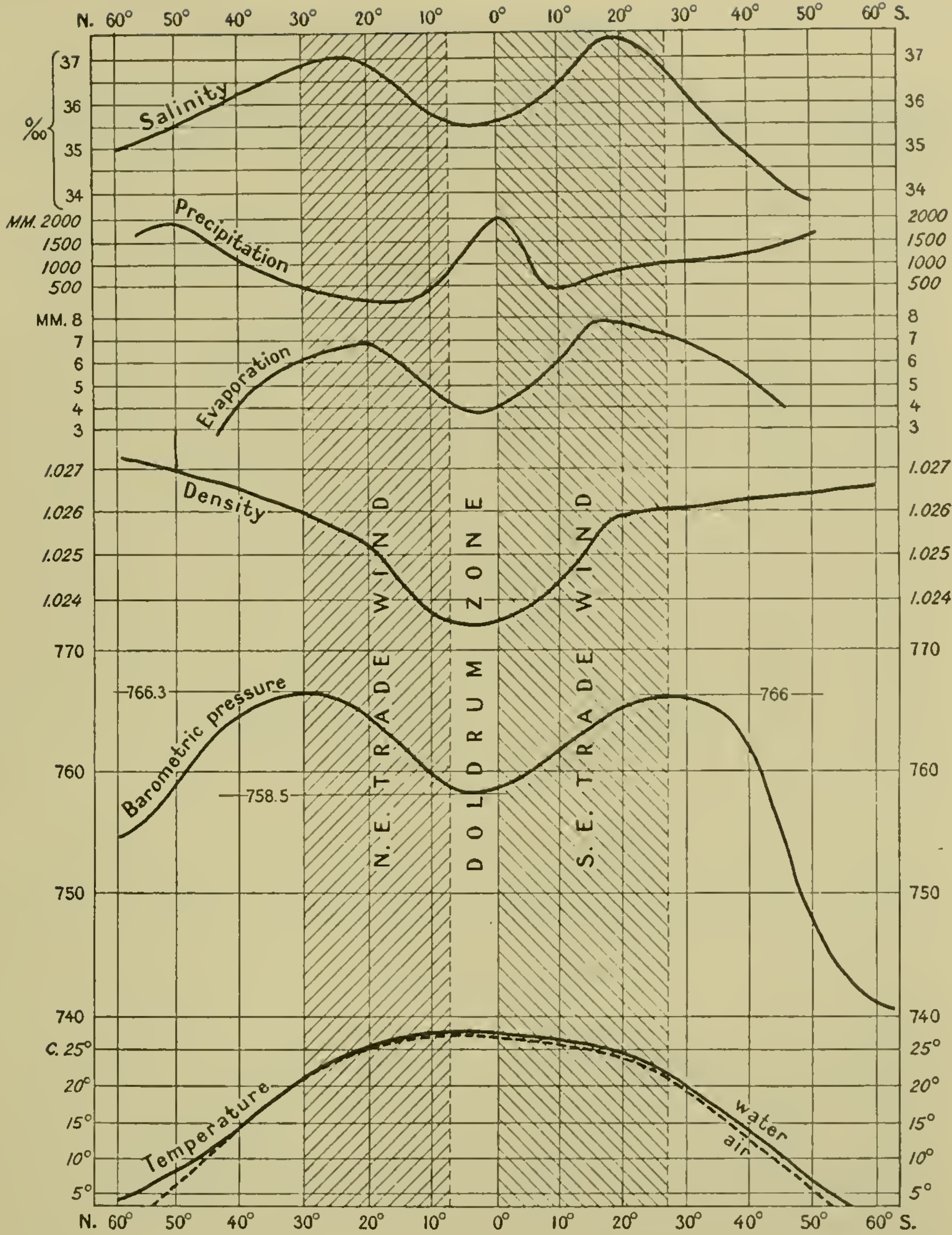


FIG. 1. Zones of calms, trade winds, and westerly winds in the Atlantic Ocean between latitudes 60° N. and 60° S., with comparative graphs showing the annual means of salinity, precipitation, evaporation, density, barometric pressure, and the temperature of air and surface water.

After Schokalsky (1917) with the addition of the atmospheric pressure curve from Schott (1912).

here in July, and the northeast trade in January. The mean annual rainfall at Buenaventura, Colombia, during a seven-year period (1910–1916) was more than seven meters, with a yearly maximum in October.

f. Winds and Seasons in Guiana.

The wind régime in Guiana results from a seasonal oscillation of the trade winds and of the zone of equatorial calms from one side of the equator to the other. There are thus two dry seasons corresponding, respectively, to the periods of the northeast and southeast trades, separated by two periods of calms and rains. In Brazilian Guiana the dry season lasts from August to February, rainfall beginning when the southeast winds decline. Farther north a double invierno obtains. At Cayenne the main rainy season holds sway from April until July, the southeast trade restoring a dry cycle from July to December. Then the rains commence again, but during February and March there are almost always a few weeks of fine weather due to the reign of the northeast trade wind, which never reaches as far as the Amazon. In Dutch Guiana, and more especially in British Guiana, the four seasons alternate regularly and are approximately equal in length. The rule of the northeast trade wind, however, increases more and more as one progresses northwestward. At Georgetown the verano of the northeast trade (February to April) is more marked than that of the southeast trade (September and October). The heaviest rains come during May, June, and July, and in December and January.

g. The Line of Doldrums.

As noted above, the trade wind of the northern hemisphere does not advance at any time of year much to southward of French Guiana. But the southeast trade wind, the northerly limit of which recedes as far as Cape São Roque during the austral summer, moves rapidly northward during the northern summer, crosses the equator, and sometimes makes itself felt as far as the mouth of the Orinoco. The mean axis of the zone of calms dividing the trade winds lies, therefore, a few degrees north of the equator. This axis, as measured by barometric pressure, resulting wind direction, and precipitation, rather than merely by temperature, is the meteorological equator. The discrepancy between its position and that of the geographic equator is observable equally along the coast of the Guianas and offshore on the Pacific side in the vicinity of the Galápagos Islands. It is one of the phenomena having to do with the unequal divisions of land and water between the northern and southern hemispheres. Over the Pacific Ocean and near the continent, for instance, this line, which marks the doldrums, runs in a generally west-northwest east-southeast direction toward the South American coast, which it meets near Panama during the northern summer and at the geographic equator during the northern winter. In summer a rain-bearing southwest monsoon replaces the southeast trade wind in the oceanic bight at the northwestern corner of the continent (that is, the Cocos-Malpelo-Buenaventura-Balboa area). In winter the northeast trades blow as northerly winds over the Gulf of Panama and almost down to the equator.

The southeast trade wind blows briskly and regularly along the Atlantic coast as far as the mouth of the Amazon from June to January. During the remainder of the year this part of the coast is prevailingly calm because the northeast trade wind never reaches it, even though it is largely responsible for rainfall in the interior of the continent.

h. The Southern-Summer Rainfall Region.

South of the equator, except in the anomalous coastal strip of easternmost Brazil, the meteorological conditions are the reverse of those in the north-equatorial belt. In other words, they are entirely homologous with those of the northern-summer rainfall region, for the bulk of the precipitation coincides with the austral summer. During the winter the high-pressure systems over the oceans to eastward and westward widen until they unite across the continent and fill almost the whole belt between the equator and latitude 40° S.

Low-pressure systems in the interior of South America appear to be the prime cause of the inward movement of vast quantities of moisture that provide the heavy summer rainfall of the tropics everywhere except along the arid west coast and in the peculiar region of northeastern Brazil to be described later. Over the equator (and between the zones of the trade winds) there is a moisture-laden upper current which moves westward throughout the year above the Amazon Valley, and is largely responsible for the continual rains in the upper part of the basin. When the sun moves southward, this equatorial air is reinforced by large quantities of moist trade-wind air from both the northeast and the southeast. When the sun moves north of the equator, the southern edge of the Amazonian low-pressure area shrinks as far as about 10° S., and the northern part of the basin then comes under the influence of the equatorial calms. At the same time the northerly coastal slopes begin to be well supplied with rain by the inflow of moisture-laden air from the Caribbean and the North Atlantic.

i. The Amazonian Climatic District.

The Amazonian climatic district opens out like the small end of a funnel from the valley of the river toward the coast, adjoining the northern-summer rainfall region near the Guiana border, and running across the mouths of the Amazon and down to a point near Fortaleza in the state of Ceará. The wettest months are January to May (on the coast), but rainfall seldom fails at other seasons. As would be expected, it is heaviest in the vicinity of the estuary when the tropical calms prevail, as between December and April. During the southern winter, when strong easterly winds blow in from the greatly enlarged south Atlantic high-pressure area, the climate tends to be fresh and dry. In a low-lying district at the mouth of the river, as at Salinas, Pará, and for some distance along the coast in both directions, is a strip in which the rainfall is distinctly heavy, approaching a mean of 2500 millimeters per annum. Here the distinction between the two annual seasons is not so much that between wet and dry as between very wet and moderately wet.

It would appear from this digest that South American summer rainfall bears a close resemblance to the monsoon type. Since the continent as a whole, however, is warmer during every season than the surface of the surrounding oceans, there is no such great winter outflow of high-pressure atmosphere as proceeds from the interior of Asia. The only notable complete monsoon system in South America is the small-scale one in northeastern Brazil.

j. The Chilean Mediterranean.

Two coastal exceptions to the widespread summer rainfall régime of the continent are found, namely, one in this same semi-arid, monsoon region of Brazil, and another in south-central Chile. Both of these widely separated territories receive most of their rain during the austral winter.

The latter of the two is the Chilean Mediterranean region, the limits of which are about 27° and 36° south latitude (approximately from Copiapó southward to Concepción). As in similar regions elsewhere on western continental coasts, this is characterized by winter rainfall, the summer months, especially to northward, being quite dry. Copiapó has a mean annual precipitation of only about 16 millimeters, all of which falls between May and August. We have to go southward almost to Talcaguano before reaching a part of the coast that receives some rain during every month of the year, with the peak (*circa* 120 millimeters) in June and the annual average approaching 500 millimeters. The same rule holds offshore, as at the Juan Fernández Islands, and also southward, with rapidly augmenting total precipitation, as far as the belt of permanent westerly winds.

The weather of the Chilean Mediterranean is alternately that of the westerlies and that of the trades. In the austral winter, when the zone of westerlies has spread equatorward, brisk breezes and moderate rainfall prevail. In summer, when the southeast trade-wind belt shifts poleward, a period of mild, dry, and nearly continuous fair weather sets in.

k. The Brazilian Semi-Arid Monsoon District.

The second important region of winter rainfall, referred to above, comprises a short stretch along the northeastern seaboard of Brazil, especially in the states of Ceará and Rio Grande do Norte. Here a peculiar semi-arid area extends inland in a southwesterly direction between Cape São Roque and the well-watered Amazonian region. It suffers from occasional floods and recurring droughts, and because of its climatic trials, is whimsically known to the Brazilians as the "Job of the North." True monsoon conditions in miniature prevail here. The northeasterly winds that rule in summer are probably the southeast trade wind combined with a summer monsoon, and warped by it from the normal course as soon as the barometric pressure is sufficiently lowered in this part of the continent. The southerly and southwesterly winds that replace it in winter represent the reverse monsoon, which begins when the pressure over the continent rises.

The center of least rainfall is found within a narrow strip abutting on the sea between the Assu and Apody Rivers in Rio Grande do Norte. During the austral summer, when most of the surrounding territory receives heavy rains, this section is dry. Most of its rainfall comes during the southern autumn and winter, when the remainder of tropical South America, south of the Amazon, has a relatively scanty supply. The explanation of the comparative aridity of this corner of the continent seems to be that the local interior uplands act as a wedge between the sea winds from the northeast and those from the southeast. These winds therefore carry the bulk of their moisture beyond the region, uniting to deposit it in the low-lying central parts of the continent.

At the island of Fernando Noronha, well off the coast, and at Natal, Recife, and other points near the easternmost projection of the continent, rainfall is more copious but its annual distribution is similar. The rainiest month is April at Fernando Noronha, June at Natal and Recife. Throughout the whole general region the driest part of the year comes between September and December, when the northern limit of the southeast trade-wind belt is retracting.

l. Rainfall on the Brazilian Coast North of Rio.

The interior summer rainfall region, referred to above, comprises an enormous area in the central and eastern parts of South America, and reaches the sea along the stretch of coast between southern Pernambuco and Rio de Janeiro. The moisture-laden Atlantic air is attracted toward the interior by the great low-pressure system established during the southern summer, and to this westward movement the Brazilian plateau appears to offer slight resistance, despite the fact that its highest points lie along the eastern edge.

m. Anticyclonic Coasts and Transcontinental Lows.

To southward of the trade-wind zone, circulation of the air is regulated by the high barometric constants of the south Atlantic and Pacific. The first determines the south and southeast winds on the northern coast of Chile; the second the northeast winds which run down the east coast as far as the Río de la Plata. On either side of the continent these winds are stronger and more regular in summer. That is the time when the land is warmed, when the pressure is diminished, when the gradient between the high pressure of the oceanic atmosphere and the lighter continental atmosphere is greatest. In the southern winter the pressure increases on the continent until it exceeds that over the surrounding oceans, and the winds become irregular. To southward of 30° S., the normal winds are interrupted by the passage from west to east of cyclonic depressions such as those that cross the North Atlantic. The cold waters and high pressures of the Pacific coast seem to interpose a barrier to them, and they never turn northward west of the Andes. It is for such reasons that storms are unknown along the Peruvian coast. Instead, the lows go to the southward around Cape Horn, or cross the continent directly, reaching the Atlantic between northern Argentina and southern Brazil. Then they usually turn southeast, to the southward of the South Atlantic high-pressure field. However, in winter (May to October), and especially during July and August, at the time when the northeast winds are feeble along the Brazilian coast, these depressions frequently run northward as far as the latitude of Rio de Janeiro. They determine the shifting winds (north winds followed by south winds), with sharp variations in temperature. The cold and often violent winds called pamperos follow their passage. Ward (1903, 359) has written:

> Cyclonic storms are . . . very common in the latitudes occupied by the prevailing westerly winds. The passage of such cyclonic storms across Argentina causes marked changes in wind, temperature, and weather. The warm, damp northerly wind (*norte*) in front of these depressions is followed by the cool, dry *pampero* from the southwest, on the rear. The pampero corresponds in general to our own [North American] northwest wind, which is the rear indraft into a cyclonic centre. It is usually cool, dry, and bracing. The exclamation attributed to the first Spanish arrivals in this region, "Que buenos aires son estos!" must have referred to the conditions which prevail with a southerly wind, and not to those which the *norte* brings. The name *Buenos Aires* perpetuates, as is often the case with geographical names, a climatic feature of the region in which the city lies.

n. The Zone of Westerlies.

Beyond 40° of south latitude, or thereabouts, the barometric pressures reduce rapidly toward the polar continent. This is the belt of great west winds—the "Roaring Forties, Furious Fifties, and Shrieking Sixties." Throughout this zone, however, the most important climatic truth is the inconstancy of the weather. We speak as a matter of course of the "westerlies" of these latitudes, but in reality the winds are shifting all the time. Their strength and direction depend much on the season, and at no time are they to be compared in steadiness with such a wind as the southeast trade. It has been shown that in the South Atlantic the maximum line of the westerly winds, determined by multiplying the average velocity of such winds by their frequency, is found between the latitudes of 45° and 50° S. Here the average force is 5.38 of the Beaufort scale and here, too, the percentage of easterly winds is least (Deacon, 1933, 171).

In the Pacific the belt of prevailing westerly winds seems to extend farther southward than in the Atlantic. The general course, however, is around the world, and the gusts and gales, interrupted now and then by the passage of lows, always begin again with renewed intensity. Southern Chile, together with the whole of Tierra del Fuego, is under the influence of the westerlies throughout the year. The winter precipitation maximum in this part of the continent is explained by the effect of the Pacific northerly winds which serve to strengthen the westerlies at this season. Wherever there is direct exposure to these winds, rainfall or snowfall is heavy at all seasons, and only in the eastern, low-lying part of Tierra del Fuego does it drop below a high figure on the coast.

Altitude is the only requirement necessary to condense still more water from the humid winds of these latitudes, as may be demonstrated by comparing the mean yearly precipitation of Ushuaia, which is 34 meters above sea level, with that of Staten Island, directly to eastward and to leeward, the snow-covered heights of which rear a thousand meters, more or less, above the Atlantic. The respective figures for rain and snow, reduced to millimeters of water, are 479 for Ushuaia and 1701 for Staten Island. The latter has, in fact, even heavier precipitation than that shown by the recorded tables for the island of South Georgia.

A somewhat similar relationship is that between the Falklands and South Georgia. At both these localities the winds blow chiefly from between southwest and northwest, and gales are frequent. At Stanley the average annual precipitation amounts to 640 millimeters. In the sheltered district of Cumberland Bay, South Georgia, it is 1400 millimeters; on the high land of the interior, and on the exposed southwesterly coast it must be far greater. Snowfall at South Georgia is heaviest in autumn (May), the period of the year when the barometric pressure is lowest and the storm-tracks are farthest south.

o. The Diagonal Desert Strip.

There remains for consideration the Peruvian-Chilean-Patagonian desert region, which is of commanding geographic importance on much of the west coast of South America. This extends along the Pacific from just north of the Gulf of Guayaquil southward beyond Copiapó (27° S.). Then it crosses the Andes, reaching the Atlantic near the mouth of the Río Colorado (40° S.), and continues down the coast of Patagonia to the Strait of Magellan, beyond which the westerly rain-bearing winds make themselves felt right across Tierra del Fuego.

The fundamental cause of the aridity in this zone is the high wall of the Andes, which completely cuts off Atlantic moisture in the trade-wind belt, while it is equally effective in intercepting moisture from the Pacific in the westerly belt. Along the arid west coast, rainfall occurs only at long intervals of years, if at all, but mists (*garúa*) resulting from the condensation of moisture at sea are common during the summer months at the seashore and at moderate elevations inland. The cool surface of the Humboldt Current causes the sea winds to condense their water vapor as effectively as rising land. It should be noted here that the coastwise, more or less onshore, winds that blow from a southerly quarter along the reaches of Peru and Chile which are bathed by the Humboldt Current, represent only a deflected moiety of the southeast trade wind. Western continental coasts, especially such as rise steeply to great heights, always have a tendency to pull the trades inshore in this manner. Less than a day's sail to westward from the Peruvian coast, one finds the southeast trade wind blowing steadily on its wonted course.

From Copiapó southward the continental temperatures are low enough to make occasional rains possible, particularly in winter when radiation cools the land more quickly than the sea. South of Valparaiso westerly winds become more pronounced and the inshore northward-flowing current ceases to be recognizable as an intercepting factor. From Valdivia southward, the whole Pacific face of Chile has rainfall of over 2500 millimeters per annum, and a narrow belt extending along the western slope of the Andes receives more than twice that much. In the south Chilean region the climate, inhospitable enough on the mainland, becomes even worse in the archipelago. The precipitation is excessive, the winds fierce and cold, and the sky almost invariably overcast.

General aridity, on the other hand, dominates the Patagonian region to leeward of the mountain chain. In response to the increasing force of the westerlies toward the south, together with the lessening altitude of the Andes in the same direction, the isohyets tend to turn away from the mountains toward the Atlantic as they approach the Strait of Magellan. The lowlands of Tierra del Fuego are, therefore, relatively humid as well as windy and cold. But northward, the winds blowing across the Patagonian plateau from the Andes are themselves dry and thus tend to absorb any surface water across which they pass. The small rainfall of the Atlantic coast comes mainly during the southern winter and is associated with interruptions of the westerly winds.

p. Sea Birds in Relation to Gales and Lee Shores.

Long-continued onshore winds of great violence are always possible hazards to pelagic birds, especially to species that do not rest upon *terra firma* except during their nesting season. In the northern hemisphere the auks and their relatives belong within this category during the large proportion of the year spent to southward of the breeding grounds. In the southern oceans, petrels, fulmars, shearwaters, and terns are the birds most liable to become the victims of such storms. The danger can hardly be called common or widespread, because the birds concerned are as a whole admirably fitted to cope with the worst weather conditions of the region. Nevertheless, in the zone of westerlies and on the exposed windward coasts of South America, Africa, and Australia, vast numbers of sea fowl are from time to time beaten down on lee shores. While we know less of what actually occurs in South America than in the other southern continents, one might infer that the destruction in the south of Chile would be worse than anywhere else in the world. Here there is the tremendous stretch of the South Pacific to windward, and the west-wind zone is broader than elsewhere. To the known strength and persistence of the gales is added the fact that the continent extends southward almost twenty degrees of latitude beyond either Australia or Africa, besides which petrels are extremely abundant in waters between 40° and 60° S.

Whitlock (1927, 154; 1931, 263) has recorded the effect of winter storms on oceanic birds along the west coast of Australia, between Bunbury and Perth. His data are referred to in more detail in certain of the biographies that follow. Suffice it to say here that during strong westerly gales he found thousands of petrels and terns driven ashore in a moribund state. On one occasion ten Giant Fulmars and seven of the smaller albatrosses were among hosts of lesser birds, most examples of which had washed ashore alive only to perish later. Whitlock attributes the weakness of the birds to their inability to obtain sufficient food during prolonged periods of very rough weather.

Murphy and Vogt (1933, 325), in discussing the reason why Dovekies or Little Auks (*Alle alle*) are occasionally blown ashore in great numbers along the Atlantic coast of North America, have pointed out a chain of stimuli and reactions which indicate perhaps more clearly just why petrels and other sea birds sometimes come to grief on lee shores. These authors note first that when beset by such untoward circumstances a bird may lose 50 per cent of its body weight before finally succumbing from exhaustion. They write:

The physiological processes of birds are extraordinarily rapid, but the katabolic sequence during starvation and exhaustion is the same as among other vertebrates. As the first stage, the glycogen or animal starch in the muscles and the liver is used. This is followed by the combustion of fat throughout the body. Until the glycogen and fat have been practically all utilized, the destruction of muscle fiber is very slight, but thereafter the protein of muscle tissue is drawn upon rapidly for the energy of life and movement. The heart is the last muscular tissue to be diminished.

Any starving animal reaches at a certain point a sudden toxic destruction of tissue, which represents the pre-mortal breakdown, and which is irreversible. During such a process of exhaustion and starvation the loss in body weight is very great indeed. Since skeleton, skin, and feathers are composed of material that is not combustible, a bird may literally become reduced to "skin and bones." Possibly as much as 90 per cent of its muscle tissue may be destroyed to supply energy before death ends the process. It is, therefore, not surprising to find that some of the Dovekies had lost half or more of their original weight.

The Dovekies, like other pelagic birds, ordinarily waste no energy in fighting the gales of their oceanic range. On the winter feeding grounds they more or less drift with the prevailing wind, slowly while on the water, but becoming part of the more rapidly moving medium as soon as they take the air. Probably their tendency to work to windward prevents undue leeway in normal weather, besides which, winds from new quarters sooner or later bring their compensating force. But doubtless even a very strong and prolonged wind lacks any particular significance for the birds, unless it may eventually cause their planktonic food to descend to deep and inaccessible levels. Ordinarily, the Dovekies would merely move along contentedly and unconsciously with the wind, still within the range of their pasturage, until a leeward coastline set in motion a new series of reactions.

The situation is exactly the same as that of the strong-winged Procellariiform species. In the southern oceans many petrels spend their lives in a region of almost perpetual gales. Probably the strongest winds that blow cannot incommode them so long as they have sea room. But when chance and gales bear them down on such a lee shore as the west coast of Australia, for example, they face the unwonted but instinctive experience of *combatting* the wind, striving to keep offshore. The result is likely to be the same for any species, however powerful on the wing. Rapid combustion of tissue is followed by exhaustion, and dying birds are washed ashore by breezes that would have no effect whatever upon them on the high seas (Murphy and Vogt, 1933, 345).

q. Birds and Hurricanes.

Notwithstanding that practically all of South America lies to southward of the path of Atlantic tropical cyclones, these meteorological disturbances have exercised a profound effect upon the sea birds of the area under consideration.

In the first place, the Caribbean-Antillean region is directly to leeward of many late summer cyclones that cross most of the expanse of the northern equatorial Atlantic. This inevitably means that neotropical coasts and waters are more or less peppered each season by stray sea fowl from the eastern Atlantic. This fact alone may go far toward explaining why the Cape Verde Islands, the West Indies, Central America, and the Galápagos Islands share in common one species each of tropic-bird and frigate-bird, and why one booby ranges from the African coast to the Isthmus of Panama. Conversely, we should not expect the American Brown Pelican to reach the Old World (which it does not), because its range in the same belt lies to leeward, with respect both to the trade winds and to the normal cyclonic trends.

Secondly, tropical cyclones assist in the transportation into the northern hemisphere of sea birds belonging strictly to the South Atlantic avifauna. A striking instance of this is presented below in the case of the South Trinidad Petrel listed under the discussion of Cyclone Number 3 of the selected examples.

Since the meteorological equator lies in the northern hemisphere, tropical cyclones never originate in the South Atlantic Ocean. Neither can they have birth within several degrees of the equator, because in such low latitudes the deflecting force of the earth's rotation cannot be effective in originating a vortex. Nine degrees of north latitude is the southernmost known line of origin of such a movement in the North Atlantic, and most of the cyclones begin in the zone between 10° and 20° N. Since high temperature and high humidity are both favorable, the doldrums possess all the requirements for setting them in motion.

The typical course for these storms is first to move westward, then to curve toward the north, and finally to swing in a northeasterly or easterly direction. The movements cannot break through the permanent high-pressure area (anticyclone) over the North Atlantic Sargasso region, and hence they skirt to southward of this before recurving, the longitude of the recurve depending upon the position or extent of the high-pressure area. Beginning during the month of August, a large proportion of the North Atlantic cyclones originate far to eastward of the Caribbean region, particularly just south of the Cape Verde Islands, where the doldrums are most in evidence during August and the first half of September. Many of these late storms (September and October) do not finally dissipate until they have reached a high latitude. This is doubtless why most of the tropical sea birds carried into various parts of North America by such movements have been recorded during the latter part of the summer and the early autumn.

Cyclonic storms characterized by winds of 100 kilometers per hour or more have an extraordinary effect in transporting sea birds for very great distances. Why this should be so is not easily answered, for, during a large part of their course over the ocean, such disturbances are as a rule of relatively small area. Furthermore, the system of storm winds at sea usually moves forward at a rate considerably less than the average flight-speed of ocean birds, so that the latter should theoretically be able to outstrip the storm center and subsequently to get clear of the peripheral regions of violent rotary winds, dense clouds, and rainfall. Mackaye (in Forbush, 1925, xxii) discusses the matter as follows:

> These hurricanes, moving north as they do, naturally carry with them any birds flying in their path. It may be assumed theoretically that the influence of such great disturbances on southern sea birds is exerted in the following manner: The wind revolves around the storm center in a direction opposite to the course of the hands of a watch held in a horizontal position. The effect of this revolving gale is felt at a great distance from the center, and the wind velocity is said to reach at times over 100 miles an hour at sea. Probably no bird can long face a gale blowing 60 to 70 miles an hour. As the storm center at sea usually moves first toward the Atlantic coast north of the Caribbean Sea, birds flying over waters that lie south of the center but at some distance from it and under the full influence of the gale would be carried first eastward out to sea, then northward and finally as the storm center moved north along the coast would be driven in from the southeast, east or northeast upon the shore, provided they lived to reach it. Others nearer the storm center might be carried more than once around it before reaching land. Birds migrating at or near the center of the disturbance probably would be caught in the tremendous upward draught there, and might be carried to great heights. Only birds of powerful flight would be likely to

withstand the storm, and small land birds driven to sea by one of these hurricanes probably would never see land again. Sea birds caught near the surface by hurricanes are sometimes crumpled up and driven into the sea. In many cases birds cast ashore during these storms are completely exhausted, and in some cases many die of exhaustion after they reach the shore. Such storms probably account for most of the accidental occurrences of sea birds on the coasts of Massachusetts.

The above seems to me to be hardly adequate to cover the most remarkable cases of long-distance transportation. From evidence connected with the "trapping" of birds within the vortex of a cyclonic storm, and with the occasional conveyance of strong-winged species of sea fowl from the eastern equatorial Atlantic to points far in the interior of North America, I am inclined to believe that an ocean bird might be carried along within the so-called "eye" of a hurricane because, when once entrapped, it would tend constantly to rebound away from the periphery of gales, and thus to retreat toward the quieter center.

Let us consider, for instance, the cyclone of late August, 1933, the long course of which is shown in figure 3, and which is Number 3 in the list below. This storm carried a South Atlantic sea bird to central New York State and an eastern Atlantic sea bird to Ontario. Up to August 17, when the movement was still in the eastern Atlantic, the area of gales around the center was probably never more than 125 kilometers in diameter. By August 20, however, the ring of gales had increased its diameter to 600 kilometers, more or less, with the encircling cloud and rain fringe larger in proportion. Now it seems to me altogether probable that the birds of the two species referred to were actually caught *inside* the swirl of this storm. Under such circumstances, they might be carried along without becoming panicky, without experiencing any sense of difficulty, feeding normally, and tending always to turn inward toward the calm of the slow-moving center when they had flown far enough in one direction to come into heavily wind-whipped waters. The system as a whole, by the way, was moving forward during this period at a rate not exceeding 25 kilometers per hour. Only when the vortex came into close proximity with the land, as I conceive the situation, would the birds thus held in unconscious durance begin to fight the gales, perhaps to be carried into the higher altitudes of the atmosphere and to be buffeted as helpless waifs for long distances overland before being cast out centrifugally, subsequently to fall exhausted.

It is only through some such process as this that I can comprehend the transportation of Black-capped Petrels from points east of the Caribbean to the Mississippi Valley, or of Madeira and South Trinidad Petrels from the central or eastern north equatorial Atlantic to Ottawa and Ithaca, respectively.

Regarding the actual presence and behavior of birds in the vortex of cyclonic storms we have, fortunately, some slight information. Vague accounts of birds seeking refuge upon vessels are likely to appear in the newspapers during every hurricane season. Exact records are rather more difficult to find, but one such has been published by Cradock (1908, 435), and the United States Weather Bureau, through the courtesy of Dr. C. F. Marvin, has supplied me with several others.

Admiral Cradock, when in command of a British destroyer, was once obliged to run toward the calm center of a typhoon in the China Sea. When the vessel

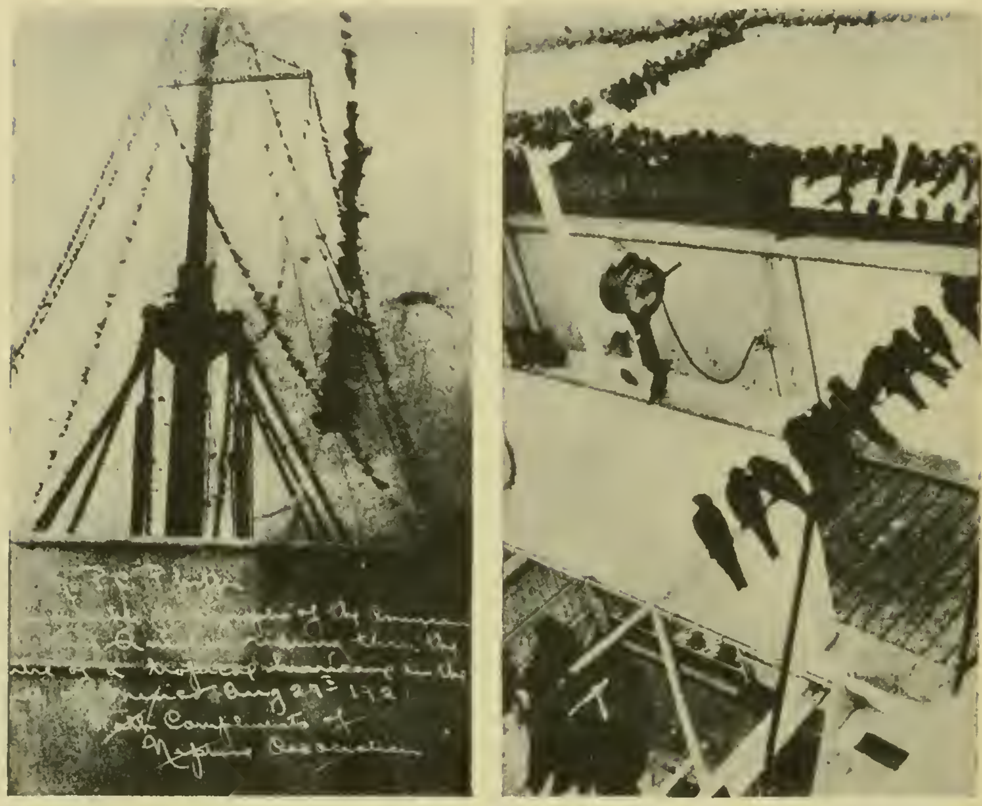


Fig. 2. Birds, chiefly swallows, seeking refuge on a steamship in the "eye" of a hurricane, Gulf of Mexico, August 27, 1926.

Courtesy of the United States Weather Bureau

reached a position well inside the whirl of devastating winds, vast numbers of Asiatic kingfishers and other land birds sought refuge upon her. Still nearer the center, where the sky was bright overhead and the atmosphere practically a complete calm—although the waves were toppling about without direction in the utmost chaos—the air was filled with fugitive land birds, fluttering all about the destroyer and everywhere else within the range of vision.

On September 3, 1933, the American steamship 'Golden Horn' underwent a similar experience in the calm center of a typhoon encountered a short distance to eastward of Shanghai. According to the vessel's log, many different species of birds, including terns as well as land birds, littered the decks, more than 300 being counted upon the bridge alone.

Still more graphic, and belonging to our own tropical region, is a record accompanied by photographs and made on board the American steamship 'West Quechee' in the vortex of a hurricane in the Gulf of Mexico on August 27, 1926. In the "eye of the storm," at the time the camera was brought into use, the wind was blowing at a rate of only 9 or 10 kilometers per hour. Birds, which seem to be migrating land birds, chiefly swallows, filled the air about the vessel and were so thickly strewn on deck that they could be scooped up by the armful.

The hurricane months in the American tropics are from June to November, with the seasonal peak in August and September. Many of the later disturbances each season sweep the northeasterly coast of South America. Birds picked up by these storms are in general more likely to be carried northward than toward the interior of South America. Yet, unnumbered waifs must no doubt be blown inland south of the Caribbean, especially during the latter part of the northern summer when so many of the disturbances cross Trinidad and the projecting mainland peninsulas of Paraguana and Goajira. At some future date, when our knowledge of South American sea birds has become less fragmentary, we shall doubtless acquire plentiful records bearing upon this. Since we have thus far little more than theory to support our conclusions, it will be altogether appropriate to consider specific instances of the extraordinary transportation of tropical sea birds into North America by the seasonal cyclonic storms. The question, as noted heretofore, has been treated briefly by Mackaye, but some of the data below will link it up more closely with birds belonging to the South American oceanic area.

Before citing several historic cyclonic storms and their associated ornithological phenomena, it may be well to refer to the widely varying rate at which these wind systems proceed along their courses. The speed ranges from less than 150 to an extreme of about 2000 kilometers within 24 hours. These figures represent the total forward movement of the storm, and have nothing whatsoever to do with the force of the winds blowing around the vortex. In general, the slower the progression of the cyclone along its path, the greater the extent of destruction over any land area, owing to the continuance of hurricane winds at one place for a greater length of time.

Storm-waves produced by hurricane winds travel, of course, very much faster than the cyclonic system itself, and frequently serve as precursors of what is to follow. The waves and swells of greatest size and length develop in the rear right-hand quadrant of the cyclonic area, and proceed at a rate of 65 kilometers or more per hour in the direction in which the area was moving at the time of their origin. Even the movement of sea birds very often, perhaps usually, outstrips the storm itself, and a surprising number of records in the literature tell of the presence of waifs twenty-four hours or longer in advance of the vortex, or even ahead of appreciable winds. Ober (1880, 179) speaks as follows of the flocks of Sooty Terns which are known as the heralds of hurricanes among certain of the Lesser Antilles:

> Immediately preceding the hurricanes, there arrive off the Caribbean coast vast numbers of birds called, from their cries, "Twa-oo." They are said to be the harbingers of hurricanes, and only appear during the calms, immediately before a storm. They cover the water in large flocks, and come in from the desolate sandy islands where they breed. They are the sooty tern (the *Sterna fuliginosa*), but are known to the natives as "Hurricane-birds." When I arrived in Dominica the sea was black with them, but on the morning after the storm they had disappeared, to a bird, as completely as though blown into another sphere.

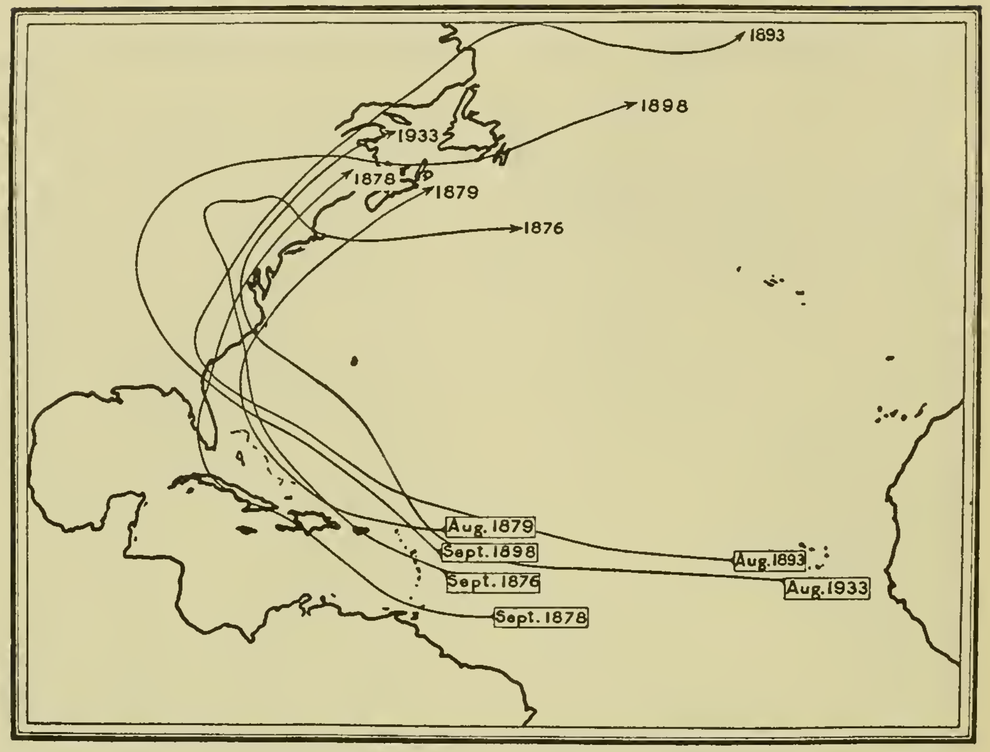


Fig. 3. Courses, so far as determined, of six cyclonic storms responsible for the transportation of pan-tropical sea birds to extralimital regions in North America.

Vivian (1904, 55) likewise reports that at Cape Nelson, in British Papua,

> . . . a coming "blow" from the southward was always heralded some hours before by the appearance of a few Frigate-Birds . . . which hovered in the locality while the wind lasted . . . It would be more appropriate to call them "Prophet-Birds."

Figure 3 shows the approximate courses of three August and three September or September-October, Atlantic cyclonic storms. Through a comparison of the files of the United States Weather Bureau (Garriott, 1900; Mitchell, 1924) with the 'A. O. U. Check-List of North American Birds,' and other sources, these six particular hurricanes have been selected with special reference to their effect in transporting tropical sea birds.

(1) August, 1879. A cyclonic storm which barely reached the eastern border of the United States. On August 17, its center was off the Carolina coast. On the morning of the 18th the wind velocity was estimated to be 165 miles per hour (265 k.p.h.) at Cape Lookout, North Carolina, after the anemometer had been carried away. On the 19th the center was off Nova Scotia.

During the remainder of the month, Black Skimmers (*Rynchops nigra*) were recorded on the coast of Maine and in the Bay of Fundy.

(2) August, 1893. A very destructive hurricane which, unlike the last, penetrated the eastern seaboard of North America as far as the Appalachian

Mountains. On the coast between Florida and North Carolina more than a thousand human lives are believed to have been lost, mostly through storm-waves.

The disturbance has been traced back to its point of origin, near the Cape Verde Islands, about August 18. On the 26th the center passed the Bahamas and next day crossed the Georgia coast. On the afternoon of August 28 the center was northwest of Charlotte, North Carolina, from where it moved in a generally northeasterly direction toward central New York State, travelling 725 kilometers during 12 hours. It subsequently crossed the lower St. Lawrence valley and returned to the Atlantic well to northward of Newfoundland.

As a result of this storm thousands of Wilson's Petrels (*Oceanites oceanicus*) were washed ashore, dead and dying, along the coast of North Carolina. The 15-kilometer stretch of beach between Beaufort Harbor and Cape Lookout was literally strewn with them (Pearson, 1899, 249).

During the last four days of August and the first few of September, moreover, no less than five specimens of the West Indian Black-capped Petrel (*Pterodroma hasitata*) were taken, respectively, at Blacksburg, Virginia, Oneida and Cayuga Lakes, New York, Pittsfield, Massachusetts, and in Vermont. An example of the Madeira Petrel (*Oceanodroma castro*) was recovered at Washington, D. C., on August 29, and a Black Skimmer at West Springfield, Massachusetts, about the same date.

(3) August, 1933. This disturbance originated to southwestward of the Cape Verde Islands about August 14. It first moved westward for several days and, when northeast of the Lesser Antilles, turned northwestward, passing not far south of Bermuda. It next switched more toward the west, crossed the coast near Cape Hatteras during the night of August 22, and reached Washington, D. C., on the following day. By this time the recurve had begun, and the subsequent movement was north-northeastward toward the mouth of the River St. Lawrence.

This storm had a most remarkable effect in the transportation, and inland distribution, of sea birds from both the tropical Atlantic and the north temperate Atlantic. The outstanding record is that of the South Trinidad Petrel (*Pterodroma arminjoniana*) found alive at Caroline Center, near Ithaca, New York, on August 26, 1933. This species had never before been known from North America (Murphy, 1934, 151; Allen, 1934, 134).

Hardly less noteworthy is the record of a Madeira Petrel taken alive in the streets of Ottawa, Ontario, on August 28. Furthermore, a Wilson's Petrel (*Oceanites oceanicus*) was collected on Lake Titus, Malone County, New York, on August 26; 20 Leach's Petrels (*Oceanodroma leucorhoa*) were found dead on the shores of Oneida Lake, New York, during early September; and many more examples of the last-named species were scattered over other parts of the Middle Atlantic States.

According to the hypothesis advanced at the beginning of this section on birds and hurricanes, it may be assumed that the South Trinidad and Madeira Petrels were transported *inside the whirl of the storm* from somewhere in the eastern tropical Atlantic. The same explanation would obviously not fit the records of the Wilson's and Leach's Petrels, for during August neither of these species would be likely to be present in large numbers in any part of the Atlantic crossed by this particular cyclonic vortex. In this connection it is important to note that the wind at any point in the path of the storm blows from *all* directions around the "eye." Thus the North Atlantic species scattered over central New York and Pennsylvania by the cyclone of late August, 1933, are just as likely to have been borne inland from the New England coast as from any more southerly part of the Atlantic. The meteorological disturbance as a whole was moving at the time in a northeasterly direction, but the violent winds in its right van were blowing in from the Atlantic to eastward and northeastward.

It may, therefore, be essential to distinguish between (1) vortex-borne sea birds, which are transported along the linear path of a cyclonic center; and (2) gale-borne sea birds, which may equally well be carried in a direction forming an angle with the course of the vortex. The hurricane of August, 1933, offers the most convincing examples of both categories.

(4) September, 1876. This hurricane reached the northerly islands of the Lesser Antilles on September 12, coming from the southeast. On the 13th it crossed Porto Rico and, after skirting the northeasterly edge of the Bahama Bank, turned more toward the north and was due east of Savannah, Georgia, on September 16. Next day the center reached the North Carolina coast, after which it was deflected by a high-pressure area along an unusual inland course, toward the northwest. When it had penetrated well into the continent, however, it hooked about abruptly and swept eastward across Pennsylvania, New York, and New England, and thence out to sea. Between September 16 and 18 the passage of the storm was marked by very heavy easterly gales between Cape Hatteras and Cape Cod.

In its wake examples of the Sooty Tern (*Sterna fuscata*) were recovered at Owasco Lake and Lake Champlain, New York, and at Williamstown and Lawrence, Massachusetts. A Tropic-bird (*Phaëthon lepturus cateshyi*) was taken at Knowlesville, New York, and a Frigate-bird (*Fregata magnificens*) at Halifax, Nova Scotia. During the same month, moreover, a Cape Pigeon (*Daption capensis*) was collected at Casco Bay, Maine, though the presence of this southern-hemisphere species cannot definitely be linked up with the hurricane.

(5) September, 1878. This disturbance brushed the South American coast and was the most southerly, throughout the early part of its course, of the six selected examples. It originated during August, probably in the eastern part of the Atlantic. On September 1, the center was over Trinidad, from where it turned northwestward across the Caribbean, reaching Haiti on September 4, and running through most of the length of Cuba before the beginning of the recurve carried it slowly northward through Florida and onward up the seaboard of the United States into the maritime provinces of Canada, which it entered on September 13. Heavy precipitation and widespread destruction attended this hurricane both in the West Indies and on the continent.

Immediately after the passage of the storm, Sooty Terns were reported from

Lake Ronkonkoma (Long Island), and Highland Falls, New York, and from Piscataquis County, Maine. A Brown Booby (*Sula leucogaster*) was taken on Cape Cod, Massachusetts.

(6) September–October, 1898. An example of a cyclonic storm which passed far into the interior of the continent, despite the fact that it crossed the coast well to northward of the Gulf of Mexico. The storm is notable, furthermore, for the complete correlation between its course and the extraordinary records of tropical sea birds in the Mississippi Valley, as noted below. The center passed to northeastward of the Antilles and the Bahamas and struck the continental coast of the United States on October 1, between Jacksonville, Florida, and Savannah, Georgia. It then swept inland far to westward of the Appalachian Mountains and northward through the interior, before looping to eastward across the Great Lakes and passing out to sea south of the St. Lawrence and Newfoundland on October 5.

On October 4 and 5, respectively, examples of *Pterodroma hasitata* were captured at Augusta, Kentucky, and Cincinnati, Ohio.

THE HYDROLOGY IN RELATION TO OCEANIC BIRDS

Movements within the sea are due to meteorological causes. In a world without breezes, we should doubtless still have a flowing and sorting of ocean waters because of the dynamic effect of unequal heating by the sun. Actually, however, the most obvious of these movements, such as the definite ocean currents, are produced by the secondary agency of wind.

Life zones governing the distribution of birds at sea are ultimately determined by physical properties of the surface waters. The well-nigh inexorable control of certain special types of oceanic environments upon birds has not yet been generally realized by either zoölogists or oceanographers. The distributional boundaries and barriers of animals inhabiting land areas, such as mountain walls, deserts, broad rivers, lines of abrupt change in temperature or rainfall, etc., are accepted as a commonplace. Naturalists recognize, moreover, that the ranges of fishes and of innumerable marine invertebrates can be readily correlated with the temperature and chemical content of sea water. But oceanic birds seem, in the main, to have been regarded somewhat naïvely as aërial rather than aquatic animals, notwithstanding that their relationships to sea and land, as concerned with feeding and breeding, respectively, are precisely the same as those of the seals among mammals or the sea turtles among reptiles. Members of none of these groups have escaped the necessity of using the land as a cradle, but their true medium, and the source of their being, is, nevertheless, the sea.

In this book we shall have abundant opportunity to note how the majority of oceanic birds are bound as peons to their own specific types of surface water. The bonds are in some cases effective throughout the life of the organism, while in others they apply chiefly to the reproductive period. In a very few instances there appears to be complete freedom from any sort of hydrological control, which means that certain species of birds can thrive equally well in water exhibiting the widest possible range of temperature, salinity, and other characteristics. But such rare instances only serve to emphasize by contrast the far more familiar circumstances in which the limits of avian ranges suggest that the ocean abounds in invisible walls and hedges, and that trespass, afloat as well as ashore, is in the nature of a zoölogical anomaly.

Now in seeking to determine the relationship between ocean water and the composition of bird life in a given district, the first and most useful clue is temperature. Water temperature, rather than air temperature, may be said to govern the distribution of sea birds. The control is rarely a direct one between the warmth or coolness of the water and the sensory system of the bird, although there is evidence of such a simple and immediate relationship in the case of certain penguins confined to the temperate zone, and doubtless among other birds as well. In most instances, however, the control is bound up rather with a long ecologic sequence—with a ladder of phenomena beginning with sunlight and photosynthesis and ending in the nature and quantity of organisms upon which birds may feed. From a biologist's point of view, temperature tells more than any other measurement we may make about the associated qualities of sea water and the life that it is fitted to sustain. Bigelow (1931, 54) has written:

> There is as good reason from the biologic side as from the strictly physical for studying the temperature of the sea, because this, more than any other one feature of the water, directly controls the distribution of marine life, animal and plant. Because of the important rôle of temperature in governing the rates of animal and plant metabolism, . . . the seasonal changes in the temperature of the water present special problems to the marine biologist in his studies of important events in the life cycles of animals and plants, such as their breeding periods, the duration of the periods of incubation or of larval life, rate of growth, feeding activity at different seasons, seasonal migrations, and many others. The temperature optima and the lethal limits need also to be determined at different stages in development for every species the life history of which is under examination. This question is of practical import in the case of several important food fishes, crustaceans and mollusks: the thermal knowledge that the biologist needs in such cases is, furthermore, of an extremely detailed sort.

But, if the quality of the water may tell us something about birds, the birds should also tell us much about water. A Snow Petrel requires water which is cold; a tropic-bird prefers water which is clear, dense, saline, and moderately warm; the Brown Pelican avoids waters that are silty or turbid; the Blue-faced Booby clings to waters inhabited by flying fish which, in turn, are limited to waters of definite temperature and gaseous content. Hardy (1928, 218) has said:

> In the sea everything is hidden from us. It is only after we haul up our nets, our trawls, our water-sampling apparatus that we can attempt to piece it all together into the geography of the whole and say that here lies a great belt of plankton "jungle," there a comparatively barren area, and here again a zone of cold water coming from the Pole. These characters are not fixed like the forests and deserts of the land; but within certain limits are moved by the ocean currents and increased or diminished in size and density by the climatic conditions from time to time. This makes their geography not impossible, but more difficult; at first we can only sketch out roughly the possible limits of these zones.

Now one of the objects of this book is to demonstrate that sea birds, which are more easily observed than almost any other animals, offer a ready key to many characteristics of the ocean water and of its hidden life. The correlations are still very imperfectly worked out, and yet a single specimen of an oceanic bird from a remote and little-known island is, in some cases, sufficient to give a broad clue to the characters of the surface waters in the vicinity and the kinds of organisms that inhabit them. Furthermore, as we shall see in connection with studies made at the northern end of the Humboldt Current, birds are sensitively adjusted to, and quick to respond to, periodic changes in the character of surface waters. In the retreat of certain groups of birds from an area that has formed part of their range, and the invasion of the same region by other species from a different maritime life zone, we can sometimes see a reflection of what is simultaneously occurring in the way of actual replacement of one kind of surface water by another.

1. The Nutritional Basis of Marine Life

The organic source of all food in the sea, for creatures of the depths as well as those of the surface layer and of the air above, is the microscopic plant life, comprising mostly the diatoms and brown algae which, obtaining their sustenance directly from the nutrient ions in the circulation, build up tissue that becomes the food of small crustaceans, certain fishes, etc., which, in their turn, are devoured by birds and other higher animals.

> The sun's rays penetrate into the upper layers of the water; oxygen and carbon dioxide are dissolved from the atmosphere and mineral salts are brought in from the land by rivers. These are ideal conditions for plant life; the sea is one great culture medium. Just as the agents favouring life are scattered through the medium, so is life itself; it is scattered as a fine aquatic dust of microscopic single-celled plants in untold billions (Hardy, 1928, 211).

In the presence of sunlight the microscopic plants assimilate the carbon of carbonic acid and restore oxygen to solution, thus bettering the conditions for animal life. Under optimum circumstances, these plant forms may number tens, or even hundreds, of thousands per liter of ocean water. They exist principally in a stratum within a hundred meters of the surface, though they sometimes penetrate three or four times as far, and their dead remains are uninterruptedly settling into the lightless depths. But so-called "vertical" circulation, in which as a rule, the angle of ascent is probably very slight, in many parts of the ocean returns masses of deeper water to the surface and thereby prevents food substances in the form of decomposition products from accumulating out of reach of the photosynthetic plant zone. This means that while water denuded of some of its chemical nutrients is carried down, other masses of water that have been enriched during their sojourn below are being restored to the surface. Here, if the food material is not directly available to the algae, it may be utilized by bacteria and worked over into substances which enable the profuse development of other plant life to go on.

Harvey (1928, 165) calls attention to the important fact that, in addition to a supply of phytoplankton suitably spaced in time, a further condition necessary for maximum population is that the energy of plant life passed on to the plankton-feeding animals must, before the latter die, be handed in turn to carnivorous animals; therefore it cannot be assumed that where vegetable, carbohydrate, and protein food exists there will necessarily be an animal population to eat a fixed proportion of it. In the case of simple death of a phytoplankton cell, writes Allen (1934, 178), it may be supposed that decomposition by bacteria or other saprophytic forms brings derivatives from the body substance to a soluble or suspended condition in the surrounding water, from which some of them may be removed by another cell for its own use. For some particular atom it may be possible for the circuit to be very short, *i. e.* diatom—bacterium—sea water—diatom. In most cases it is longer as: diatom—copepod—herring—cod (or bird)—bacterium—sea water—diatom. Long or short, there is no room for doubt that photosynthetic organisms occupy the key position in the food exchanges of the ocean. Harvey's diagram of the closed circuit is as follows:

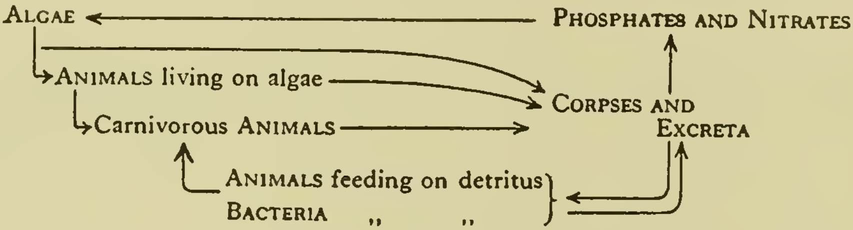


FIG. 4

This schema shows that the fertility of an ocean will depend for the most part upon two factors, namely the length of time taken by the corpses of marine organisms and excreta to decay, and the length of time taken by the phosphates and nitrates so formed to come again within the range of algal growth. Where the corpses fall in deep water, well below the light intensity necessary for photosynthesis, and where there is no vertical mixing of the water or deep currents to take the phosphates and nitrates to lesser depths, they are likely to remain lost for many years to the cycle of life owing to the long period which must elapse after the salts are reformed from dead organisms and before they again reach the upper sunlit layers. The process of decay will be slower in the cold bottom water of a deep ocean than in the comparatively warm bottom water of shallow areas. In most places it is the time taken for the re-formed salts to be transported to the upper layers which will predominate, rather than the length of time taken by the dead organisms to decay (Harvey, 1928, 168).

In this causal sequence the diatoms are the connecting link between the energy of the sun and the oceanic animal world, including birds. The diatoms surpass in bulk or annual productiveness all other aquatic plants a thousandfold. They are the pasture of the sea; they are highly nutritious and there are perhaps no deleterious species. They are everywhere available, though most so in ocean waters of relatively low temperature, and because of their abundance they represent the sole food supply of certain marine animals, the partial sustenance of many more, and the ultimate source of life for all.

Harvey describes the diatoms as single-celled plants, mostly beyond the range of the unaided eye except where they are growing in such abundance as to make visible slimy masses on wet surfaces or in water. Their color is usually a pleasing shade of brown, which shows a peculiar richness when many are massed together. This hue is caused by "diatomin" which covers and hides the green chlorophyll necessary for photosynthesis. They are supposed to be allied to the "Green Algae" (Conjugatae) such as the pond-scums and brook-silks. Their outstanding characteristic is a rigid siliceous covering fashioned on the fundamental pattern of a pill box, but much modified in many species. Most botanical texts tell little about them and the encyclopedias are the best references so far as ordinary accessibility is concerned. Enthusiastic diatomists consider the sculptural designs on some of the siliceous coats of sedentary diatoms as being among the most beautiful things in the world, but these beauties are not so evident in the majority of the plankton forms, which have thinner coverings and more attenuated shapes.

> Upon these plants feed a host of more or less microscopic animals in which all the large groups in the animal kingdom are represented—if not in adult life then in their younger stages. By far the most important of these animals are the small crustacea; the ocean teems with them, they are the "insects" of the sea. Pelagic fish, such as the herring, pilchard, and mackerel, and the great whalebone whales, . . . feed directly upon these plankton animals. From this planktonic world there falls to the sea-bottom a never-ending rain of dead and dying material which feeds the life of the depths; on the sea-bottom are "forests" of plant-like animals which, rooted to the ground, stretch out their arms and tentacles umbrella-like to catch this rain of falling food. Upon these, again, feed the creeping animals and the bottom-living fishes (Hardy, 1928, 211).

Now low temperature and other characteristics such as low salinity, which is usually associated with low temperature in the southern oceans, make for an abundance of life far in excess of that found in warm sea water. The food substances of all forms of life in the ocean comprise carbonic acid, nitrites and nitrates of calcium and magnesium, etc., phosphates, silica and salts containing a few other elements. These all exist in very small quantities, at most in the proportion of a few parts per million of water. The vast quantity of living substance in the ocean is therefore built up from materials present in exceedingly dilute solution, and the solution is dilute just because organisms are incessantly using up the materials. But sea waters of low temperature are favorable to a high gaseous content and are, moreover, richer in the mineral nitrogenous compounds (ammonia, nitrites, and nitrates) than are temperate or tropical waters. The waters of the Antarctic, for example, contain on the average 0.5 per million of nitrogen in the above forms, as compared with an average content of 0.15 per million in the North Atlantic, and 0.10 in equatorial seas. The plankton, and especially the phytoplankton, is therefore far more abundant in polar than in warm oceans, and especially so in shallow coastal waters of relatively low salinity. Owing to the angle of incidence of a low sun, and the dense screen of plankton, the photic zone is thin. Growth is mostly restricted to the upper hundred meters or so, with much reduced reproduction in the lower strata. The microscopic plant forms, obtaining their food substances directly from mineral sources, combine the simple nitrogenous salts with carbohydrate resulting from the synthesis of water and carbonic acid under the action of sunlight, and produce proteids. This protophytic type of growth is the basis of the existence of all animal organisms, from tiny copepods to birds and whales.

But the abundance of nutritive substance in cold sea water, which has been so greatly stressed by oceanographers, does not alone account for the abundance of life. An additional reason lies in the vastly larger number of co-existing generations. Loeb's (1908, 411) illuminating experiments upon larval sea urchins demonstrate that the temperature-coefficient of duration of life differs enormously from the temperature-coefficient of development. From this he concludes that the chemical processes which determine development are altogether different from those which cause old age and natural death. According to the formula deduced by Loeb, if the longevity of an echinoderm larva at T° C. is equal to D., its length of life at a temperature of (T-n) degrees will equal 2^n D. In other words, a lowering of the temperature n° C. multiplies the length of life by 2^n. When the temperature-coefficient of longevity at 10° C. equals 1000, Loeb found the coefficient of development to be only 2.8. With regard to the extraordinarily rich plant and animal life in the surface waters of the cooler seas, he applied the principle as follows: Within the range of the experiments, reduction in temperature of 10° C. increases longevity a thousandfold; reduction of 20° C. increases longevity a millionfold; but the corresponding periods of development are multiplied by only about three and nine, respectively. From this it follows that at 0° C. many more successive generations of the same species must exist contemporaneously than at 10° or 20° C.

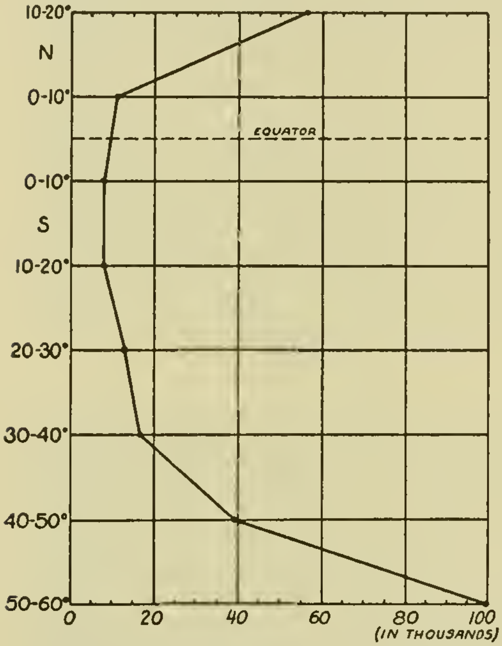


FIG. 5. Mean quantity, in thousands of organisms per liter, of the collective plankton in the upper 50 meters of South Atlantic water, expressed in ten-degree units between the equator and latitude 60° S.

After Hentschel (1933)

In tropical seas the predominating groups of marine invertebrates are those which secrete large quantities of calcium carbonate, comprising such forms as corals, macrura, brachyura, anomura, lamellibranchs, gasteropods, etc. In the antarctic seas these are largely replaced by organisms containing little lime, among which may be mentioned tunicates, hydroids, holothurians, annelids, amphipods, and schizopods. Among the last, the Euphausians or opossum-shrimps, which have a non-calcareous carapace, exist in inconceivable myriads and furnish food for vast numbers of vertebrates. The secretion of calcium carbonate is determined mainly by temperature. We see an effect of the cold environment in the feeble development of large molluscan shells or limy skeletons either in antarctic waters or in the deep sea. Even the shelled pteropods of warm oceans tend to be replaced to southward by naked forms.

2. The Zones of Surface Water

In the southern oceans, on either side of South America and to southward, there are several kinds of surface water, each zone having its typical amplitude of temperature and salinity as well as other more or less distinctive conditions for the support of plant and animal life. These areas have clearly marked geographic limits and are, naturally, closely related to the general climatic stamp of the respective belts in which they lie. Succeeding one another as they do from polar to equatorial latitudes, we should expect to find a considerable area of water which might be called temperate or Mediterranean but, as a matter of fact, the only region possibly deserving such a designation lies along a section of the Pacific coast. On the eastern side of the continent the diverse temperatures of opposing currents (as is true also in the western North Atlantic), and the relatively vast geographic influence of the polar regions upon a "water hemisphere," bring sub-tropical and sub-antarctic conditions into such close contact that a temperate oceanic region, in both the hydrological and biological meanings of the term, is practically eliminated.

Through the extensive researches of the recent 'Meteor' and 'Discovery' expeditions, zonal divisions in the South Atlantic have become more precisely known than are those of the South Pacific. Deacon (1933, 171; 1934, 129) has reported upon the four Atlantic regions, called the Antarctic, Sub-Antarctic, Sub-Tropical, and Tropical; Hart (1934, 1) has studied the relation of the hydrological circumstances to the associated animal life in the more southerly of these areas. With the conditions in the deeper layers of the ocean, we need not concern ourselves, but in so far as the findings refer to surface waters they bear a highly illuminating relationship to the distribution of South Atlantic sea birds. We may assume, moreover, that substantially similar zonal conditions, more or less modified as to outline and area, hold for the South Pacific.

The 'Meteor' crossed the whole breadth of the South Atlantic no less than ten times during her epoch-making cruise. If the illuminating charts and graphs published by Hentschel (1933) emphasize any one general point more than another it is the essential harmony in the distribution of primary foodstuffs, microplankton, and all higher organisms, including birds, as determined by the temperature and movements of ocean water. Thus this author's maps showing the relationships of phosphate to plankton abundance, the distribution of plankton in general, the color of sea water in relation to contained life, the order of importance of the several distinct types of phytoplankton pasturage, the abundance of Metazoa of all classes, etc., substantially agree with one another and with the chart indicating the relative numbers of sea birds in all parts of the Atlantic between latitudes 20° N. and about 65° S. (Fig. 53, p. 117).

From an ornithologist's point of view, these data supplement and extend the North Atlantic observations of Jespersen (1930, 14), who found, during lengthy periods of work on the 'Dana,' that the regions yielding the least quantity of plankton in the surface waters were always those inhabited or invaded by the fewest oceanic birds. While such a conclusion may sound, *a posteriori*, like "an elaboration of the obvious," the ecology of the matter is highly complex and deserving of much further research.

Layers of ocean water of markedly different temperatures and salinities present to each other a surface of discontinuity, and behave more or less as though they were separated by a solid wall. Neither heat nor the substances dissolved in the water are readily exchanged between the two. Such discontinuities exist in the open ocean and form, in fact, the physical basis of the zones we are about to discuss. Deacon has shown, for example, that north of latitude 28° S., in about longitude 30° W. of the South Atlantic, there is a very warm layer of tropical water at the surface, separated by a well-marked discontinuity from the underlying water. The surface layer is inhabited by certain organisms not characteristic of the surrounding sub-tropical waters, and is almost depleted of phosphate and nitrate, which can be renewed through vertical mixing only at an extremely slow rate. Deacon also informs me *in litteris* that there are similar layers, depleted in greater or less degree of nutrient salts, in the eastern South Atlantic as well as in the Pacific and Indian Oceans, and that their southern borders are close to the mean annual isotherm of 23° C. for the surface waters.

On the other hand, Atlantic sub-tropical water may be carried as far south as latitude 48° S. by the Brazil Current. Sometimes, indeed, one may come upon areas of sub-tropical water entirely surrounded by sub-antarctic water. Such observations indicate that the convergences may be locally sinuous and that they rarely follow definite latitudinal lines for any great distance. The most northerly position of the Sub-Tropical Convergence in the South Atlantic, for instance, is close to latitude 37° S., on the meridian of Greenwich. Near Bouvet Island, typically antarctic waters extend northward far beyond latitude 50° S., whereas to southeastward of Cape Horn they are pushed southward well beyond latitude 60° S. In the central part of the South Pacific the Antarctic Convergence is again bent northward, as though by the pressure of waters flowing out of Ross Sea. Deacon shows that bottom contours, even at great depths, also affect the courses of the convergences, while the influence of such features of surface topography as the southern tip of South America, and the islands of the Scotia Arc, is even more obvious in throwing these boundaries out of their conventional relation with the parallels of latitude.

In parts of the South Pacific, sharp transitions between sub-antarctic and sub-tropical waters, as marked by abrupt horizontal changes in salinity and temperature, are relatively difficult to find. This is particularly true in the eastern part of the ocean, where the Humboldt Current and related influences tend to obscure the ideal pattern. Observations made during a voyage of the 'Carnegie' suggest that there is a clear Sub-Tropical Convergence in about latitude 31° S., at a point as far from the South American coast as longitude 110° W. Vallaux (1933, 177) states that in crossing the Pacific this convergence undulates between the wide limits of latitudes 28° and 40° S., but that in the eastern part of the ocean, which alone falls within our special field, it lies between 30° and 37° S., in so far as it can be determined at all.

Later, when discussing the resident sea fowl of Juan Fernández, San Felix,

FIG. 6. Zones of surface water, and their convergences, in south-polar projection.

The relative zonal positions of the pan-antarctic islands prove highly significant with relation to their respective avifaunas. For example, South Georgia and Macquarie, which lie on opposite sides of the pole in the Antarctic Zone, are inhabited by the same species of diving petrel (*Pelecanoides georgicus*). The circumpolar islands in the Sub-Antarctic Zone, from the Falklands to Auckland, share a different species (*Pelecanoides urinatrix*).

and San Ambrosio Islands, and other parts of the eastern South Pacific, we shall have occasion to see that the zonal problems of that ocean are considerably less simple and diagrammatic than they are in the South Atlantic.

a. The Antarctic Zone.

Determination of the four zones in the South Atlantic is based principally upon temperature and salinity. The Antarctic Zone of surface water is a well-defined, cold, poorly saline stratum, from 100 to 250 meters in thickness, lying above a warmer and deeper layer of water. Its comparative freshness (less than 34‰) is due to the melting of pack-ice in summer and to precipitation which, between latitudes 50° and 60° S., amounts to more than 1000 millimeters per annum, or at least 700 millimeters more than the total extent of evaporation. This layer of antarctic water tends to flow northward at the surface, for reasons stated below, until it meets with the lighter sub-antarctic water, whereupon it descends but continues northward as a deeper "creep."

In the Antarctic Zone the surface temperature in summer ranges from about −1.0° C. in the south to 3.5° C. at its northern boundary; in winter from −1.8° to about 0.5° C. In the southern part of the zone the salinity may be as low as 33.00‰ during the summer. The surface water is extraordinarily rich in nutrient salts, the amount of nitrate + nitrite nitrogen running up to 55 milligrams per cubic meter during October and November. The phosphate content never falls below 50 milligrams per cubic meter, so that in this zone there is nothing corresponding to the complete utilization of nutrient ions by the phytoplankton of north temperate latitudes in summer. The oxygen content is of the order 90–95 per cent saturation in winter, with frequent supersaturation in spring. Near South Georgia, in January, surface water has been found to be supersaturated with a content as great as 110 per cent. At the same time large catches of diatoms were obtained, and the water had a high hydrogen ion concentration. The lowest oxygen content is found in late summer, when water temperatures are highest.

In the Antarctic Zone the effect of the prevailing westerly winds north of 66° S. is to set up drift currents with surface movements toward the northeast and with a total transport of waters in a northerly direction. The increased speed of this surface movement during the southern summer is to be explained not by stronger winds but by the liberation of great quantities of water from melting ice and a resulting thermohaline circulation. From the eastern side of the West Antarctic chain of islands (Graham Land) a nearly uninterrupted southwesterly gale blows out over the ocean, carrying dry and cold air.

The Antarctic Convergence with the next zone to northward is also called the Polar Front, and is an important faunistic boundary, dividing the surface waters of two zones. It is indicated by sudden change in surface temperature and is usually found along a line at which the coldest part of the antarctic water sinks below the level of 200 meters (Mackintosh, 1934, 83). It marks the extreme northerly limit of pack-ice, although actually the pack is rarely found quite so far north. In summer the line runs not far north of the parallel of 50° S., at least in mid-ocean. Just north of this convergence there is a region of pronounced vertical mixing in the southern half of the Sub-Antarctic Zone.

The influence of the antarctic ice extends, of course, much farther outward than that of north polar ice. The northern limit of floe-ice varies greatly from year to year—in the northern part of Weddell Sea it may amount to 1500 kilometers. Nevertheless, the differences between the continental and oceanic types of climate are nowhere shown more consistently than between 55° and 62° S. Tierra del Fuego, for example, does not belong to the Antarctic Zone, and is largely covered with dense forests, while Bouvet Island, in the same latitude, is always blanketed with ice and snow, is practically without vegetation, and is surrounded by pack-ice during much of the year.

Deacon points out that from a hydrological point of view South Georgia, the South Sandwich group and all more southerly islands, as well as Bouvet, lie in the Antarctic Zone. Further eastward the Crozets and the neighboring islands lie to northward of the convergence, as do also the Falklands. To northeastward of the Falklands the influence of the southward flow of water from the Brazil Current can be seen in a permanent effect upon the surface isotherms. Here the mean temperature is 6° or 7° C., or at least 5° higher than that of the average surface temperature around South Georgia.

In a recent lecture before the members of the Royal Geographical Society Dr. D. Dilwyn John, of the 'Discovery II' Expedition, has described with singular vividness the climatic and biotic meaning of the Antarctic Convergence. His words are as follows:

We began in the west with a line of stations from the western entrance of the Magellan Straits to the south. It ended when we could go no farther, at the edge of the pack-ice. The remainder of the survey consisted of similar lines of stations in a north-to-south or south-to-north direction. The meridional direction is in this area the best suited for our purpose. It is at right angles to the big water movements of the area. Our purpose is to build up a picture of these movements, to define their limits, and to know their flora and fauna. That is to be done most rapidly for a given current by making section after section across it. The southern limit of each line was the edge of the pack-ice. The northern limit was quite as definite a geographical boundary, although it is in the open sea, and not visible to the eye, and not to be defined in a word.

One might well ask, what can this boundary be, far away in the open sea? It might be supposed that sea-water throughout the oceans mixed readily, that there would be something like an even and gradual transition from the water of minus temperature, poor in salts because of melting ice and falling snow, at the Antarctic ice-edge, to the warm water rich in salts in the tropics. It is not so: there are successive zones from north to south separated by sharp boundaries. Antarctic surface water is very cold, and although it is poor in salts it is heavier than the warmer more saline water of the neighbouring zone to the north, the temperate zone of the southern hemisphere. This temperate zone is called the sub-Antarctic. Now Antarctic surface-water moves for the most part towards the east because of the prevailing westerly winds, but it has a northerly movement too. Where it meets sub-Antarctic water the very different densities of the two do not allow of ready mixing, and the heavier Antarctic water sinks sharply below the lighter sub-Antarctic and continues its flow northwards below it.

This, the line along which the heavy Antarctic surface-water meets the lighter surface-water of the sub-Antarctic and sinks below it, is the boundary in the surface of the open sea that I spoke of. It is called the Antarctic Convergence. It is a physical boundary very easily and precisely detected with a thermometer by the sharp change in temperature as one passes from one zone to another. It can be detected as easily if not so precisely by a zoologist with a tow-net, because

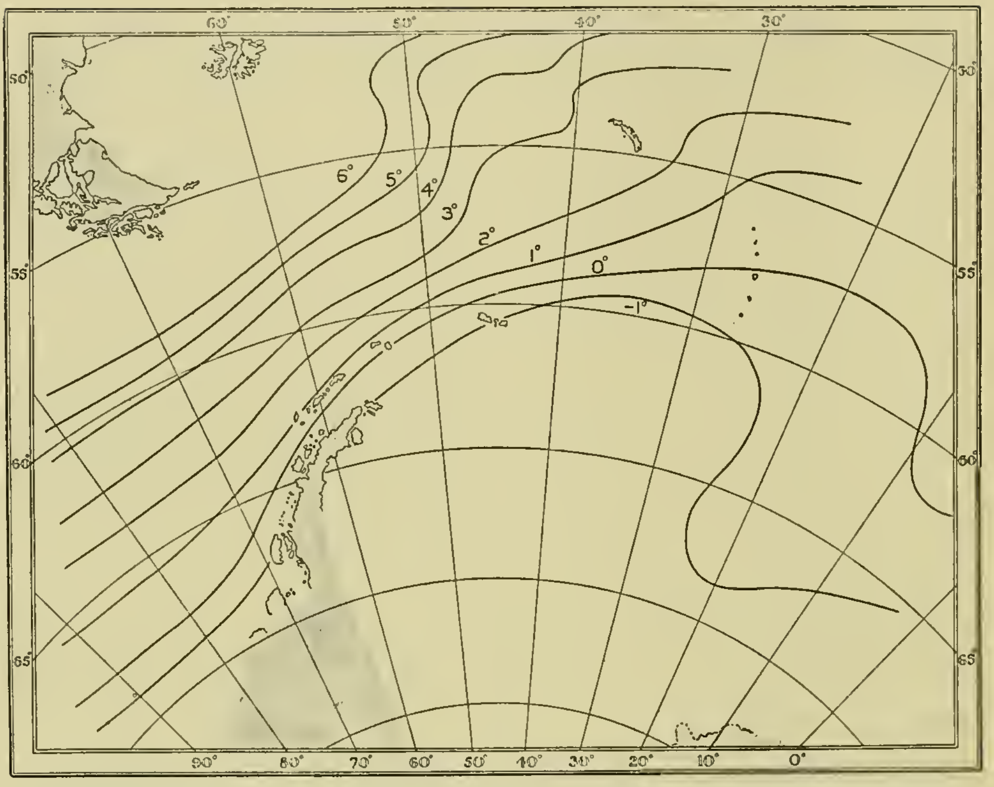


Fig. 7. Approximate positions of the mean summer isotherms of surface temperature between South America and the Antarctic Archipelago.

From Mackintosh (1934).

each of the two waters has a distinctive fauna of floating animal life. The zoologist need know only the species of prawns of the genus *Euphausia* to which *Euphausia superba*, whale-food, belongs. They are so numerous in the surface that his net will always catch some. If, in the neighbourhood of the convergence, he takes *Euphausia vallentini* or *Euphausia longirostris* he is in sub-Antarctic water. He will have crossed the convergence and be in the Antarctic when his net brings back *Euphausia frigida* and not *vallentini* nor *longirostris*. But we, whether sailors or scientists, know and will remember the convergence best in another way: as the line to the north of which we felt one day, at the right season, after months in the Antarctic, genial air again and soft rain like English rain in the spring. I can remember a number of those days vividly. It was like passing at one step from winter into spring. In the southernmost lands in the sub-Antarctic, the islands about Cape Horn, the earth smells as earth should smell and as it never does in the Antarctic. It is no doubt the north-easterly course of the convergence between the longitudes of Cape Horn and South Georgia, so that the former is left far to the north and the latter to the south, that accounts for the vast difference in the climates of two islands which are precisely the same latitude and only 1000 miles apart. The lower slopes of Staten Island are clothed with beech trees with so rich an undergrowth that it is difficult to push through. Darwin compared the richness of the region to that of a tropical forest. South Georgia, the other island, is a true Antarctic land. The snow-line of South Georgia is lower than the tree-line of Tierra del Fuego.

We have shown that the Antarctic Convergence is continuous around the Southern Hemisphere. It runs for the most part in the latitude of about 50° S. In the longitude of Cape Horn it lies much farther to the south than elsewhere. This is because South America has a greater southerly extension than any other land-mass in the hemisphere, and sub-Antarctic water in forcing its way around it pushes the convergence to a high latitude—to over 60° S. In every longitude in the Southern Hemisphere there is a point at which, going southwards, one finds Antarctic conditions to begin: that is the Antarctic Convergence in that longitude (John, 1934, 383).

The southward migration of sea birds in the springtime of the southern hemisphere is, of course, primarily a breeding journey. Yet it must be regarded also as partly a feeding migration, like that of the whales, for beyond doubt the original occupancy of inhospitable islands and of the antarctic mainland coast by birds was directly related to the rich resources of the surface waters. Within the Antarctic Zone the food of birds, as well as of whales and one or more species of seal, consists mostly of "krill," which is the Norwegian whaleman's name for the Euphausian crustaceans or opossum-shrimps. The word, which has been taken over into English scientific literature, has an earlier analogue in "brit," the general English term for right-whale feed in the surface waters of the northern hemisphere. However, since brit refers primarily to copepods and other Entomostraca, krill may well be retained for the Euphausians and related Malacostraca which make up the principal food supplies of surface vertebrates in the Antarctic.

While there are numerous members of the genus *Euphausia*, the most abundant species, found in practically all stomachs of penguins, petrels, pelagic seals, and whales in the far south, is *Euphausia superba*. The swarms of this form are the krill *par excellence;* at times the species makes up the almost exclusive food of penguins (Rustad, 1930, 9). The food of the krill, in turn, consists largely of diatoms which, as Hentschel (1933, pl. IV) shows, make up the predominant microplankton of these waters, with peridineans, Protozoa, and other organisms following. Thus the building up of the bodies of birds and whales is only one state removed from the organic fixation of the radiant energy of the sun by the phytoplankton.

(1) BIRDS TYPICAL OF THE ANTARCTIC ZONE

In the American quadrant of the far south the following forms are characteristic of the Antarctic Zone.

PENGUINS

Aptenodytes forsteri
Pygoscelis adeliae
Pygoscelis antarctica
Eudyptes chrysolophus

ALBATROSSES

Diomedea exulans exulans
Phoebetria palpebrata

PETRELS

Daption capensis
Pachyptila desolata
Priocella antarctica
Thalassoica antarctica
Pagodroma nivea
Oceanites oceanicus oceanicus
Fregetta tropica
Pelecanoides georgicus

SKUAS

Catharacta skua ("high" and "low" antarctic races)

These 15 or 16 forms are not of equal individual value as markers of antarctic surface waters. Neither are they all confined exclusively to the Antarctic Zone as breeding birds, while several of them pass very far outside it during their annual migrations. Nevertheless, they all nest chiefly to southward of the Antarctic Convergence, and they comprise an assemblage of quite distinct breeding range from any that follows. A few comments are called for.

The three species most closely confined to distinctly polar waters are the Emperor and Adélie Penguins and the Snow Petrel. It is at least possible that a direct response to an extremely low optimum temperature, rather than control of the range solely through special kinds of food, accounts in part for the restriction of these species within pack-ice waters.

The three species that penetrate farthest south are the Emperor and Adélie Penguins and the Antarctic Skua (*C. s. maccormicki*). The last-named, however, migrates during the polar night into the tropics or even into oceans of the northern hemisphere (Peters, 1934, 311). Wilson's Petrel does likewise, while the Cape Pigeon and the Antarctic Fulmar (*Priocella*) fly close to the equator at least in cool-current regions, as on the west coast of South America.

The Macaroni Penguin perhaps nests sparingly at a few islands just north of the Antarctic Convergence, but it is far more characteristic of islands within the Antarctic Zone. The same may be said of the Light-mantled Sooty Albatross (*Phoebetria*). The typical Wandering Albatross is included within this assemblage because, as I shall show later, the form breeding at Tristan da Cunha, at the extreme northern border of the Sub-Antarctic Zone, belongs to a distinct subspecies. A different race of Wilson's Petrel (*Oceanites*) likewise nests in the Fuegian portion of the Sub-Antarctic Zone. The only breeding whale-bird of South Georgia (*Pachyptila desolata*) is confined to the Antarctic Zone, at least in New World waters. I believe that Dabbene (1923, 134) was in error when he recorded the definitely sub-antarctic *Pachyptila vittata* (= *forsteri*) from South Georgia (cf. also Peters, 1931, 49).

b. The Sub-Antarctic Zone.

The Sub-Antarctic Zone of surface water is a much deeper and warmer layer than that of the Antarctic, and is one in which salinity and temperature decrease with depth. It corresponds almost entirely with the belt of westerly winds, and the water in it flows toward the east and northeast, the trend being most northerly in the windiest latitudes, which lie between 45° and 50° S. Consequently in the southerly part of the zone, near the convergence with antarctic water, there is a constant tendency toward upwelling in the open sea. Furthermore, vertical mixing throughout this zone is promoted by the almost continually rough weather, making the formation of shallow discontinuity layers impossible. Such instability militates against high production of the phytoplankton in the level of optimum illumination.

The surface temperatures throughout the Sub-Antarctic Zone increase, south to north, from about 3° to 11.5° C. in winter and from 5.5° to 14.5° C. in summer. The salinity ranges from about 34‰ to 34.5‰. The phosphate and nitrate content of the water is high compared with that found in equivalent northern latitudes, and the presence of from 3.5 to 5.5 milligrams of nitrite nitrogen in the upper hundred meters shows that more nitrate is being generated.

The Sub-Antarctic Zone includes Cape Horn, the Falkland Islands, and as much of the Patagonian coast as is influenced by the Falkland Current, which may be regarded as a local extension of sub-antarctic water, and the influence of which occasionally reaches as far north as the mouth of the Río de la Plata. Gough Island lies within the Sub-Antarctic Zone, but Tristan da Cunha is on the line of convergence with the sub-tropical surface water. On the Pacific side of the continent, the narrow littoral strip of the Humboldt Current, which contrasts sharply with the outlying heated surface water, is characterized to a partial extent by sub-antarctic conditions.

The break in meteorological and oceanographic environment is very conspicuous as a traveller leaves the zone of sub-tropical surface water and enters the sub-antarctic. Quick shifts in the wind are accompanied by changes in temperature more marked than any familiar in the northern hemisphere, while cloudiness, precipitation, etc., vary with equal suddenness.

Since many birds and lower oceanic animals are common to both the Antarctic and Sub-Antarctic Zones, the term "Pan-Antarctic" has sometimes been applied to all waters south of the mean surface isotherm of about 12° C. (Rustad, 1930, 15). This idea is not without usefulness but, on the other hand, the antarctic and sub-antarctic waters are definitely separable, both in physical characteristics and in floral and faunal correlations. Furthermore, the Sub-Antarctic Zone is itself divisible into southerly and northerly temperature belts which, however, we may disregard for the present.

While the Sub-Antarctic Zone is not without Euphausian crustaceans, their numbers rapidly diminish north of the convergence with antarctic surface waters, and their rôle as bird-food is filled by other organisms. Conspicuous among the latter are the anomuran crustaceans of the genus *Munida*, which form a distinct group of "whale-feed" (Matthews, 1932, 481). By the southern whalemen they are called "lobster-krill." The pelagic, post-larval stage of certain species of *Munida*, known as the "Grimothea stage" because it was originally described under that name as a different organism from the adult, is abundant in the comparatively warm sub-antarctic water around Cape Horn, Tierra del Fuego, the Falkland Islands, and the Patagonian and southerly Chilean coasts. The surface temperatures here range mostly below 10° C., and the creatures occur in enormous shoals, the Grimotheas of *Munida gregaria* sometimes coloring the surface of the ocean bright red. However, in Humboldt Current waters as far north as the Peruvian coast, where the temperatures are considerably higher, there are also at times vast numbers of *Munida*. These crustaceans are unknown in the water of the Tristan da Cunha region, which is close to the Sub-Tropical Convergence, and are entirely absent from the much colder waters of South Georgia, Bouvet Island, and the Weddell Sea area.

Munida forms a substantial part of the food of many sea birds, including gulls, cormorants, petrels, and penguins. The abundance of the swarms of these crustaceans is indicated by the frequency with which they are referred to in the literature of voyages. The 'Meteor' records tell of vast "clouds" of *Munida gregaria* on the Argentine coastal shelf in latitude 44° S. (Hentschel, 1933, 151). Captain James Cook noted them in the same latitudes more than a century and a half ago. Still earlier reports are cited by Matthews of the 'Discovery' Expedition. Thus Simon de Cordes, Sebald de Wert, and Dirk Gherritz, sailing southward along the Atlantic coast of South America on March 12, 1598, wrote,—"having passed Río de la Plata, the sea appeared as red as blood. The water was full of little red worms, which, when taken up, jumped from the hand like fleas."

(1) BIRDS CHARACTERISTIC OF THE SUB-ANTARCTIC ZONE

PENGUINS

Eudyptes crestatus
Spheniscus magellanicus

ALBATROSSES

Diomedea exulans dabbenena
Diomedea epomophora
Diomedea chlororhynchos
Phoebetria fusca

PETRELS

Halobaena caerulea
Pachyptila forsteri
Pachyptila belcheri
Adamastor cinereus
Puffinus creatopus
Puffinus gravis
Puffinus griseus
Puffinus assimilis elegans
Pterodroma macroptera
Pterodroma incerta
Pterodroma brevirostris
Pterodroma mollis mollis
Pterodroma cookii defilippiana
Pelagodroma marina marina
Fregetta grallaria
Pelecanoides magellani
Pelecanoides urinatrix (2 or more subspecies)

CORMORANTS

Phalacrocorax albiventer
Phalacrocorax magellanicus
Phalacrocorax gaimardi

SKUAS

Catharacta skua chilensis
Catharacta skua antarctica

GULLS

Leucophaeus scoresbyi

A number of other oceanic species might well be added to this list of nearly thirty forms, but I have omitted them because of lack of certainty regarding their zoögeographic affiliations. Furthermore, it would not be inappropriate to include here several birds of the beaches, or common to both salt and fresh water, in southern South America and neighboring insular localities. Among these are a grebe (*Colymbus rolland*), two or more geese of the genus *Chloëphaga*, the steamer ducks (*Tachyeres*), and such shore birds as the two resident oyster-catchers (*Haematopus ater* and *H. leucopodus*). The South American Tern (*Sterna hirundinacea*) is also essentially sub-antarctic, and does not extend southward into the antarctic islands as was formerly supposed. Because of its penetration into cool-current areas near the equator, however, I am reserving discussion of the species for a later section.

A few slightly dubious points qualify the sub-antarctic list as it stands. The distinct race of the Wandering Albatross (*dabbenena*) breeds, so far as known, only in the Tristan da Cunha-Gough Island district. The Royal Albatross (*epomophora*) is believed to nest in Tierra del Fuego. Both matters are fully discussed in the biographies. The Dark-mantled Sooty Albatross and the Yellow-nosed Albatross may occupy breeding stations a little to northward of the Sub-Tropical Convergence in the Indian Ocean or elsewhere. Nevertheless, they are typically sub-antarctic birds. Nature is not conventional, and island breeding grounds must be used where they are, not where they ought to be. The Galápagos Albatross, for example, nests on an island close to the equator, and yet, as will appear later, it belongs not to an equatorial, but to a definitely temperate oceanic zone.

The last aspect also has a bearing on the somewhat puzzling zonal position of a number of petrels belonging to Juan Fernández, and to the still more northerly twin islets of San Felix and San Ambrosio. The average surface characteristics of the Pacific Ocean in the neighborhood of these islands are far less thoroughly known than the corresponding parts of the South Atlantic. A shearwater (*Puffinus creatopus*) and several other petrels inhabit one or both of the groups mentioned. *Pterodroma cookii defilippiana*, for instance, is known to breed at Mas Atierra, Santa Clara, and San Ambrosio. Because of the high-latitude, trans-Pacific relationships of the last-named strongly marked subspecies, I believe that it should be regarded as sub-antarctic rather than sub-tropical. *Puffinus creatopus* has its closest kin in *P. kuhlii*, with races in such diverse parts of the world as the Mediterranean-Azorean region and the sub-antarctic Indian Ocean. For the present *P. creatopus*, which nests as far south as Mocha Island, Chile, may be regarded as a sub-antarctic shearwater, particularly because of the fact that it makes a long trans-equatorial migration, which would be a very unusual trait in a sub-tropical bird.

Several other petrels of the Juan Fernández group, however, I regard as sub-tropical, despite the fact that they nest on a borderline island inhabited by such a definitely sub-antarctic bird as the Magellanic Penguin. The petrels referred to all have affinities with sub-tropical forms in other parts of the world. Their status is discussed below.

Certainly no one of the four species of *Pterodroma* inhabiting Juan Fernández belongs to the western South American littoral temperate region, to be described hereafter, for the birds properly coming into that category comprise a peculiar and heterogeneous aggregation, all confined to the Humboldt Current. If we had specific information about the food organisms of the various species, the task of zonal allocation would be greatly simplified, but this is a field of inquiry that has barely been touched.

Among the sub-antarctic birds listed, three of the shearwaters (*Puffinus creatopus*, *gravis*, and *griseus*), and possibly the skuas, make long, trans-tropical migrations. Other species range widely in the southern oceans, while still others appear to be highly sedentary.

(2) BIRDS COMMON TO BOTH THE ANTARCTIC AND SUB-ANTARCTIC ZONES

PENGUINS
Aptenodytes patagonica
Pygoscelis papua

ALBATROSSES
Diomedea melanophris
Diomedea chrysostoma

PETRELS
Macronectes giganteus
Procellaria aequinoctialis
Garrodia nereis

CORMORANTS
Phalacrocorax atriceps

GULLS AND TERNS
Larus dominicanus
Sterna vittata

SHEATH-BILLS
Chionis alba

The penguins of this pan-antarctic assemblage are remarkable for the breadth of their range. The two species once occupied both South Georgia and the Falkland Islands in great numbers. In former times the King Penguin apparently extended its breeding area still farther southward into West Antarctica, as indicated in the subsequent biographical account. The Gentoo Penguin actually nests a full degree of latitude beyond the southernmost limit of the Ringed Penguin (*Pygoscelis antarctica*), which is regarded as a species of the Antarctic Zone (Gain, 1914, 52, and chart of distribution).

The albatrosses and petrels in the list mostly penetrate during migration well into the cool-current districts of tropical latitudes. The gull even pushes its breeding grounds into low latitudes along both the eastern and western continental coasts, but particularly on the Pacific side. To what extent the exact picture may be qualified by subspeciation is not yet certain. The Kelp Gull of the South Shetlands has been described as a weakly distinct race, *Larus dominicanus austrinus* (Fleming, 1924, 139). In any event, the range of the resident form of this gull on the west coast of South America is continuous throughout 50 degrees of latitude. In producing such an extraordinary phenomenon, doubtless both the land and the sea exert an influence, and perhaps it is not altogether harmonious to combine littoral with strictly pelagic birds in codifying the zonal associations. *Larus dominicanus* represents an approach toward "zoneless" species of very wide distribution, such as a cormorant, *Phalacrocorax olivaceus*, which will be discussed later.

The question of the two pan-antarctic cormorants also has its unsolved aspects, for it appears that slightly differentiated subspecies of *atriceps* are restricted to the Antarctic and Sub-Antarctic Zones, respectively.

The observations of the 'Meteor' naturalists make it clear that we still have a vast deal to learn about the distribution of pan-antarctic and other oceanic birds while they are at sea, far from their nesting ground. Hitherto sea birds have been called either littoral or pelagic, which seemed far enough to carry such a functional classification. But Hentschel strongly suggests that there are degrees of "pelagicity." Thus the 'Meteor' encountered *Macronectes*, the Giant

Fulmar, practically everywhere in the southern South Atlantic, while *Procellaria aequinoctialis*, although observed hundreds of miles from land, appeared, nevertheless, to be bound to the coasts to a greater extent than its larger relative. During repeated spannings of the ocean, at various seasons, *Procellaria* was observed northward to 29° S. on the American side, and to 17° S. on the African side where Benguela Current influence is effective. But the species was decidedly more abundant toward the respective continental coasts than near mid-ocean. Not a single example was seen at any time of year between 15° and 25° of west longitude, and very few for a long distance on either side of this strip.

Furthermore, the 'Meteor' data led Hentschel to the conclusion that there are definite "gaps" along the northern border of the range of albatrosses, into which these birds do not ordinarily enter. He also believes that, although many species of albatrosses are likely to be seen together, most or all species have also special pelagic centers of concentration, which are more or less definite geographic districts, and from which the species concerned tends to exclude its rivals (Hentschel, 1933, 121).

For some of these opinions one can imagine sound oceanographic bases, even if they are not yet established. The reason why such a strong-winged wanderer as *Procellaria* should not pass across the most remote belt of the ocean, after it has already gone so far, is more difficult to fathom. But all parts of the 'Meteor' records are deserving of very careful consideration, because of the length of the voyages and the thorough technique of the scientific party. There are suggestions here for quite new fields of observation and interpretation.

c. The Sub-Tropical Zone.

The Sub-Tropical Zone of surface water is much warmer and more saline than the sub-antarctic water. Just to northward of the convergence the temperature varies from about 15.5° C. in winter to 18.5° in summer. This increases to an annual average of close to 23° C. at the Tropical Convergence, and likewise the salinity rises to 36‰ toward the north. The nutrient ions show a very striking decrease as compared with sub-antarctic water, and the phosphate, nitrate, and oxygen content all fall off abruptly toward the equatorial border of this zone. Oxygen, in fact, decreases steadily northward in the surface layers of the Sub-Tropical and Tropical Zones from about 80 per cent of saturation in latitude 28° S. to about 40 per cent at the equator. The water is not favorable for diatom growth because of the small amounts of phosphate and nitrate at the surface. Where, however, they are replenished by upwelling, as along the African and Peruvian coasts, the conditions are good.

The Tropical Convergence, between tropical and sub-tropical waters, is less well defined than the other convergences. In the South Atlantic it corresponds in summer with the isotherm of 23° C. The boundary passes between St. Helena and Ascension; hydrologically the former is sub-tropical, Ascension, tropical (Deacon, 1933, 171–238).

The biotic change between sub-antarctic and sub-tropical waters corresponds with the alteration in physical characteristics. The volume of plankton becomes very much reduced, so that throughout large areas the collective population of surface organisms may not average higher than ten to each liter of water (Hentschel, 1933, pl. I). Among the microplankton, peridinians and coccolithophores take precedence over the diatoms. Copepods replace the types of pelagic Crustacea that rank first in more southerly zones, but an equivalent richness of individuals is rare and sporadic. The average number of copepods, in both adult and nauplius stages, may range, according to Hentschel, between five and ten to each 4000 cubic centimeters of water. Siphonophores, like the sallee-man and the Portuguese man-o'-war, pelagic gastropods, salps, dolphins (*Coryphaena*), and flying fishes replace the visible fauna of the colder waters. In general the variety of surface life may be said to increase, while its numbers and total bulk vastly diminish. The count may rise sharply in surface waters adjacent to an island, such as St. Helena, a subject to be reverted to below. The effect upon sea birds of such a local concentration becomes immediately apparent.

Between the biota of the Sub-Tropical and Tropical Zones there are few breaks. Rather, the two belts form a warm-water or pan-tropical zoögeographic region extending for a long distance on either side of the equator, as described for the Atlantic by Schott (1926, 281). Therefore a discussion of the sea birds had best be deferred until we have considered the physical conditions of tropical waters.

d. The Tropical Zone.

In the Tropical Zone the water temperature at the surface ranges between 23° and 29° C., the latter being found just north of the equator. In this line of highest temperature the salinity is at its minimum of 35.5‰ because of heavy rainfall and the low rate of evaporation during the season of calms. The light surface water, however, always floats upon water of greater salinity and density, which is observable in cross sections as shallow as 50 meters. The salinity increases to 37‰ or more in latitude 15° S. So far as the warmer belt of the South Atlantic is concerned, the western parts tend to become highly saline at the surface because of evaporarion due to sun and trade wind. Along the middle part of the Brazilian coast the water may have a salt value up to 37.5‰, in spite of much rain at certain seasons. This is considerably higher than the salinity in the eastern part of the ocean at the same latitude.

There is no detectable phosphate in the surface waters of the Tropical Zone, and only minute quantities of nitrate nitrogen. Since vertical mixings between the surface and deeper layers are impossible, the probable source of this nitrate is the tropical thunderstorms, flashes of lightning being supposed to cause combinations of nitrogen and oxygen in the atmosphere.

(1) TROPICAL AND SUB-TROPICAL SEA BIRDS

The pan-tropical oceanic birds tend to be more local and sedentary than most of the species in the preceding groups. Many must be regarded as more or less land-bound, rather than pelagic, and this applies even to the Procellariiformes. Only the tropic-birds and a few of the terns undertake distant travel between seasons of reproduction, and no intertropical species regularly invades the cooler oceanic belts of the northern or southern hemispheres. As an example, *Pterodroma arminjoniana*, the endemic petrel of South Trinidad Islet, contrasts strongly in this respect with Wilson's Petrel and the Sooty Shearwater, both of which migrate from the cold south to the cold north. In the same way the Fairy Tern (*Gygis*) contrasts with the Arctic Tern, the latter making annual journeys from the verge of the Arctic to the far south and back.

Doubtless the spell of uniformity figures more strongly than the degree of absolute temperature in the control of pan-tropical sea birds. The specific heat of water is so high that in the conflict between air temperatures and water temperatures the ocean wins an overwhelming victory. The marine circumstances are utterly different from those over rapidly-absorbing and as rapidly-radiating land surfaces. Between the outer borders of the two trade wind belts relative hydrographic and atmospheric monotony is the rule, and over very large parts of the oceans the surface temperature undergoes an annual range of not more than 3° C. (Schott, 1926, pl. XI). To such conditions the life within the sea, and the birds which form an ecologic part of it, have conformed throughout many ages.

As hinted above, it is difficult to distinguish between tropical and sub-tropical oceanic organisms, but in the South American region the following five sea birds seem to be typically sub-tropical.

Petrels

Pterodroma neglecta
Pterodroma arminjoniana
Pterodroma externa
Pterodroma leucoptera masafuerae

Terns

Procelsterna albivitta

The breeding range of *Pterodroma neglecta* lies well to southward of the Tropical Convergence all the way across the Pacific, from Lord Howe Island to Juan Fernández. In the Atlantic its representative species is *P. arminjoniana*, endemic at South Trinidad and Martin Vas (20° 30′ S.). *Pterodroma externa* is common to Juan Fernández and the Kermadecs. *Pterodroma leucoptera masafuerae* is a member of a species with races in tropical and sub-tropical regions of both the southern and the northern hemispheres. The Juan Fernández form is placed in the foregoing group chiefly because no other sea bird that might be assigned to the Tropical Zone nests at these islands.

The Gray Noddy (*Procelsterna albivitta*) reaches the South American region from southern Polynesia only at the islets of San Felix and San Ambrosio. It is sometimes regarded as a subspecies of the tropical *Procelsterna cerulea*. I believe, however, that it is rather a well-marked, sub-tropical, representative species, with several subspecies of its own. The specific range includes Lord Howe, the Kermadec, Henderson, and Easter Islands.

The following 23 birds, several of which are represented by more than one race, belong either to the Tropical Zone or to both tropical and sub-tropical waters of one or both hemispheres.

PETRELS

Puffinus lherminieri
Pterodroma hasitata (including *P. caribbaea*)
Pterodroma phaeopygia
Oceanodroma castro

TROPIC-BIRDS

Phaëthon aethereus
Phaëthon lepturus

PELICANS

Pelecanus occidentalis occidentalis

BOOBIES

Sula nebouxii
Sula dactylatra
Sula sula (="*piscator*")
Sula leucogaster leucogaster
Sula leucogaster etesiaca

FRIGATE-BIRDS

Fregata aquila
Fregata magnificens
Fregata minor
Fregata ariel

TERNS

Thalasseus eurygnatha
Sterna fuscata
Sterna anaethetus
Anoüs stolidus
Anoüs minutus
Gygis alba

The list calls for a few comments.

Audubon's Shearwater (*Puffinus lherminieri*) is an excellent example of a world-wide pan-tropical species, of which two races occur within the South American field. *Oceanodroma castro* spreads out through an even wider range of latitude, but it appears to be confined to the eastern halves of both the Atlantic and Pacific. Since there is no present connection between the two parts of the range by way of the Indian Ocean, this petrel offers an outstanding instance of discontinuous distribution.

In the Atlantic, *Oceanodroma castro* breeds across the entire belt of the tropics and sub-tropics, occupying one or more islets at each of the following stations: St. Helena, Ascension, Cape Verde Islands, Canary Islands, Madeira, Azores. It is thus quite different in its zoögeographic affinities from such petrels as *Pterodroma mollis* and *Pelagodroma marina*, which have northern-hemisphere races as close to the equator as the Cape Verde Islands (15° N.), but which then skip the tropics and the southern sub-tropics, only to reappear with endemic races at Tristan da Cunha (37° S.). From the latter island *Pterodroma mollis*, at least, forages toward colder rather than warmer surface regions, and is a typically sub-antarctic bird.

In the distribution of the large White Booby (*Sula dactylatra*) we may note an exceptionally clear connection with the food of the species. The bird subsists principally upon flying fish, and its known breeding stations at the Bahamas, scattered West Indian localities, the Brazilian Abrolhos, Ascension, the Galápagos, the Ecuadorian coastal island of La Plata, San Felix, San Ambrosio, and elsewhere the world around, all lie close to rich "flying fish waters." The 'Meteor' chart, showing the relative abundance of these fishes in various parts of the Atlantic, points graphically toward this ecologic correlation (Hentschel, 1933, 114).

It is eminently worth noting that the two species of noddies (*Anoüs stolidus* and *A. minutus*) included in the list extend their range southward throughout all the South Atlantic islands to Tristan da Cunha, beyond the Sub-Tropical Convergence. Here, then, we find two thoroughgoing pan-tropical birds sharing the same insular station with such equally characteristic sub-antarctic types as the Rockhopper Penguin, the Yellow-nosed Albatross, whale-birds (*Pachyptila*), and skuas. It all goes to show that, since birds must nest on land, and since islands are spaced without reference to any meteorological scheme, the distributional determinants are somewhat elastic in borderline districts.

A number of other sea birds, particularly terns, might perhaps be added to the pan-tropical list, but in certain such instances it is difficult to decide whether distribution is not controlled more by continental than by oceanic factors. For this reason even *Thalasseus eurygnatha* has been included with some hesitation.

3. Ocean Currents

Thus far we have considered the bird life of oceanic zones broadly corresponding with the climatic belts of a hemisphere surfaced chiefly with water. Certain irregularities, unconventionalities, and inconsistencies in the system have been hinted at, and the way is now clear to attack such anomalous circumstances in more detail. We shall find that various sorts of minglings, warpings, and extensions do, indeed, affect the borders of practically all areas of homogeneous surface waters, resulting in some cases in extreme alteration of the great interparallel plan sketched above.

In producing such action, the more stable movements of ocean water, as impelled by winds and deflected by the continental buffers, play the major rôle. Thus currents affect every sort of life in at least the upper layers and, in turn, exercise large control over the numbers and distribution of sea birds. Currents can, on the one hand, fence off sterile wastes in the sea while, on the other, they can produce centers of teeming wealth and abundance. In a few instances they are responsible (in so far as, through interaction with living organisms, any environment can be creative) for quite new and distinct aggregations of oceanic bird life, evolved out of material drawn together from widely different climatic sources, and not fitting into any of the marine zones thus far discussed. The Humboldt Current avifauna is an instance of such a result within the South American field.

As a preparation for discussing birds and ocean currents together, the geophysical basis should be briefly outlined.

Owing to the progressive increase in the eastward linear velocity of the earth's surface from the poles toward the equator, masses (as of air or water) moving in the direction of the equator necessarily fail to maintain an easterly component equal to that of the parallels of latitude at which they are successively arriving. In other words they "fall behind" or turn toward the right in the northern hemisphere and toward the left in the southern. The converse is true of currents moving away from the equator or in the direction of the poles. These elementary facts explain why the trade winds blow, respectively, from the northeast and the southeast rather than from due north and due south; they explain also why the general circulation of both atmosphere and ocean water tends to be clockwise in the northern hemisphere and counterclockwise in the southern hemisphere.

A drift current is produced by the force of the wind upon the surface of the ocean. The direction of water at the surface, however, does not remain in line with that of the wind which caused the movement, but tends to be 45° *cum sole* from the course of the wind at the moment of impact (*cum sole* is the direction of the sun's apparent azimuthal motion, *i. e.* counterclockwise in the southern hemisphere). For such reasons the southeast trade winds give rise to a surface transport of water in a *southwesterly* direction. Furthermore, the direction of a surface current of water turns uniformly *cum sole* with depth, and at the same time its velocity decreases according to a logarithmic spiral until, when the direction of movement has turned through two right angles, it has only one-twenty-third of its surface value. This is the "depth of frictional influence."

The primary results of these circumstances are that in middle latitudes the movement of ocean currents along the east coasts of both North and South America is in the general direction of the poles, (*e. g.* the Gulf Stream and the Brazil Current), whereas on the west coasts the flow is toward the equator (*e. g.* the California and Humboldt Currents). It follows that in the Atlantic littoral region tropical or sub-tropical oceanic conditions spread far to northward and southward, roughly through 60 degrees of latitude. In the Pacific littoral, on the other hand, coastal waters of high temperature are contracted within a belt barely 30 degrees of latitude in width, owing to the intrusion toward the equator of cool currents from both the north and the south. In fact, the only characteristically tropical waters in contact with any part of the western coast of America lie in a narrow zone between the Gulf of Guayaquil (latitude 3° S.) and the Gulf of California.

Ocean currents profoundly affect much of South America, and in that part of the world exhibit, perhaps, their maximum influence upon the distribution of sea birds. Two of the South American currents act in some degree as extensions of the Sub-Antarctic Zone of surface water toward the tropics. These are the relatively short and feeble Falkland Current, which flows northward along the southern part of the east coast, and the great Peruvian or Humboldt Current, which produces highly anomalous biotic conditions along more than half the length of the west coast.

Graphic representation of ocean currents can be, at best, little more than crudely diagrammatic. As a matter of fact, the entire surface water of every oceanic area is in constant motion in several planes, such movement being exceedingly variable in certain regions and relatively constant in others. The named ocean currents are merely the vectors of such movement within zones which exhibit a definite permanent or seasonal trend. For a proper understanding, the accompanying chart showing the principal currents influencing the character of surface waters around South America should be tempered by consideration of Meyer's far more nearly exact approximation of the circulation of South Atlantic surface waters during a single southern-hemisphere summer month.

a. The Central Anticyclonic Regions.

The ocean currents of the South American maritime area mostly arise from the west-wind drift of sub-antarctic latitudes and from the great counterclockwise movements around the permanent high-pressure fields of the South Atlantic and the eastern half of the South Pacific. Both of the latter center approximately on the parallel of the tropic of Capricorn. In the Atlantic, for example, between 38° and 30° S., surface water moves eastward under the influence of the wind, carrying Brazil Current water towards Africa. Between 30° and 10° S., water flows westward, as a result of the southeast trade winds, conveying water from the Benguela back toward the Brazil Current. This completes an anticyclonic movement extending over the whole width of the ocean.

The central parts of these South Atlantic and South Pacific current-rings correspond with the North Atlantic Sargasso Sea. They are relatively lifeless regions, so far as the surface waters go, and are characterized by high temperature, exceptionally high salinity, and by water of an extraordinarily deep blue color and of unsurpassed clarity.

The high temperature is naturally favored by the latitude, and by the large percentage of sunny days. Sunshine, in turn, increases evaporation. In parts of the Atlantic area off the coast of Brazil, the salinity sometimes reaches a strength of 38‰, while in a corresponding part of the South Pacific, to westward of southern Peru, surface ranges are close to 36.5‰. Within these anticyclonic regions there is neither increment of fresh water from melting ice, nor dilution from continental rivers or ocean currents. The latter flow around the "Sargassos" rather than into them. While the areas are not entirely without local currents, these have no definitive and constant courses; judging from derelicts and other flotsam, the direction of movement is largely unpredictable, despite the fact that the southeast trade wind blows steadily over a major part of the areas. There is a tendency for the surface waters to accumulate centripetally, and to sink as they become more and more dense, a fact clearly indicated by the high temperatures and salinities of the subsurface layers at least as far down as 400 meters.

The exceptional transparency of the water is due in part to causes already stated; all sediments from the coast are, of course, precipitated before they can be carried to such remote reaches of the sea. In the North Atlantic Sargasso,

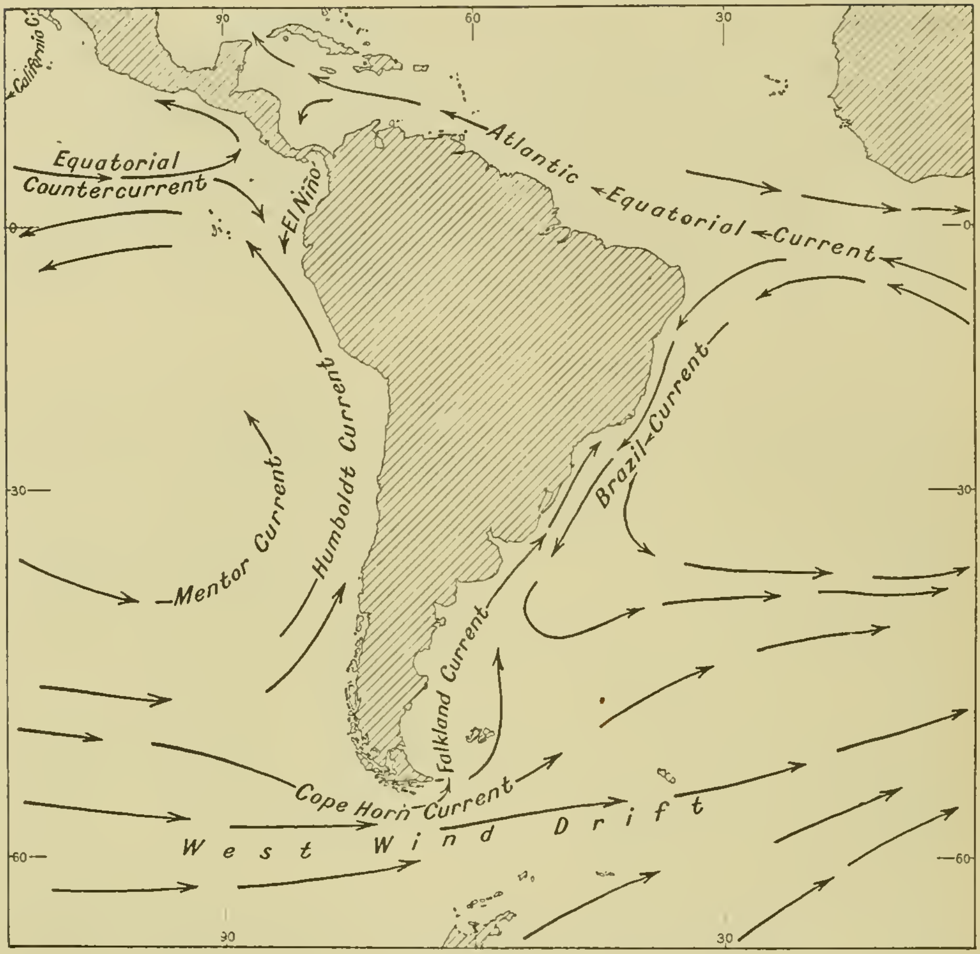


Fig. 8. Schematic diagram to show the course of the principal current movements named in the text.

which may be taken as a type of all such regions, a white two-meter square can be seen with the naked eye down to a depth of 66 meters. The paucity of plants and animals is also a contributing factor to the transparency, for such a condition implies very little life either of microscopic plants or of larger organisms. Furthermore, waters rich in plankton usually appear green; those poor in plankton, blue.

From an ornithological point of view these central oceanic regions are the deserts of the sea. The important food of pelagic birds is made up of schooling organisms, whether fishes, cephalopods, or crustaceans, and in the anticyclonic centers all such forms of life belong more to the depths than to the surface waters. Therefore abundant bird life is to be sought farther southward, or in the peripheral regions of regular currents and mixing waters. The presence of an oceanic island within one of the permanent high-pressure fields may, to be

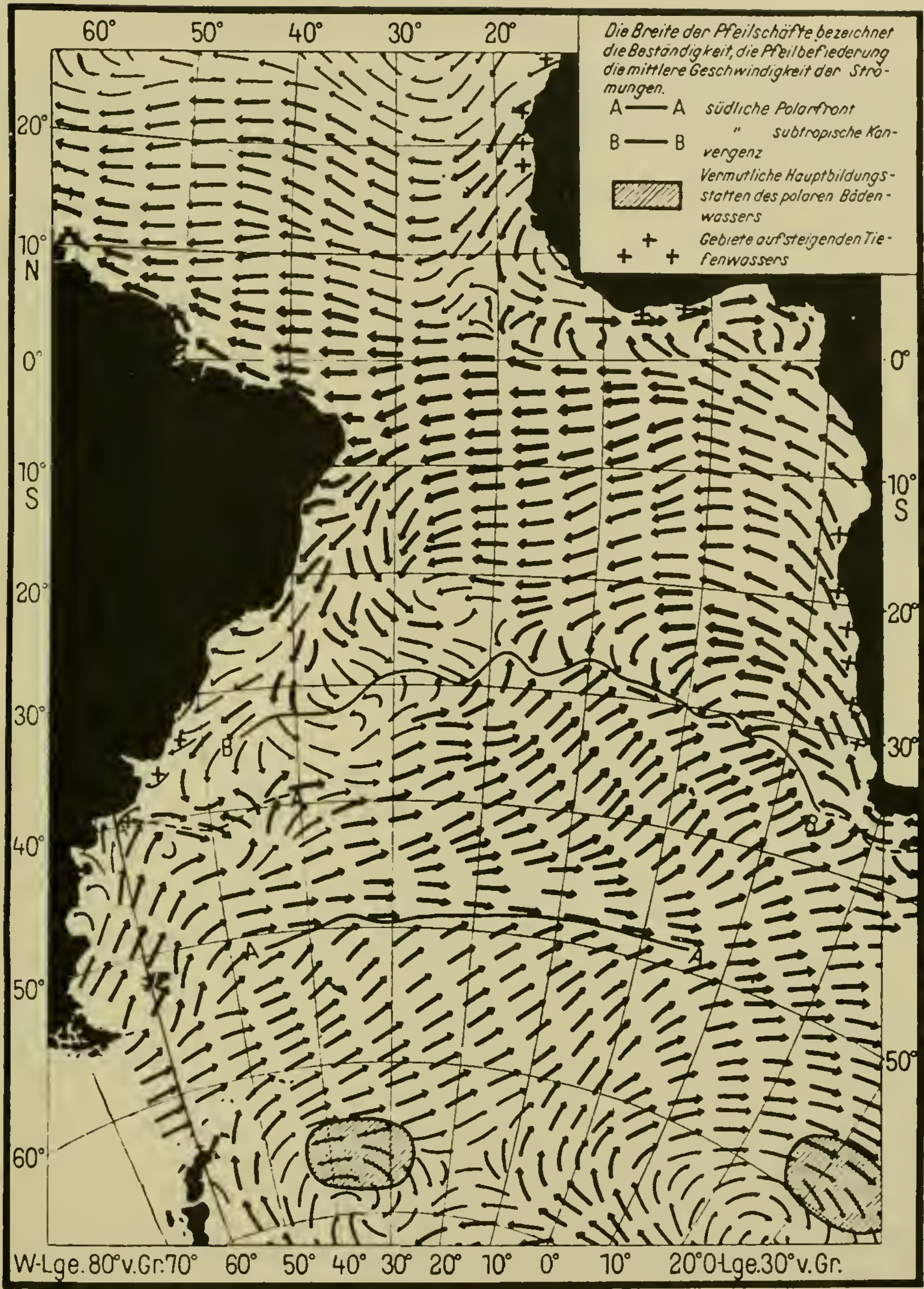


FIG. 9. Flow of the surface waters of the Atlantic in the month of February. From Hentschel (1933), after Meyer.

The thickness of the arrow-shafts indicates the relative constancy of movement, while the extent of barbing indicates the relative mean velocity.

sure, mean a local aggregation of marine birds, sometimes in enormous numbers, but there is a special reason why birds of such colonies can find sufficient food in surface waters close to their nesting ground. The mere shallowing of the ocean on the submarine slopes of islands accounts in large measure for a concentration of avian food in the only layer in which it can become available, namely the uppermost. This becomes increasingly true if the island happens to lie in a path of current movement, for this compels a constant and plentiful store of food organisms to approach the surface in the vicinity of the birds' nesting ground. In effect, the food resources of the ocean are improved through temporary reduction in the volume of water beneath a given surface area, and a resultant crowding of the organisms inhabiting it (Murphy, 1924, 231).

The soundness of an explanation based upon such an index as the numbers of sea birds is shown by plankton studies of the 'Meteor' Expedition. Hentschel (1933, 138–141) concludes that islands without harbors, coves, or appreciable coastal shelves can have little effect upon the quality of life in the sea. As regards quantity, however, he reports greatly increased counts of high-sea plankton in the waters immediately about, or not far from, many of the small Atlantic islands, such as Ascension. Around St. Paul Rocks, which rise from great depths, the 'Meteor' party found the largest plankton concentration of an entire cross-section of the equatorial Atlantic.

b. The North Equatorial Current.

The Equatorial Current skirts the northern margin of the South Atlantic high-pressure area and crosses the ocean in the full sweep of the southeast trades. Because of the closeness of its path to the equator, little deflective force results from the earth's rotation, and the current runs at high speed toward the easternmost projection of the South American continent. In general, a sustained wind produces a surface drift of water amounting to about 1.5 per cent of the wind's velocity. The speed of the Equatorial Current therefore tends to be least in January, and most during the late summer of the northern hemisphere, the height of the southeast trade wind season.

The rate of the Equatorial Current has been a historic matter of concern to navigators. Throughout the sailing-ship era it was next to impossible for vessels bound toward the South Atlantic to make headway near the South American coast, or to double Cape São Roque against the current and the southeast trades. The necessary easting was therefore gained in the zone of the northeast trade winds, and the equator was crossed in mid-Atlantic.

In November, 1839, Sir James Clark Ross was set far to westward by this current while endeavoring to make St. Paul Rocks. Recently the well-powered German oceanographic ship 'Meteor' attempted to describe a circle around these same islets on May 10 but, on account of a northeasterly set of 3.15 kilometers per hour, the figure became a pronounced ellipse (Spiess, 1928, 78). The ponderable character of such a flow of surface water becomes still more impressive, however, when observed from a fixed base. The following illuminating note was jotted down by Moseley (1879, 68) during the cruise of the 'Challenger':

I never properly realized the strength of an oceanic current until I saw the equatorial current running past St. Paul's Rocks. Ordinarily at sea the current of course does not make itself visible in any way; one merely has its existence brought to one's notice by finding at mid-day, when the position of the ship is made known, that the ship is 20 miles or so nearer or farther off from port than dead reckoning had led one to suppose she would be, and one is correspondingly elated or depressed. But St. Paul's Rocks is a small fixed point in the midst of a great ocean current, which is to be seen rushing past the rocks like a mill-race, and a ship's boat is seen to be baffled in its attempts to pull against the stream.

Nearer the South American coast the 'Meteor' party measured velocities in the Equatorial Current of 53 kilometers in 24 hours, and off Guiana, in latitude 11° N., of 89 kilometers in 24 hours (Spiess, 1928, 282, 317).

At Cape São Roque the Equatorial Current divides, and the northern part flows along the northeasterly coast of South America, passing the shores of Brazil, Guiana, and Venezuela, and entering the Caribbean. Throughout this part of its course it is probably the strongest ocean current anywhere within the field of our study. Moreover, as we shall see, its waters, and consequently the life it harbors, are more affected by the outpouring of great rivers than those of any other ocean current in the world.

c. The Brazil Current.

The Brazil Current flows southward along the eastern face of the continent, varying seasonally in its force and direction. Ordinarily it is strongest in the stretch between the Abrolhos Islets and Cape Frio, where its course is approximately southwestward. Farther northward, as near Bahia, the movement of surface water is sometimes turned in a northerly direction by the trade wind, during the period between May and September. South of the tropic of Capricorn the Brazil Current becomes so weak that it is of no concern to navigation, though it is still capable of exerting a periodic influence upon the character of the ocean water as far southward as Patagonian latitudes.

In general the water of the Brazil Current is very warm and very blue, which is the equivalent of saying that it is relatively poor in plankton, fish life, etc. The sea bird fauna has in general a West Indian stamp, with the notable absence of the Brown Pelican, a bird which would doubtless thrive along the southerly seacoast of Brazil but which has been excluded from the region by an oceanographic barrier to be discussed later. There is also a certain seasonal intrusion of sea birds from the Atlantic Sub-Antarctic Zone.

It is interesting to note that even such microscopic organisms as the Foraminifera of the Brazil Current exhibit the same general type of geographic relationships as the birds. Cushman and Parker (1931, 19) show that along the Brazilian coast, as far south as the harbor of Rio de Janeiro, the foraminiferal fauna is practically identical with that of the West Indies. To southward of Rio, however, a cool-water fauna begins to appear, with numerous species common to the Cape Horn region and to the Humboldt Current zone of the West Coast. Many of the Atlantic warm-water species apparently do not range along the coast much to southward of São Paulo, although a few Foraminifera prove common both to Brazilian and Falkland Island waters.

From such data, as well as from the warming effect of the Brazil Current upon waters not far northeastward of the Falkland Islands, we may conclude that there is a constant meeting, mixing, and biotic struggle between these warm waters and the cool waters of the Falkland Current. The area of contact, however, lies largely in the belt of westerly winds, with a consequent tendency for the surface waters to be carried offshore, and with more or less upwelling along the edge of the continental shelf from cooler layers of intermediate depth.

Even when the Brazil Current is exerting its most powerful effect along the coast to southward of latitude 40° S., its climatic influence upon the shores to westward could hardly be a warming one. In fact, the reverse of this might naturally be expected, for, with warmer air over the water off the coast, a stronger flow of cooler air from the pampas would ensue.

(1) THE POVERTY OF TROPICAL BIRD LIFE OFF SOUNDINGS

In the Tropical Zone to which we have thus far confined our attention under the heading of Ocean Currents, the relative paucity of bird life on the high sea, when contrasted with conditions in cooler latitudes, is very striking. In general, intertropical sea birds are closely associated with islands, archipelagoes, or continental coast lines. Alexander (1928, 359), after describing the rich variety of tropical sea birds, goes on as follows:

> The foregoing remarks on the large numbers of species of sea-birds found in the tropics might lead to the supposition that birds were more abundant in tropical seas than in higher latitudes. In reality, however, the opposite is the case. One may travel for days across the tropical oceans and see no birds at all. . . . Even on many tropical coasts the numbers of sea-birds are small.
>
> On the other hand many small, desolate, sun-baked islets off the coasts of the continents, and numerous coral islands in mid-ocean, swarm with sea-birds whose cries may be heard for miles across the water and which may appear at a distance like a column of smoke rising from the island. Since many of the species of tropical sea birds breed erratically at almost any time of year such islands are hardly ever without some nesting birds. Even where the colony of a particular species nesting on an island has a definite breeding season, another colony of the same species on a neighbouring island may breed in a different month, and in exceptional cases birds of the same species may have two distinct breeding seasons in the year on the same island, or the breeding season may differ greatly in different years.
>
> Most of the sea-birds which breed in the tropics do not seem to range very far from their breeding grounds.

Richards (1909, 5) likewise emphasizes the exceedingly small number of pelagic birds noted by himself and several watchful fellow naval officers during a protracted cruise in the warmer parts of the Pacific. The average on the high sea figured out at approximately one bird for each 200 kilometers of travel. Brooks (1934, 186) more specifically describes the alternation between birdless regions and those of high avian concentration on a voyage between San Francisco and Tahiti. During the first two days, he writes, one sees examples of the North American coastal species, after which there may be five or six days in which faithful watching will yield only an occasional petrel. Within a few degrees of the equator, when the scattered cumulus clouds become thicker and grayer, a confused swell makes up, and rainsqualls come and go, birds suddenly appear. These may include storm petrels, larger kinds of Procellariiformes, and tropic-birds and, when one is not too far away from some island, multitudes of terns may be sighted. As the steamer moves onward, the birds drop away as abruptly as they had appeared. Such alternating phenomena, continues Brooks, are due in the main to the interrelations of currents and countercurrents, along the boundaries of which a swirling and upwelling of water fertilizes the surface. In a cold ocean such as the North Atlantic, the eddies produced by the meeting of such currents as the Gulf Stream and those flowing from the Arctic, cause a similar effect with relation to bird life in certain localities. Instead of the erratic whirls and rainsqualls of the doldrum belts, however, we find rather the production of fogs and slicks. The composition of the bird life, moreover, is somewhat different, but the principle is the same.

The 'Meteor' investigations show that in the South Atlantic a definite boundary between regions rich in pelagic birds and regions poor in pelagic birds crosses the ocean between latitudes 20° and 25° S., from the Benguela Current on the African side to a point south of Cape Frio on the coast of Brazil (Hentschel, 1933, 116). On the other hand, the 'Meteor' chart of the birds systematically recorded during watch periods throughout the voyages indicates at least two centers or tracks of relative abundance in parts of the ocean within ten degrees of the equator. One of these is in a tongue of water stretching 900 kilometers northeastward from the mouth of the Amazon. The other and more important area lies along a northeast-southwest line corresponding approximately with the shortest distance between Africa and South America.

The latter is the part of the ocean which some geographers designate as an "Equatorial Strait" connecting the northern and southern moieties of the Atlantic (Vallaux, 1933, 377). Its breadth is but 1530 sea miles or 2840 kilometers. Moreover, it is dotted with several islands that support large numbers of nesting oceanic birds, namely, St. Paul Rocks, Fernando Noronha, and the Rocas Reef. Finally, as Hentschel points out, it is also on the line of fairly heavy maritime traffic, which may exert an influence in drawing some of the birds farther than usual from land. The avian concentration is thickest between the African coast and about 20° of west longitude, doubtless owing to the effect upon food of a complex mingling of currents in the ocean to westward of Senegal.

In the oceanic high-pressure areas discussed above, bird life is, of course, extraordinarily scarce. Much of our knowledge of the southern-hemisphere anticyclonic centers proceeds less from direct observation than from analogy with conditions in the North Atlantic Sargasso. The latter is notorious as a region poor in life (except in the depths). Thirteen species of surface fishes represent the total number observed by Dixon during many years' observation. The same author also quotes Darwin, who wrote, "There was more variety of life in and about one leaf of Kelp growing about the shores of Tierra del Fuego than in the whole Sargasso Sea" (Dixon, 1925, 441). In bird life, the entire region is singularly poor, as I myself learned during a lengthy voyage through the axis of the area from a point near Bermuda to the Cape Verde Islands.

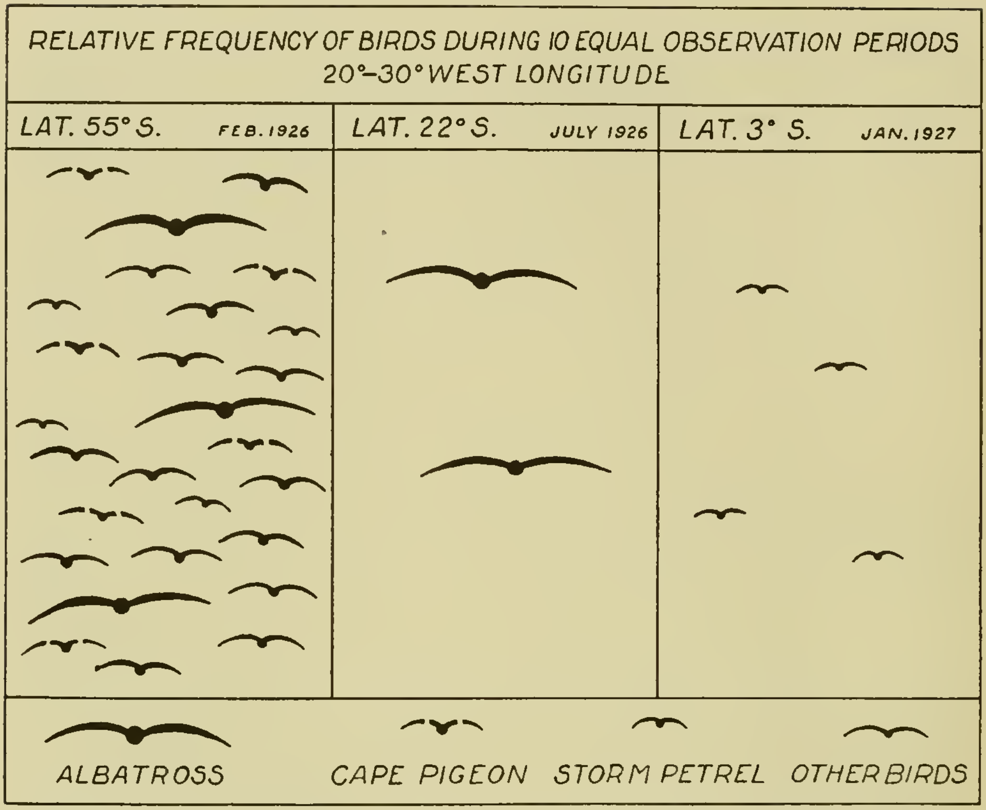


Fig. 10. Relative abundance of sea birds in three latitudinal zones of the South Atlantic. After Spiess (1927).

Moreover, on a straight course from north of Madeira to São Luiz do Maranhão, Layard, an excellent observer, saw almost no bird life, and his sea captain, who made the same trip regularly, reported that he had never observed conditions otherwise. On another occasion Layard sailed from Pará on March 17, *en route* for Lisbon. Between the mouth of the Amazon and a point within 100 miles of Madeira not a single bird was seen (Layard, 1872, 336; 1873, 331).

The work of Jespersen during the 'Dana' Expedition and other cruises is still more specific. This author confined his records to sea fowl observed at a minimum distance of about 90 kilometers from land. The fewest birds were noted toward the center of the Sargasso Sea, where the average was sometimes as low as one bird per day for periods up to 99 days. In the same area the records reveal the largest number of days during which no birds at all were sighted. Such data are balanced against adequate plankton counts from the surface water, with the expected correlations (Jespersen, 1930, 9).

Most groups of sea fowl may be wholly or partly ruled out as being in the strict sense pelagic within the intertropical zone. Certain migrants from the north or the south, such as petrels, terns, jaegers and possibly skuas, as well as phalaropes, regularly cross it along more or less fixed routes, but the truly indigenous pelagic species are reduced to a few petrels, terns, noddies, boobies, and tropic-birds.

The last-named are the only members of the Pelecaniformes which are pelagic in the same sense that petrels are pelagic. Cormorants and pelicans, of course, are bound to their insular or continental coasts to such a degree that they seldom lose sight of land. Boobies wander somewhat farther, and yet even they are very rarely seen more than one or two hundred kilometers from shore unless they are crossing a continental bight, such as the Gulf of Guinea. The Brown Booby (*Sula leucogaster*) appears to be the member of the family most likely to be sighted over the high seas. Finally, the man-o'-war birds, which have such a roaming reputation, also prove, when the data are critically sifted, to cling surprisingly near either their nesting ground or the continental shore line. This is natural, considering that the man-o'-war birds depend for their food partly upon robbing other sea birds; nevertheless, they have a pelagic repute among sailors and travellers which is widespread and hard to eradicate.

Now Jespersen's prolonged observations yielded but one man-o'-war bird as far as 500 kilometers from the nearest West Indian island, and only one other as far as 350 kilometers from land (1930, 26). Hentschel (1933, 122) reports after many crossings of the South Atlantic in the 'Meteor,' "*Fregata* habe ich nur in der Nähe von Küsten und Inseln . . . gesehen." Most of the supposedly offshore records in the Pacific have also been made, as a matter of fact, at points close to one or to several islands. It should be remembered that a man-o'-war bird out of sight of land does not necessarily mean that the land is out of sight of the bird.

Such facts are easier of comprehension when we stop to consider that no less than four species of *Fregata*, namely *aquila*, *magnificens*, *minor*, and *ariel*, and apparently several more subspecies, occupy islands lying in warm oceans within easy flight range of one another and of South America. From this we may infer that while these birds obviously possess the means of surviving, and of establishing new colonies, when they are involuntarily transported long distances, as by storms, their habits are, nevertheless, relatively sedentary. Therefore, when Walt Whitman wrote concerning the man-o'-war bird—

> At dusk that look'st on Senegal, at morn America

the only flight involved was a poetic one.

Tropic-birds (particularly *Phaëthon lepturus*) are, however, frequently observed in the remotest parts of the warmer oceans, and are even characteristic of the barren anticyclonic areas. Yet their small absolute numbers, as compared with the multitudes of petrels to be seen in high southern latitudes, are a fair index of the relative availability of food in the surface waters of the respective zones. Most oceanic birds feed upon freely moving organisms, and cuttlefish make up the bulk of the food of tropic-birds. The 'Dana' naturalists found no other organisms in the stomachs of eight of them taken far from land. Cephalopods, of all oceanic invertebrates, make up the greatest single food resource common to widely varying zones. In cold waters the chief combination of importance to birds is probably cephalopods, crustaceans, and small schooling fishes; in warm waters cephalopods and flying fish take high rank. But cephalopods and fish are at least ten times as abundant in the surface waters beyond latitude 40° S., and in cold coastal currents, as they are within what we may call collectively the Sargasso regions; and the corresponding ratios with reference to crustaceans are nearer ten thousand to one.

d. The Cape Horn Drift.

The general eastward drift in the southern Pacific, which flows along a median axis of about 50° south latitude, is impeded by the long poleward extension of the South American continent and is deflected to southward of Cape Horn. The resulting current through Drake Strait, abetted by the Burdwood Bank and other contours of the ocean bottom east of Tierra del Fuego, keeps bergs and floe-ice from reaching waters around the Falkland Islands. Farther eastward in the Atlantic, bergs are familiar in lower latitudes: in mid-ocean, near the Tristan group, as far north as 37° S.; in the Cape region of Africa up to 35° S. They are practically unknown to wesrward of the Falklands. A few records from the Patagonian coast, off Bahía Blanca, perhaps represent bergs that have drifted inshore after passing well to eastward of the Falklands.

After rounding the southern tip of the continent, the Cape Horn Drift divides, one branch looping northward on both sides of the Falkland Islands, while the other and larger passes to eastward on both sides of South Georgia. Hardy, of the 'Discovery' Expedition, has explained the peculiar effect of this current in making South Georgia one of the world's great centers of whale population. His remarks apply equally well to the amazingly abundant bird life of that island which, it will be remembered, belongs to the Antarctic Oceanic Zone, despite its relatively low latitude. Hardy (1928, 220) writes:

We found that all the Euphausians were concentrated along the north-east side of South Georgia. Immediately at each side of the island was a zone some 15 miles broad very poor in plankton, and outside this an encircling zone of thick plant plankton, largely diatoms of the species *Corethron valdiviae*, with outside this again an area of more mixed but less dense plankton.

We may guess at the explanation of this. South Georgia is a long narrow island, some 100 miles long by some 15 across; it is placed almost at right angles to the main westerly drift coming up from the Drake Straits. The currents set up round it will be like those set up round any long object forced sideways through a fluid—the water will be forced in a curve round either end to meet in an eddy some distance behind it, leaving an area of "dead" water immediately against the land. The growth of plant life in the sea is limited . . . by the quantity of available phosphate. This as the summer advances gets used up in the upper layers. Here, where the main ocean current from the west strikes the continental shelf of South Georgia, there will be an upwelling of water rich in phosphate from the deeper layers on the west side of the island.

Fig. 11.

It is here that we get the densest growth of diatoms, which are carried round either end into the area behind the island. . . . Here in this sheltered water are all the Euphausians, young and old, which feed directly upon the diatoms. It is like a sheltered nursery for them, supplied by food on either side. This theory appears to fit in very well with the results of phosphate analysis obtained by Mr. Clowes, our hydrologist, and is perhaps the explanation why South Georgia, so peculiarly situated, should be one of the richest whale-feeding grounds of the world.

The enriching effect of the presence of islands is, of course, reflected by the bird life in the same latitudes. The 'Meteor' naturalists found relatively few birds on the open reaches between the South Shetlands and Bouvet Island; at times even the nearly ubiquitous Cape Pigeon failed to appear in the daily census. Supplementing the factors described above by Hardy, Hentschel (1933, 141) also refers to the favorable effect of abundant bird guano upon plankton in the coastal waters of such an island as Bouvet. The influence of the modern antarctic whaling industry upon bird population and bird concentration is discussed elsewhere, in the section relating to petrels and albatrosses. Suffice it to say here that in enclosed waters occupied by whaling shore stations, such as the crater harbor of Deception Island, counts of the zoöflagellates sometimes show more than a million to each liter of water (Hentschel, 1933, 156).

The Cape Horn Current brings much ice from Bellingshausen Sea, on the western side of West Antarctica, into the South Atlantic and, together with the chilled winds from the same direction, is responsible for the rapid fall in temperature experienced in passing from west to east in this belt. Thus the annual mean at Ushuaia is 6.2° C., that at Cape Pembroke, the eastern extremity of the Falkland Islands, 5.9° C., and that at South Georgia 2.1° C. (Brooks, 1920, 98). Such atmospheric temperatures well reflect the differences between the Sub-Antarctic and Antarctic Zones of surface water. The west winds and the Cape Horn Drift prevent the additional ice coming out of Weddell Sea from having any direct effect upon the South American region, but the ocean to eastward, toward Bouvet Island and the southern Indian Ocean, is further chilled by it. Many of the results, as we shall see, are closely correlated with the peculiar distribution of certain penguins and other sea birds. Furthermore the conditions are in large part responsible for the fact that the eastern or African side of the South Atlantic is, on the whole, richer in birds and other pelagic organisms than the western side.

e. The Falkland Current.

The Falkland Current is strongest along the outer edge of the Patagonian coastal shelf, which is the only extensive shallow-water region on the American side of the South Atlantic. Between 40° and 45° S., or thereabouts, it flows northward at the rate of nearly two kilometers per hour, and here its surface temperature is also lowest because of upwelling caused by the prevailing winds from the land, *i. e.* the westerlies. On the continental shelf itself the temperatures are somewhat higher. The northward extent of the current is variable, as previously indicated, but the area of mixing between its waters, those of the shelf, and those of the drift from the north, are very rich in life and are famous for a vast concentration of sea birds at certain times. Here pelagic petrels and littoral gulls, cormorants, and penguins mingle in force. Here, as has already been recounted, Mr. Beck found some of the best collecting grounds of the Brewster-Sanford Expedition.

Southeastward of the mouth of the Río de la Plata, sharp differences in water temperatures are especially notable. Here also cool dry southwesterly winds meet the warm northerly winds that bring thundershowers. Widespread fogs are frequent during the southern winter season, sometimes reaching into the estuary of the great river. There is also much amplitude in the seasonal range of temperature because of the clear skies that generally prevail in the southern summer and the heavily overcast skies of winter.

Climatic conditions along the coast are somewhat similar to those of the Newfoundland region in the north, where warm and cold currents likewise come into contact. But Patagonia, as Schott has said, stretches practically from the polar zone to the tropical.

f. The Humboldt Current.

In crossing the breadth of the South Pacific the Sub-Tropical Convergence undulates between about 28° and 40° of south latitude. In the middle reaches of the ocean the line falls between 30° and 37° S., but midway between Easter Island and Juan Fernández it loops again northward. Still nearer the continental coast it loses definiteness and significance because of new oceanographic complexities.

The heart of the permanent anticyclone lies north of the convergence, between the neighborhood of Easter Island and the continent, its longer axis closely paralleling the tropic of Capricorn as the whole center fluctuates poleward or equatorward with the changing seasons. On its southern side is the zone of westerlies, to northward that of the southeast trades, and to eastward the coastwise winds which, near the land, show the usual onshore and offshore diurnal alternations, although always proceeding from a southerly quarter. The oceanic wind system, therefore, tends to blow counterclockwise around the periphery of the high. The region as a whole is prevailingly tranquil, with transparent, deep blue water and clear horizons; clouds in these latitudes pertain mostly to lofty coasts and the peaks of islands. It is, indeed, the particular part of the South Sea that earned Magellan's appellation of "Pacific."

The courses of surface movements of the water are, naturally, correlated with the winds. Of the Sub-Antarctic West Wind Drift we need add nothing to what has been said above, but to eastward of the high-pressure center, and particularly in the littoral belt of the greater part of the west coast of South America, are surface flows which determine the entire complexion of the marine avifauna, not to speak of their broader effect upon climate, hydrology, and the life of the land as well as of the sea.

Moving northward along the eastern border of the high-pressure nucleus, but still far from the coast, is a current of blue, moderately warm water, which should perhaps be regarded as merely the offshore edge of the cool coastal current but which Kerhallet, in 1853, named the Mentor Current. The discoverer computed its velocity in latitude 26° S. as from 18 to 21 sea miles per day, or approximately 1.5 kilometers per hour (Vallaux, 1933, 195).

Zorell (1928, 166) has maintained that the Humboldt Current should be regarded as only a relatively cool oceanic stream, holding that the very low temperatures encountered along the tropical coast of Peru, and at times even of Ecuador, are only an incident among many phenomena associated with a broad and deep body of water. This leads me to say that there are doubtless two senses in which the term Humboldt Current may be used. One of these is climatic or oceanographic, and, from this point of view, characteristics of the water hundreds of kilometers from the shore, where the temperature is always high, may be as necessary to an understanding of the current as knowledge of the surface temperatures close to land. The other sense is strictly biotic and zoögeographic, and in the present connection mainly ornithological. Since it is the indubitably cool coastal water that is responsible for all the peculiarities and anomalies of sea bird distribution in the region, it should be made clear that by Humboldt Current I mean specifically the narrow littoral zone of upwelling, together with its northwesterly seaward extension near the equator.

The cool coastal current takes its origin not from latitudes bordering the Antarctic, but in the west wind zone, from where it passes into the sphere of the trade winds. These, as previously noted, become deflected to southerly or even southwesterly winds along the steep Andean seaboard. The current is observable along the coast from the vicinity of Mocha Island, Chile (38° 30′ S.) northward to Cape Blanco, Peru (4° 27′ S.). From the latter general neighborhood it sets west-northwestward, flows on both sides of the Galápagos Islands, and is lost beyond longitude 100° W. in the south equatorial drift.

Significant features of the surface waters in the current are first, relatively low temperatures in close proximity to the land, with rising temperatures offshore along lines usually perpendicular to the trend of the coast; and second, extraordinary uniformity of temperatures throughout the greater part of the length of the current, a uniformity which is little affected either by latitude or season of the year. Both of these facts would strongly suggest that the low temperatures close to shore are due to upwelling from cooler intermediate layers, rather than to northward transportation of sub-antarctic surface waters. The latter would, of course, become gradually warmed during their progress into the tropics, and the Humboldt Current would show appreciably rising temperatures from south to north, which is not in accord with the facts. Upwelling would, in any event, be inevitable in view of the meteorological régime. An accelerated left-hand trend, and continuous vertical circulation, is caused by the steady southerly winds parallel with the coast, which tend to force the surface water offshore at an angle of 45° from their path.

The Humboldt Current flows at velocities of from .3 to .6 sea miles per hour, or occasionally more, off Peru, increasing to from 1 to 2 sea miles after turning westward toward the Galápagos. The current is of relatively high salinity and is most strongly marked during the southern-hemisphere winter. The isotherms of surface water are usually parallel with the coast line, but occasionally they lie east-west because of upwelling from cool substrata. Sharp bends in the continental outline, as at Arica, enhance and complicate these effects so that the northerly coastal waters are frequently of lower temperatures than those to southward. The averages for the Mollendo-Pisco reach, for example, are lower than those off Chile, while during the southern spring and summer the Antofagasta water temperatures are anything up to 3° C. warmer than those at Callao, more than a thousand kilometers to northward.

Correlated circumstances are frequently reflected in the atmospheric temperatures at the Peruvian guano islands. Thus the means for the month of December, 1934, at islands succeeding each other from north to south or in a direction away from the equator, were the opposite of what might be expected, to wit: Lobos de Tierra, 19.35°; North Guañape, 19.68°; Pachacamác, 21.63°; Islay group, 22.5° C. For January, 1935, a corresponding sequence is: Lobos de Tierra, 21.64°; Lobos de Afuera, 21.67°; central Chincha, 22.9°; Islay group, 22.5°; Iñani, 24.2° C. Part of the effect may be due, of course, to strictly local conditions, but the general trend is significant.

The upwelling phenomena responsible for such anomalies begin a little north of Coquimbo and are active as far as Paita. Increasing breadth of the coastal shelf especially favors upwelling, which sufficiently explains the fact of cooler water in the tropical sector. North of Callao, for instance, the continental shelf is relatively wide, whereas along the northerly Chilean coast depths of 200 meters or less are found only within 2 sea miles of shore (Schott, 1931, 161).

Coastwise observations during the months of September and November, reported upon by Schott, show that to southward of Paita, Peru, lower surface temperatures are accompanied by lowered salinity, indicating that the source-level of the rising water is deficient in salt. North of Paita, in the equatorial section of the coastal Pacific, the reverse is true. Because of this Schott is entirely in accord with Sverdrup's (1930, 257) recent findings that upwelling in the Humboldt Current is practically limited to the upper 200 to 300 meters.

Average surface temperatures close to shore along the greater part of the coast of Peru range between 14.4° and 17.8° C. (Murphy, 1923, 67), a range something like 10° C. lower than the theoretical value for the latitudes. More extraordinary than the absolute temperature, however, is its general uniformity. As a corollary, the atmospheric temperatures of the coast are maintained at a monotonous level from Mocha Island almost to the Gulf of Guayaquil. Antofagasta, Iquique, Arica, Mollendo, Lima, Trujillo, Paita, etc., are all under the effective control of such oceanic influences (Jefferson, 1926, 443). Furthermore, the seaward slopes of the mountains, as well as the littoral ocean for more than 150 kilometers from shore along this stretch of coast, are, in the ordinary sense of the word, rainless. Because of these conditions the terrestrial biota is relatively poor, while marine life is both extraordinarily rich and delicately adjusted to the environment. How delicate the adjustment is becomes immediately apparent during the infrequent phenomena that temporarily interrupt the uniformity.

Between the westernmost projection of the South American continent and the Galápagos Archipelago, the Humboldt Current normally attains its maximum velocity. In this region, too, the cool, greenish waters intermingle with the much warmer blue waters of the Equatorial Current, the two often forming distinct bands or stripes, separated one from another by rips and foam-lines and accompanied by much turbulence or "boiling." Such mixing zones often prove very rich in life. The phenomena have been vividly described by Colnett, du Petit Thouars, Darwin, Beebe, and others (Murphy, 1923, 65; Vallaux, 1933, 200). Practically all of the oceanic area bounded by latitudes 5° S. and 3° N., and longitudes 85° and 100° W., is one in which opposing currents fight out a varying but indecisive battle for supremacy.

In the zones of confluence and along the boundaries between green and blue water, conditions are favorable for sea birds, as suggested above. Outside these zones, in the tropical expanses of feeble currents and marine stability, few birds are to be looked for. The matter has already been discussed, but it is worth adding that du Petit Thouars, voyaging in the 'Vénus' from Callao to Hawaii in 1838, noted especially the great relative scarcity of birds over the tropical high seas (Vallaux, 1933, 204). Birds are, of course, dependent upon marine life that comes very close to the surface. Whales, on the other hand, can penetrate somewhat deeper layers for their food. This is doubtless the reason why remote blue-water grounds, including even parts of the anticyclonic areas, were profitable hunting centers for the sperm whalers of old, notwithstanding their paucity of bird life.

The uniformity produced by upwelling along the continental coast makes the inshore waters of the Humboldt Current an extraordinarily constant environment, as well as a very rich one. No better example of relatively unchanging relationship between organism and milieu can be found than that of the diatoms of the current. I collected specimens of these microscopic plants from the surface waters along two-thirds of the length of Peru, and others from ancient pits of guano on the Peruvian islands. All samples, regardless of station, season, or year of origin, contained the same characteristic species, which is of special interest because it is not uncommon for the diatom flora of a given locality to be strikingly dissimilar at different seasons, and during the same season of successive years (Mann, in Murphy, 1923, 72).

An identical principle applies to the metazoan fauna of the Humboldt Current. The population of the surface waters is made up chiefly of a rigidly circumscribed group of organisms, varying little in constituency but running rather to the development of vast numbers of individuals within a comparatively small number of species. The percentage of endemism is also high. Bigelow's remarks on the invertebrates are doubly interesting in that they refer both to the abundance of life in the current and to the contrasting conditions in warm-water areas beyond. He writes:

> I cannot pass over without mention the extraordinary richness of the Humboldt Current in pelagic life of all kinds; a richness which has already been noted in the account of the general oceanographic features of the Eastern Tropical Pacific by its [the expedition's] leader, who speaks

of "such masses of Salpae, of Cytaeis, or Cymbulia, or swarms of other pelagic animals as to make a thick soup" . . . , and of enormous quantities of copepods, schizopods, Doliolum, and Medusae. Nor can I omit to recall the discovery, immediately to the west and southwest of the Current, of an area as barren in all forms of life, bottom as well as pelagic, as the latter is rich. Thus "As soon as we ran outside of this [the Humboldt Current] the character of the surface fauna changed; it became less and less abundant as we made our way to Easter Island, the western half of the line from Callao becoming gradually barren." On entering the current again from the barren area the reverse change was equally striking.

Paul (1932, 202) and others have emphasized similar phenomena observed during cruises of the 'Carnegie.'

An impressive picture of the almost unparalleled profusion of living creatures, particularly of fishes and birds, is given in literature which I have cited elsewhere, and from which both the above and the following quotations are taken (Murphy, 1923, 80). Coker, for example, has written:

> In contrast to the barrenness of the coast [of Peru] there is a peculiar wealth of certain forms in the open ocean. The great red seas, formed sometimes, at least, of myriads of microscopic dinoflagellates, are of common occurrence. . . . Sometimes, too, great areas of the surface of the sea are reddened by the vast numbers of small crustacea (*Munida*), which then play a part of great importance as food for the fishes and for the guano-producing birds. More striking still are the immense schools of small fishes, the "anchobetas" (*Engraulis ringens* Jenyns), which are followed by numbers of bonitos and other fishes and by sea lions, while at the same time they are preyed upon by the flocks of cormorants, pelicans, gannets, and other abundant sea birds. It is these birds, however, that offer the most impressive sight. The long files of pelicans, the low-moving black clouds of cormorants, or the rainstorms of plunging gannets probably cannot be equaled in any other part of the world. These birds feed chiefly, almost exclusively, upon the anchobetas. The anchobeta, then, is not only . . . the food of the larger fishes, but, as the food of the birds, it is the source from which is derived each year probably a score of thousands of tons of high-grade bird guano. . . . No more forcible testimony to its abundance could be offered than the estimate, made roughly, but with not wide inaccuracy, that a single flock of cormorants observed at the Chincha Islands would consume each year a weight of these fish equal to one-fourth of the entire catch of the fisheries of the United States.

As indicated previously, the zonal position of the Humboldt Current fauna is difficult to define. The native organisms have been drawn from various sources outside the area, and the fauna as a whole seems highly nonconforming and eclectic. An analysis of the native sea birds will make this point clearer, but it is also illustrated by other groups of animals. For instance, the shore-fish fauna of the Peruvian coast is mainly temperate rather than tropical in facies. The admixture of sub-tropical with distinctly temperate types of fishes gives the whole assemblage a somewhat Mediterranean cast.

The closest faunal affinities of the Peruvian shore-fishes seem to be with the Californias, a considerable number of species being common both to the coast of Peru and to Pacific waters lying just outside the tropics in the northern hemisphere. The distribution agrees closely with the oceanic circulation. Currents flowing from high latitudes toward the equator restrict the Pacific tropical waters to a belt so narrow that it is crossed by a number of species. This belt of tropical water is, nevertheless, a sufficient barrier to divide the shore-fishes of California from those of Peru to a greater extent than those of Florida are separated from those of southern Brazil (Nichols and Murphy, 1922, 513).

(1) THE PROVENANCE OF HUMBOLDT CURRENT BIRDS

The Humboldt Current is inhabited at one season or another by a variety of ocean birds from many different parts of the North and South Pacific.

First, there are the endemic species, known only from waters off the coast between southwestern Ecuador and central Chile. These will receive special consideration below.

Second, there are a number of birds of sub-antarctic or pan-antarctic affinities, such as the Magellanic Penguin (*Spheniscus magellanicus*), the Sooty Shearwater (*Puffinus griseus*), one or two frigate petrels (*Fregetta*), the Red-footed Cormorant (*Phalacrocorax gaimardi*), and a tern (*Sterna hirundinacea*), which extend their breeding ranges northward in varying extent from the Fuegian region to coasts or islands washed by the current. The same is also true of certain shore birds, such as the South American Black Oyster-catcher, and even one land bird (*Cinclodes taczanowskii*), the ranges of which are scarcely less subject to a maritime type of control than that of the strictly oceanic birds.

Third, there is a partially different avifauna in the offshore waters than in the cooler zone close to the land. For example, several petrels of the genus *Pterodroma*, with nesting grounds on Mas Atierra, Mas Afuera, San Felix, or San Ambrosio Islands, were never encountered by Mr. Beck, during the Brewster-Sanford Expedition, until he had gone by schooner a long distance from Peruvian-Chilean shores, and had left far behind the most characteristic birds of the upwelling zone, which is literally within sight of the coast.

Fourth, migrants from several different parts of the ocean, some close at hand and some very remote, enter the current seasonally. These include certain species of antarctic and sub-antarctic albatrosses, petrels such as *Daption*, *Priocella*, *Macronectes*, *Procellaria*, and *Oceanites oceanicus*, as well as one or more forms of the skua (*Catharacta*), all of which come from the south. But there are also seasonal migrants from the outer, tropical Pacific, such as the Sooty Tern (*Sterna fuscata*), examples of which appeared close to shore in central Peru during January, 1925. Furthermore, there are migrants from the Galápagos Islands, and from localities in the tropical waters to northward of the Humboldt Current. Among these are the albatross from Hood Island (*Diomedea irrorata*), a gadfly petrel (*Pterodroma phaeopygia*), the Blue-faced Booby (*Sula dactylatra*), the Swallow-tailed Gull (*Creagrus furcatus*), the Royal Tern (*Thalasseus maximus*), and at rare intervals a tropic-bird (*Phaëthon aethereus*). Finally, there are large numbers of visitants from the northern hemisphere, including such petrels as *Loomelania melania*, from breeding grounds off the Lower Californian coast, gulls like *Larus pipixcan*, from the interior of North America, and jaegers and phalaropes from the Arctic.

We might even add two more categories of birds found in the Humboldt Current, namely, (1) South American continental species, such as a skimmer (*Rynchops*), a mountain gull (*Larus serranus*), and a "zoneless" cormorant (*Phalacrocorax olivaceus*); and (2) birds like the Pale-footed Shearwater (*Puffinus carneipes*), which come, by a route still unknown, from the Australasian region.

Only a few species of birds nesting on islands in any part of the Humboldt Current between central Chile and the Gulf of Guayaquil occur also as breeding birds to northward of the region. One of these exceptions is the Blue-footed Booby (*Sula nebouxii*), which barely comes into the northern end of the Humboldt Current at the Lobos Islands, off the coast of Peru between latitudes 6° and 7° S. Farther northward this booby breeds on tropical islands from Ecuador to Mexico, including the Galápagos group. There can be no doubt about its proper allocation as a tropical sea bird. Diatoms taken from the alimentary tracts of this species (obtained by the birds by way of the herring and other fishes they devour) have proved to belong mainly to warm-water species rather than to the characteristic diatom flora of the Humboldt Current.

A second member of this small group of sea birds, which we might call tropical intrusions into the Humboldt Current, is the native pelican. In this case, however, we have at least an endemic subspecies, which ranges alongshore (never going far to sea) from central Chile to northern Peru, where it comes into contact with a tropical race. It should be added here that the American brown pelicans are taxonomically a difficult group, and that the exact relationships of the four or more subspecies occupying the Caribbean-Gulf region, the west coast of North America, the Galápagos Islands, and the Humboldt Current, have never been satisfactorily worked out. In any event *Pelecanus occidentalis thagus* seems to be a race well differentiated from any of the pan-tropical representatives.

The other Humboldt Current species which occur elsewhere as breeding birds, are two small petrels or Mother Carey's chickens (*Oceanodroma tethys* and *Oceanites gracilis*). These are also native members of the avifauna of the Galápagos Islands which mark, after all, only an outpost of the Humboldt Current, despite the admixture of birds of tropical source. In any event, there has evidently been an effective barrier of isolation between the representatives of the two small petrels occupying the Galápagos Islands and the continental islands, respectively, for distinct subspecies of each occur in the two regions.

Returning now to the endemic sea birds of the Humboldt Current, ten of which I should call full species and three subspecies, I may offer the following tentative classification relating to the probable geographic origin of the thirteen forms.

Southern Derivatives
- *Spheniscus humboldti*
- *Oceanodroma tethys kelsalli*
- *Oceanites gracilis gracilis*
- *Pelecanoides garnotii*
- *Phalacrocorax bougainvillii*

Pan-Tropical Derivatives
- *Pelecanus occidentalis thagus*
- *Sula variegata*
- *Sterna lorata*

Of Probable Northern Origin
- *Larus modestus*

Of Doubtful Source
- *Oceanodroma markhami* (northern?)
- *Oceanodroma hornbyi*
- *Larus belcheri*
- *Larosterna inca*

Thus the endemic forms, especially when in combination with the pan-antarctic, pan-tropical, and northern-hemisphere sea birds, which abide in Humboldt Current waters for large parts of the year, give the region a peculiar status. The native birds as a whole do not fit into any of the zonal categories thus far considered, nor is there any analogous avifauna to be found along the eastern coast of South America. Certain resemblances between the west-coast aggregations of littoral birds and littoral fishes are adumbrated. The only choice would seem to be to regard the peculiar and composite Humboldt Current avifauna as of temperate or Mediterranean character, and as zonally distinct from any group of birds previously listed.

(2) THE PROVENANCE OF GALÁPAGOS SEA BIRDS

The Galápagos Archipelago, being closer to the northern hemisphere and to intertropical oceanic islands than the Humboldt Current region, shows an even more miscellaneous composition in its fauna. Incidentally, the same is eminently true of Galápagan land birds. In the following list, dealing with the probable origin of the sea birds, the five endemic species are indicated by an asterisk.

Of Southern Cool-Current Origin

- **Spheniscus mendiculus*
- *Oceanodroma tethys tethys*
- *Oceanites gracilis galapagoensis*

Of Intertropical Pacific Affinities

- *Pterodroma phaeopygia* (from the north)
- *Sula nebouxii* (from the east)
- *Fregata minor* (from the west)

Of Caribbean and Atlantic Affinities

- *Oceanodroma castro*
- *Phaëthon aethereus*
- *Pelecanus occidentalis* (subspecies?)
- *Fregata magnificens*

Of Cosmopolitan Pan-Tropical Affinities

- *Puffinus lherminieri subalaris*
- *Sula sula* (="*piscator*")
- *Sula dactylatra*
- *Sterna fuscata*
- *Anoüs stolidus*

Of Doubtful Source

- **Diomedea irrorata* (closest to *D. albatrus*?)
- **Nannopterum harrisi*
- **Larus fuliginosus*
- **Creagrus furcatus*

Eight or more of the above, here indicated by specific names only, have been given subspecific names, and several such races have been regarded as endemic at the Galápagos.

g. The Niño Current.

"El Niño," the equatorial countercurrent, is a well-known phenomenon off the northern Peruvian coast, commonly appearing about Christmas time or shortly afterwards, and flowing southward.

The more or less annual effects of the countercurrent are, as a rule, observable only in northernmost Peru. During a longer cycle, traditionally believed to be seven years, its manifestations are more pronounced and extensive. At still longer intervals, representing in the latest instance a rhythm of thirty-four years, El Niño and its associated phenomena may attain their maximum expression. The combined effects during the early months of 1925, for example, were far greater than those of any season since 1891 and probably greater than in any year of record.

On January 21, 1925, I measured throughout a ten-hour period a strong, warm current flowing southward, against the prevailing wind, off Point Pariñas, Peru. A month later similar conditions still obtained off Point Santa Elena, Ecuador (Murphy, 1926, 31).

The immediate result of an advance of El Niño is to raise the temperature of the littoral ocean water by five or more degrees Centigrade. The normal plankton of the cool Humboldt Current waters next succumbs, perhaps because of the increased temperature, perhaps in part because of a different composition of salts in the water. The common schooling fish leave the region or die, and less familiar species, such as flying fish, dolphins (*Coryphaena*), and other tropical types, invade the shore waters and even enter harbors. Later, if the incursion of tropical waters is marked and widespread, disease attacks the population of cormorants, boobies, pelicans, and other guano birds belonging to the normal Humboldt Current fauna. Carcasses drift ashore in vast numbers, and the survivors of such species are driven southward.

Concurrently, tropical sea birds, which do not seem to be affected by the maladies mentioned, follow the movement of El Niño down the coast into littoral waters ordinarily avoided by them. Man-o'-war birds (*Fregata magnificens*), a large intertropical booby (*Sula dactylatra*), and the Red-billed Tropicbird (*Phaëthon aethereus*) thus accompany the warm waters to southward of their usual range. Other birds that do likewise include several species of migrants from North America which ordinarily confine their wintering to the equatorial region, such as the Laughing Gull (*Larus atricilla*) and the Royal Tern (*Thalasseus maximus*). Finally, certain antarctic or sub-antarctic birds, such as petrels of the genera *Daption*, *Priocella*, *Procellaria*, and *Macronectes*, which are normally characteristic of even the northern parts of the Humboldt Current, retreat southward before El Niño, to be seen no more until the countercurrent cycle has passed (Murphy, 1926, 27).

Along the continental coast of the northwestern bight of South America, that is in the permanent Niño district, there seems to be only one endemic sea bird which does not reach the Galápagos. This is *Sula leucogaster etesiaca*, a strongly-marked race of the Atlantic Brown Booby. The typical form apparently does not cross over from the Caribbean.

Farther offshore, as at Malpelo and Cocos Islands, there are one or more other tropical Pacific birds, such as *Gygis alba*, which do not nest more closely to the cool currents of the equatorial waters or to the continental coast.

h. Meteorological, Oceanographic, and Biological Correlations in the Northwestern Bight of South America.

The striking climatic and biological changes produced along a tropical shore line by the recurring battles between distinct oceanic zones, as described in the last two sections, have been the subject of much recent scientific attention. In a series of papers, Schott (1931, 161, etc.) has interpreted by rhe dynamic method a wealth of scattered and disjointed observation, including data recorded during earlier manifestations of El Niño than the great advance of 1925.

The area covered by Professor Schott's studies is roughly from 30° S. to 10° N. latitude, and from the coast to longirude 100° W., five hundred sea miles west of the Galápagos. The oceanic zones, in a broad sense, are those of the Humboldt Current, the Niño or Equatorial Countercurrent, and the Pacific North Equatorial Current. It is very interesting to note how surely the included islands serve as indexes of the oceanic environment. Thus the arid Lobos Islands and the Galápagos reflect complerely or in parr Humboldt Current conditions. Cocos, with its luxuriant rain forest, as plainly bespeaks the Equatorial Countercurrent. Furthermore, during "Niño years" (of which twelve or more are listed, beginning with 1791), when the terminal front of the southeast trade wind has been pushed back 8°—10° of latitude, heavy rainfall and green vegetation are as characteristic of the Galápagos as they are of the arid coasts of western Ecuador and northern Peru during the same periods.

The Humboldt Current never crosses the equator anywhere near the South American mainland, for the warm countercurrent always flows between it and the Colombia-Panama region. It is therefore impossible that there should be any causal relation between Peruvian conditions and certain recurring meteorological and oceanographic effects in the Gulf of Panama, where the winter lowering of water temperature is due solely to upwelling produced by the period of strongest northeast trade winds. The movement of rhe Humboldt Current is, of course, likewise dependent upon the prevailing wind trends and the distribution of atmospheric pressures. But the latter are lowest from January to April on the Peruvian coast, and lowest during September and October in Panama. These periods correspond with the respective regional rainy seasons.

Throughout the whole area under consideration, the oceanic régime is least stable and most complex during the winter months of the northern hemisphere. Thus the Equatorial Countercurrent reaches latitudes south of the equator during February-March but never during August-September. Data from as far as 600 sea miles west of the continental coast demonstrate that rhe Niño disturbances of 1891 and 1925 were caused by widespread movement of the tropical ocean surface into southern latitudes, which resulted in the forcing of warm and poorly saline waters against the coast to eastward and southward, displacing or overflowing the cooler, saltier waters. Opinion that any parr of this vast mass of warm water issued from the Gulfs of Guayaquil or Panama is untenable. During the very period of the Niño effect the embayed warers just referred to are nored as decreasing in temperature from 4° to as much as 8° C., wirh an increase in salinity. Indeed, during both 1891 and 1925 a cold current is recorded as flowing from the Gulf of Panama at the peak of the Niño disrurbance farther southward. It is clear that in rhe seasons of its notable outbreaks rhe Niño movement draws water from the open Pacific—thar it amounts to an invasion into the southern hemisphere of the Equatorial Countercurrent.

AUG. — SEPT.

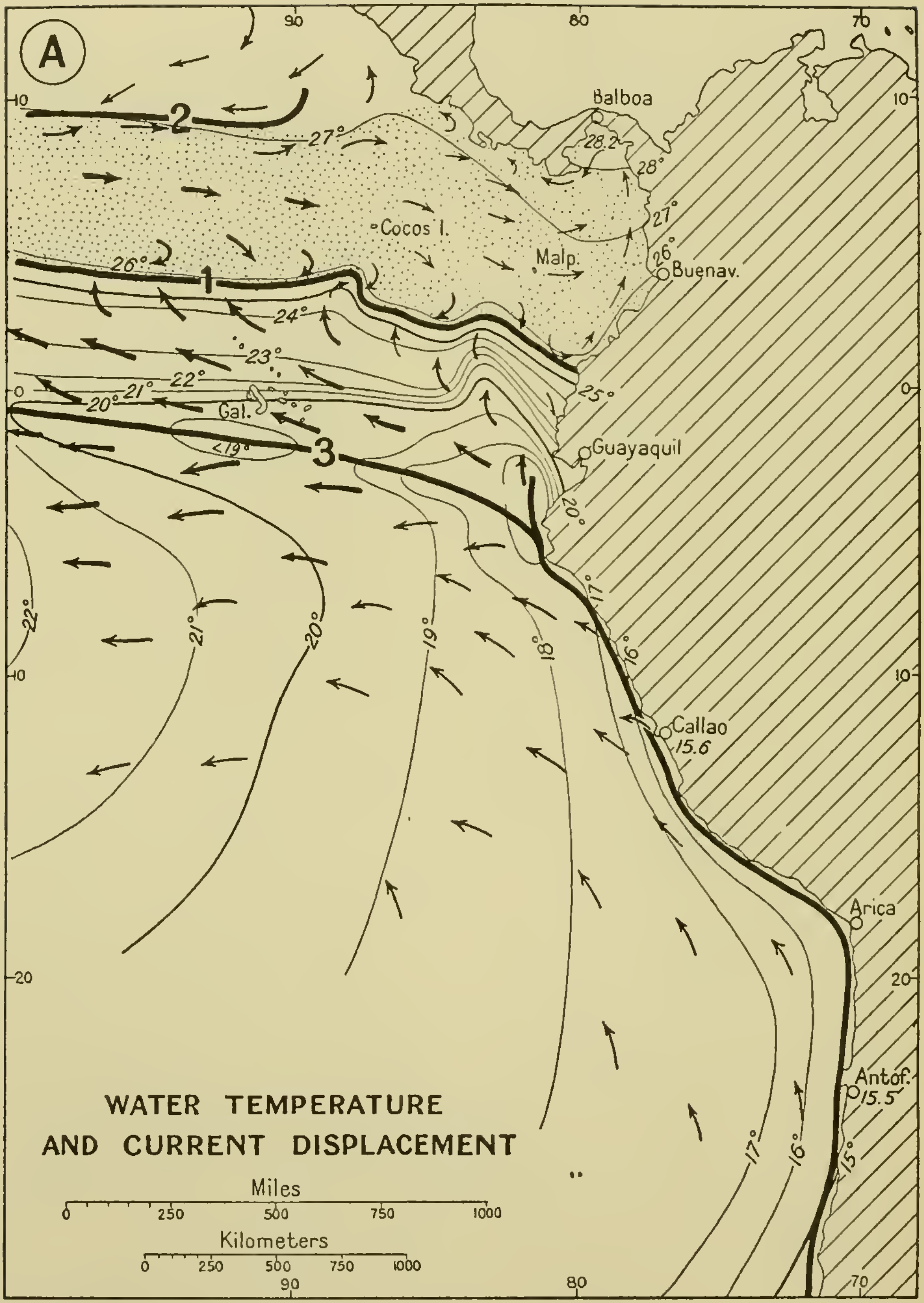


FIG. 12.

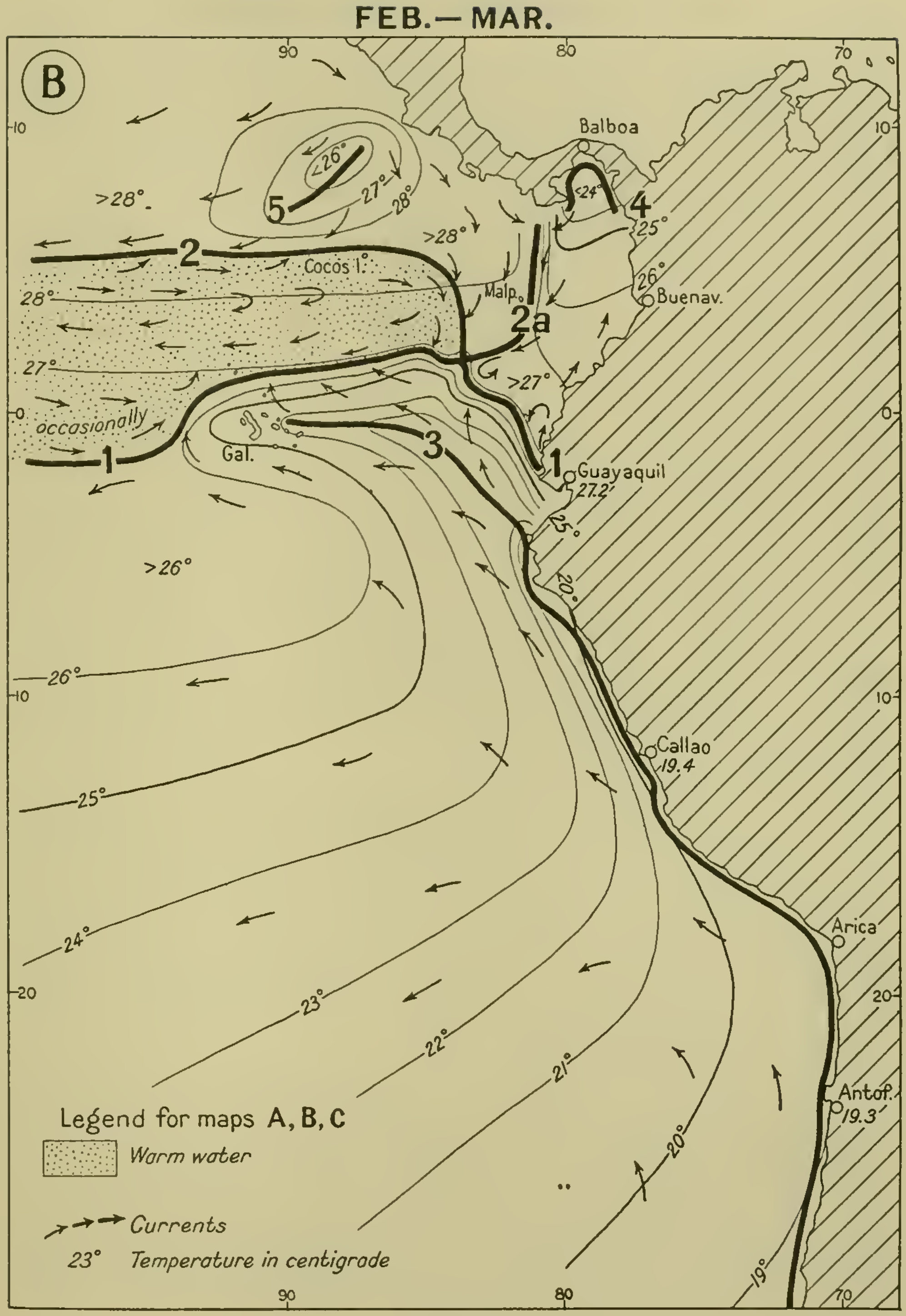

FEB.—MAR.
B
Balboa
Cocos I.
Malp.
Buenav.
Gal.
Guayaquil
27.2
Callao
19.4
Arica
Antof.
19.3
occasionally
Legend for maps A, B, C
Warm water
Currents
23° Temperature in centigrade

Fig. 13.

The distribution of salinity in the eastern tropical area of the Pacific during each northern winter is in itself an indication that the rare Niño phenomena merely represent an increase in intensity of conditions that prevail annually. Professor Schott marshals his data well for a fundamental explanation. He charts the normal stream axes and borders of the Humboldt and Equatorial Countercurrents for typical periods of August-September, February-March, and for March, 1891, the culmination of the next to the latest great disturbance. The oceanographic circumstances may then be seen to accord with the meteorological background for each period, as outlined above in the meteorological section, under a discussion of the shifting line of doldrums. Whenever the low-pressure belt is drawn south of its normal seasonal position, the southeast trades are replaced by rainy northerly to northwesterly winds, forcing warm surface water southward. A belt of lowest pressure, representing the meteorological equator, and reaching the mainland between 6° and 10° S., was a constant factor during the Niño advance of 1925. Higher pressures prevailed toward Panama, thus fulfilling the conditions for northwesterly rain-bearing winds in Peru. It is notable, (1) that the unusual rains always come when such winds occupy the ordinary range of the southeast trades; (2) that they coincide with periods of exceptional wind and rain on the continent; and (3) that the season is always between January and April.

The Niño of 1925 caused the disappearance of typical Humboldt Current phenomena as far south as Arica, Chile. During March alone the rainfall was ten times the total of the preceding ten years! The southward advance of the warm water was slow, but the return to normal was four times as fast, when the trade winds had resumed their course.

The dislocation of the meteorological equator, involving the shifting of the equatorial calm belt, with its cloudbursts, thunderstorms, and northerly monsoons, 300 to 500 kilometers southward, sufficiently indicates that the Niño results from a widespread atmospheric disturbance. Similar conditions along the west African coast, modified by the absence there of a high mountain system to deflect the trade winds, are referred to below and serve to give "Niño" a generic meaning in geography. Furthermore, the oscillations of the meteorological equator on the west coast of America have clear analogues in annual conditions during the synchronous northwest monsoon season in the Malay Archipelago and northern Australia.

Figs. 12, 13, and 14. Oceanic conditions off northwestern South America during normal periods of the southern-hemisphere winter season (map A) and summer season (map B), and at a period of exaggerated Niño phenomena, such as occurred in March, 1891 (map C).

The heavy lines numbered 1 and 2 mark confluences of warm waters (chiefly those of the Equatorial Countercurrent) with surface movements to northward and southward. Line 3 is the coolest axis of the Humboldt Current, characterized by active upwelling along the coast; 4 marks the zone of upwelling in the Gulf of Panama during the northeast trade wind season; 5 a zone of upwelling and current divergence contemporaneous with southward displacement of the Equatorial Countercurrent. The dotted line in map C denotes the approximate course of the meteorological equator at the time of the phenomena indicated.

After Schott (1931).

MAR. - Year of disturbance 1891

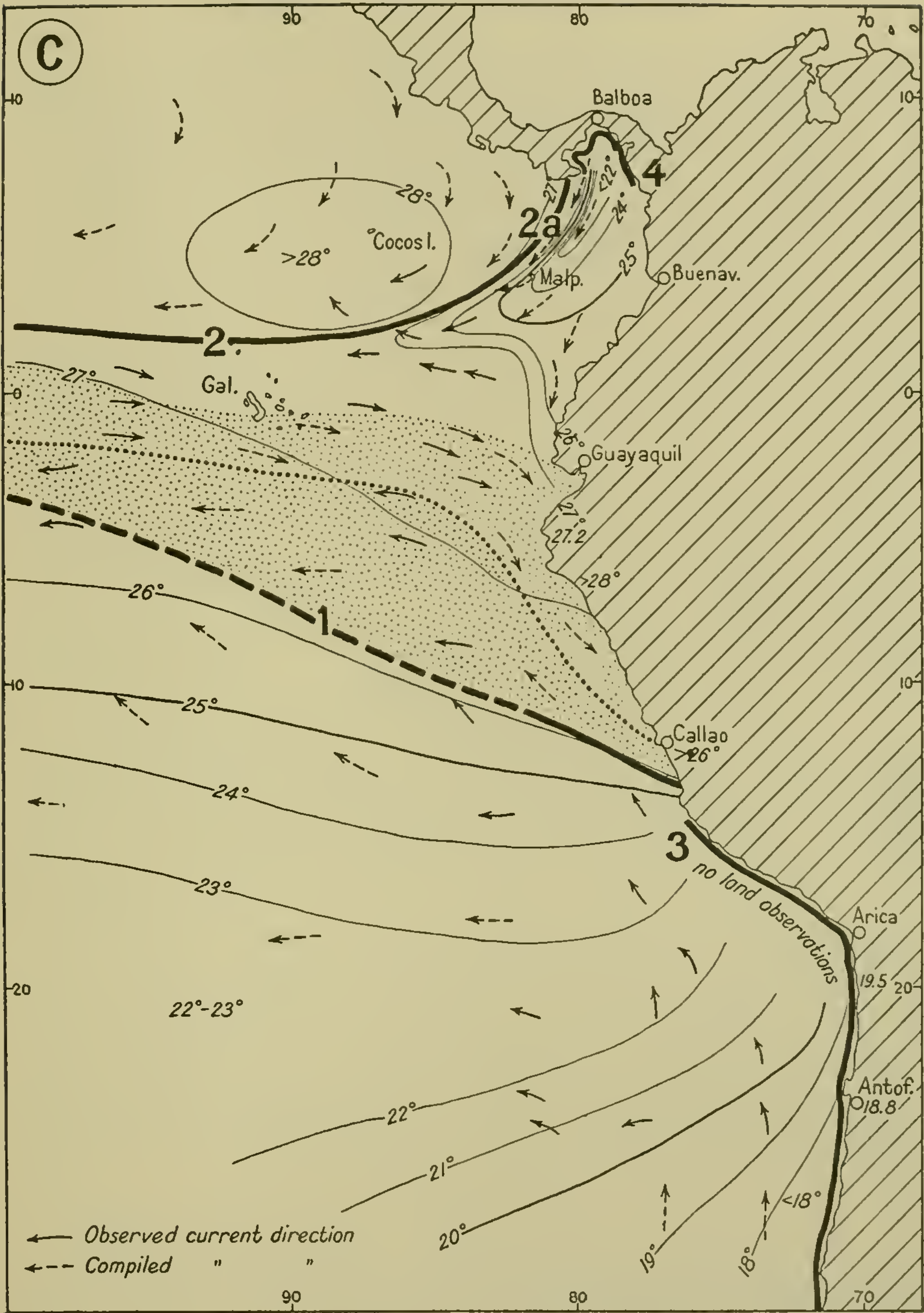


Fig. 14.

The significance of the long-term periodicity of these phenomena, which ultimately proceed from varying insolation, hardly comes within the scope of our study. However, Petterson (1929, 121) has pointed out that periods of excessive intrusions of antarctic ice into the southern oceans are always followed by derangement of what we call normal rainfall régimes in the southern continents. It has been estimated that an average of 30,000 cubic kilometers of ice float out of the Antarctic each year and, as Bowman (1930, 445) has said, variation of this on a colossal scale could not fail to have profound and far-reaching after-effects.

In the year 1922, according to Petterson, floes and bergs extended outward so far from the Antarctic that for safety's sake the southern trade routes had to be shifted northward. The outbursts of ice were succeeded after an appropriate lag by notable movements of tropical surface waters into the southern hemisphere.

The Humboldt-Niño conditions of 1925 were paralleled, for example, by a simultaneous deflection of the cool west African Benguela Current, permitting warm waters from the Gulf of Guinea to expand southward, and bringing torrential rains, corresponding with the inundations of arid western South America. Nyasaland and Rhodesia received the greatest rainfall experienced within European knowledge. At Mossamedes, latitude 15° 11′ S., perhaps the most arid station on the coast of west Africa, the rainfall in February, 1925, was more than double the highest record previously known for that month.

From a marine zoölogist's point of view, the advantages of such a time of geographic crisis are that they enable him to see, through the medium of a drama compressed within a single season, an epitome of the secular process which has been going on steadily if less violently throughout the ages. In the northern waters of the Humboldt Current, for example, he finds many animals beautifully adapted to a special and peculiar environment, and he can comprehend to some extent the selective action of this environment in molding the organism to a "fitness" which acquires ironic significance as soon as the environment itself alters. He cannot but be impressed also by the delicate balance of the controls over the environment. One might almost say that the huge and highly specialized aggregation of marine plants and animals in this region have but one danger to fear, namely warm water. Because of such reasons the oceanic bight bounded by northern Peru, the coast to northward, the Galápagos, Cocos and Malpelo Islands, offers one of the most fruitful fields for a study of the forces and inhibitions that determine the distribution of life in the sea.

(1) ZONELESS BIRDS

In a previous discussion of birds common to the Antarctic and Sub-Antarctic Zones of the South American region, reference has been made to the extraordinarily wide climatic scope in the breeding ranges of certain coastal and insular species (p. 76). Thus a tern (*Sterna vittata*), which appears to be a close but mainly sedentary relative of the Arctic Tern (*Sterna paradisaea*), nests in the

Antarctic Archipelago, at the South Orkneys, South Georgia, Gough Island, and Tristan da Cunha. The common allegation that it also inhabits St. Helena and Ascension proves to be erroneous. Nevertheless, the one species, no doubt represented by two or more subspecies, resides both at icebound islets of West Antarctica and at Tristan, the latter being at the extreme northerly edge of the Sub-Antarctic Zone. In this case water temperatures and zonal convergences seem to be thoroughly disregarded, although further taxonomic study may throw new light upon the subject.

Another tern (*Sterna hirundinacea*), which is much more satisfactorily known and which has not been subdivided, breeds at the Falklands and at Cape Horn, from these latitudes northward along the east coast of South America to the neighborhood of Cape Frio, Brazil, and on the west coast at least to central Peru. The widely accepted belief that it nests also at some of the antarctic islands proves, however, to be without foundation, and to be due to confusion of the species with *Sterna vittata*. *Sterna hirundinacea* is, in fact, confined to the continental littoral. It is typically sub-antarctic, and might appropriately have been listed above among the birds of that zone of surface water but for the fact that its range extends far into the so-called tropics because of the influence of cool currents and cool belts of upwelling. It is, therefore, not properly a "zoneless" bird, but is discussed here because of the length of its distribution across the parallels of latitude, and because of its undeserved reputation of being both an "antarctic" and a "tropical" sea bird.

The Kelp Gull (*Larus dominicanus*) is more notable. It nests at the South Shetlands, South Orkneys, South Georgia, in the Falkland-Magellanic district, northward to Rio de Janeiro, and to the Lobos Islands off northern Peru. One of its centers of maximum abundance as a breeding bird, indeed, is at Lobos de Tierra (6° 30′ S.), well over fifty degrees of latitude north of its polar nesting grounds.

Terns subsist upon both small fish and swimming crustaceans, which in one form or another must be available at all the breeding stations throughout the extensive ranges mentioned. The Kelp Gull has a broader taste in food, making use of carrion and offal, fish, shellfish and other beach invertebrates, as well as the eggs and young of many kinds of birds. In fact, its principal foci of population, whether in frozen or in torrid localities, are usually closely associated with colonies of weaker species upon which it preys. Even taking all these matters into consideration, such amplitude of range as that presented by the Kelp Gull is a distinctly oceanic phenomenon of distribution, without any equivalent in the northern or "continental" hemisphere.

Still more remarkable than any of the foregoing examples, is the case of an American cormorant (*Phalacrocorax olivaceus*). The specific range is both inland and coastal from Cape Horn to the southern United States, but the birds occurring north of Nicaragua have been separated as subspecies *mexicanus*, while a third race seems to inhabit Tierra del Fuego. The typical South American form disregards not only latitude and climate, but also altitude, water temperature and salinity, precipitation, the nature or presence of vegetational ground-cover, and almost every other obvious environmental factor. It lives and breeds along rocky, sandy, or muddy seacoasts. It is equally at home beside a glacier in southern Chile, on a barren rainless islet off Peru, among mangrove channels of the Caribbean coast, in the stump-filled lakes of Panama, on tepid rivers in the forested interior of the continent, or in lofty and frigid mountain lakes such as Titicaca and Junín. It is clear that this cormorant is superior to climate, in the ordinary sense, and that it could not possibly be fitted into any of the zones we have discussed. The probable explanation of its freedom from environmental control, aside from its patent toleration of a wide range of heat and cold, is that it feeds upon almost any sort of bottom-living fish, of which there is no dearth in either salt or fresh water of various latitudes, temperatures, and composition.

AN ORNITHOLOGICAL CIRCUMNAVIGATION OF SOUTH AMERICA

L'acqua ch'io prendo già mai non si corse.—Dante

The journey upon which we are embarking has never before been undertaken. I propose to skirt the continental coast line, with full disregard of distance, time, and circumstance. Neither weather nor current need retard us; no island of the surrounding seas shall be too remote for us to reach within a twinkling; moreover, we may view the successive prospects, as preference dictates, either through eyes of today or those of generations long departed. To describe the topography in detail would lead us too far afield. Let us in the main travel fast, halting only to picture a series of well-chosen localities along the ocean front, and at islands offshore. At each such station we may select the time of year best suited to our purpose of observing the bird life or the periodic natural phenomena concerned with the distribution of birds.

1. The Caribbean Coast

We may begin our survey of the South American coast at the Caribbean end of the boundary between Panama and Colombia (8° 41′ N.), where the promontory of Tiburón, the "Cape of Sharks," marks the northwestern extremity of the Gulf of Urabá. Southeastward as far as the low and relatively sheltered projection of the Atrato delta, the shore is high and bold, and a wild sea beats upon it during the windy season of the northern-hemisphere winter months, which is also the dry season. Inland and to southward, these same winds precipitate rain, but, as noted heretofore, coasts directly to leeward of strong trades are prevailingly dry.

Close to shore, along the western side of the gulf, are numerous steep islets, and, beyond the cliffs, the ridge of the Espíritu Santo range, rising to two thousand meters or more, can be seen clearly from the water. About the mouths of the River Atrato a foreshore has built out, and the high coast here gives way to sandy, mangrove-covered cays which line the whole head of the Gulf of Urabá, the almost fiord-like body of water extending southward from the broad bight of the Gulf of Darien. Along the western shore of the inner gulf

Fig. 15. Coasts of northern South America, the Caribbean region, and the Gulf of Mexico. In addition to the indicated courses of expeditions by Beck and Murphy, figures in circles show the location of other American Museum field work, as follows: 1, Thayer, at Grenada; 2, Tate, at Cumaná; 3, Chapman, at Trinidad.

For details of the Venezuelan coastal islands, see Fig. 16.

the Atrato pours forth through thirteen mouths. Flowing as it does from a basin of almost perpetual rainfall, it carries a tremendous quantity of water, despite its insignificant appearance on small-scale maps. Indeed, the pilot books of the South American coast credit it, though perhaps incorrectly, with being fourth in volume among the streams of a continent which is the mother of great rivers.

Eight mouths of the Atrato are navigable for small craft, such as native cargo sloops and the bongos or dugouts that are common to all forested coasts of northern South America. Delta deposits extend far into the gulf, and bars blocking the mouths show depths of two meters or less, a condition hardly alleviated by the tidal rise, which is very slight. Inside the delta, however, the river assumes impressive proportions, with soundings in the channels of from 10 to 20 meters, and a breadth sometimes exceeding a kilometer. Below Sucio, 100 kilometers from the mouths, there are no permanent habitations on the low banks, for the surrounding country is inundated during ten months of the year. The current of the river is swift, the overflow throughout widespread adjacent territory serving to relieve the head of flood-water that accumulates during the rainiest season.

The eastern shore of the Gulf of Urabá is flat and swampy, with muddy shallows for a long distance off. Toward the northerly end of this coast is a low sandy peninsula, with the large Águila Lagoon behind it, and still northward, protected by extensive shoals, Point Caribana marks the eastern gatepost.

As already observed, the months of calm in trade-wind regions are also the months of rain. In the northern springtime, when the northeast trade wind withdraws its distal fringe so that the Caribbean coasts of Colombia and Venezuela no longer submit to its influence, the rainy season commences, to continue until September or October. The amount of rainfall differs markedly within short distances along continuous coast lines and, in most localities of even heavy precipitation, there is usually a rhythmic concentration of rain during certain hours, leaving other parts of the day or night relatively clear.

The following description of weather conditions in the Gulf of Urabá is from the report of Michler, whose vessel remained in the gulf for four months including, however, only the beginning of the rainy season, during the earliest United States surveys for the project of a ship canal between the Atlantic and Pacific.

> The days and nights during this time were beautifully bright; in but few climes can the gaze rest upon the distant splendor of more perfectly glittering star-light skies. . . . The weather was usually clear. . . . It rained only once by day, though very slightly, and but once for a few moments after dark. So far from being the horrible climate represented by others, one of continuous storms, excessive heat, and miasmatic atmosphere, the veritable Pandora's box of all the malaria of the most feverish portions of the world, the atmosphere proved to be extremely delicious. It so continued during the entire stay of the *Varina* in the Gulf, from the first of December to the latter part of March, with the exception of two nights previous to weighing anchor, homeward bound. As if not to let her depart without a benefit, heavy rains, such as are only known in the tropics, fell for hours upon her decks, attended by most terrific peals of thunder. The play of lightning was so quick and intense as to vivify all surrounding nature. According to the most reliable information the rainy season along the Gulf extends from early in April to the latter part of November. The rains are not, however, by any means excessive even during this period, but occur chiefly in the shape of short, smart showers of from a few minutes to some hours duration, especially during the night, with occasional heavy and prolonged falls of one or two days. It is even by no means uncommon for intervals of from three to six days to elapse during the wet season without a day of rain. Subsequent experience of some months along the valley of the Atrato and San Juan proved that by far the greater portion of the rain of that region falls during the night (Michler, 1861, 28).

Such meteorological conditions are altogether typical of many coastal sections of northern tropical South America, whether they face the Caribbean, the Pacific, or the Atlantic. With the exception that the annual period of the rainy season would be different, the description from Michler might be equally well applied to weather in the Gulf of Guayaquil or in the estuary of the Amazon.

As with climate, so largely with the plant life of the shore, as well as with the bulk of the beach and marsh birds. From northernmost Peru around the northern edge of the continent to the Amazon or beyond, the plan for both coastal vegetation and coastal bird life is a common one, more or less modified by local influences. For the most part, the same herons, ibises, storks, spoonbills, and anhingas roost among the same species of mangrove and couridá, while overhead soar the same forms of the Black and Turkey Vultures. The same resident or migrant Limicolae patter along the wash of the waves or wade in the shallow lagoons; the same terns and skimmers quarter the brown estuaries; the same cormorants, pelicans, boobies, and man-o'-war birds pursue schooling fish to varying distances offshore. There are, of course, changes and exceptions. Here a familiar species will be squeezed out by some inhibitory influence of the environment; there a new intrusion may appear; again, the range of a certain bird may end as the form becomes replaced by a representative subspecies or species. But, in the main, the avifauna of the tropical coasts is a common one, with a continental, rather than an oceanic, element predominating. The boobies and man-o'-war birds and, to a lesser extent the terns and pelicans, reach the shores from outlying islets; to find the source of the tropic-birds and the few petrels that visit such coasts, we should have to go still farther afield.

With reference to coastal birds, and factors determining their distribution in the Santa Marta district, Todd and Carriker (1922, 67) write the following, which has a bearing upon what I have said of the tropical water birds in general:

> The Littoral is characterized by the great diversity of habitats within its limits, each of which has its peculiar species of birds. (There are some forms, however, which are present in nearly all situations.) . . . As already explained, this diversity of conditions is due in the main to the topography of the region, differences in the relative humidity, etc. . . .
>
> Beginning in the west, we have the mangrove-lined shores and waterways of the Ciénaga Grande and Magdalena delta, inhabited by many species of aquatic birds, some of which are rare or absent elsewhere in this general region. . . . Most of the water birds . . . have a more or less extended distribution in tropical America, and their presence depends mainly upon suitable habitat and local conditions, not upon zone.

Rainfall, as an example of such local factors, varies through very wide extremes along the section of the South American coast under consideration in this chapter. The head of the Gulf of Urabá lies within the same climatic district that rules the Pacific coast of Colombia, with an annual precipitation of over 2000 millimeters. But along the Caribbean coast, stretching in a northeasterly direction from the gulf, less and less rain is received toward the tip of the Goajira Peninsula, except in a narrow seaward-facing strip between the Sierra de Santa Marta and the sea. The remainder of this stretch lies in a mountain "rain-shadow," a familiar phenomenon on many restricted parts of the South American shore line. Beyond the Santa Marta range, in Goajiros, rainfall rapidly gives out. The isohyet of 500 millimeters encloses a broad belt of arid coastal country on both sides of the Gulf of Venezuela, including the whole of the peninsulas of Goajira and Paraguana. To eastward of Puerto Cabello, on the Gulf of Triste, the line runs alongshore, close to the Caribbean, as far as the Gulf of Cariaco. Both Margarita Island and the lower parts of the Paria Peninsula thus lie in the zone of prevailing aridity which, as Dr. Frank M. Chapman tells me, ends on Monos Islet, in the Bocas de Dragos, without quite reaching the island of Trinidad.

Moreover, the composition of the Caribbean coastal water varies considerably, owing to the direction of surface movements in combination with the increment from great rivers and the strength of the trade wind. From the Gulf of Urabá to the delta of the River Magdalena the coastwise current sets chiefly in a northerly or northeasterly direction. The region is "around the corner" from the general westward-setting movement of the open Caribbean, and the local flow is doubtless part of the countercurrent system that runs in a southerly direction along the Central American coast and loops to eastward in the Gulf of Darien. Off the mouth of the Magdalena, and the coast of eastern Colombia, the main Caribbean or equatorial current is in evidence. A rip or race often forms where the outpouring river water and the ocean current come into contact, an effect which has been observed as far as a hundred kilometers to northward of the delta. Here the water is bluer than in the eastern Caribbean, and sometimes long rows of floating seaweed, teeming with animal life, mark the lines between deep ocean water and the freshets from the land (Paul, 1932, 142).

The Atlantic Equatorial Current enters the Caribbean between Trinidad and the southerly islands of the Lesser Antillean chain, its strength being greatest in the strait between Trinidad and Grenada. Part of its influence is also apparent, as will be noted later, in the narrow openings into the Gulf of Paria, between Trinidad and the Venezuelan mainland. Inside the Caribbean, the current sweeps mainly north of the Venezuelan coastal islands, but, during periods of strong trades, surface tongues flow southward between these islands and form eddies along the continental coast. In the extreme southwest part of the Caribbean Sea the Equatorial Current can never be apparent, although the trade wind sometimes blows its clear and saline surface water into the Gulf of Darien. This wind, and the "vendavales" or westerly land winds of the region, together with the local movements of the surface for which they are responsible, occasionally bring about a concentration of driftwood, from many rivers and from various shores of the Spanish Main, in the constricted Gulf of Urabá.

The mighty Magdalena is the second of the great trio of rivers on the northern slope of the continent, the Orinoco being the third. The Magdalena enters the Caribbean through one gigantic main mouth, but many other exits also cut through the mangrove-covered flats along an extensive stretch of shore line. The distance between the most easterly mouth, the Boca de la Ciénaga, which flows northward into the Caribbean, and the westward-opening Boca de Matuna, south of Cartagena, is about 160 kilometers as the crow flies. Along part of the distance between these, a line of low coastal hills has forced the drainage to take several courses toward the sea.

The upper delta of the Magdalena, the area now occupied by the Ciénaga Grande, together with the network of lagoons between it and the river, was within recent geological time an arm of the Caribbean, like the present basin of Lake Maracaibo. It is evident also that this area, as well as the littoral to eastward, has been uplifted at no very remote period. The steady supply of sediment carried down by the Magdalena and the rivers from the westward slopes of the Sierra Nevada are gradually filling up the brackish Ciénaga Grande. Mangroves have secured a foothold on all sides so that there are now hundreds of square kilometers of mangrove swamps, interspersed with endless waterways that afford food and cover to myriads of aquatic birds (Todd and Carriker, 1922, 16).

The shallow bars that make the mouths of the Magdalena impassable to large vessels are covered by deeper water during the dry season than the wet, because of the vast load of silt deposited throughout the latter period. In freshets the current of the main stream may run as fast as 11 kilometers per hour. A rolling and treacherous sea is rarely lacking on the outer bar. Much driftwood, including large treet runks, is transported by this route into the Caribbean.

From the Gulf of Urabá to the "rain-shadow" strip east of the mouth of the Magdalena, most of the islets off the shore are wooded, some of them showing groves of royal palms surrounded by other vegetation. But eastward from the Goajira Peninsula and the Coro region of Venezuela the entire coast line, as well as the outlying chain of islands, has a generally parched appearance as far as the heights of the Paria Peninsula and Trinidad. Just east of the Magdalena delta, the magnificent snow-capped Santa Marta Mountains, with their highest peaks nearly always above the clouds, are visible from sea. They are, of course, responsible for the greater precipitation and increased luxuriance of the foreshore between Cape Aguja and Point Caricari. Wollaston, *en route* for the Sierra, journied westward from Río Hacha to Dibulla. He writes:

> Riding along the beach is not so simple as it sounds. The rise and fall of the tide is a few feet only, and the beach is a narrow strip of soft sand with the heavy surf of the Caribbean Sea on one hand and mangrove swamps or muddy lagoons on the other. In many places stranded logs or long projecting mangrove branches make a fence across the sand and compel the reluctant mules to take to the Caribbean Sea (Wollaston, 1925, 97).

Turning southward west of Dibulla toward the mountains, Wollaston's party encountered first a tract of grass and thorny bush, interspersed with swamps, where gigantic horseflies and other insects made travel almost intolerable until the coolness of the wooded foothills was gained.

The territory on either side of the Gulf of Venezuela, or Maracaibo (the northern tip of South America), is the driest coastal region on the whole northerly face of the continent. Inland, on the shores of Lake Maracaibo, and nearer the sea on the coast to eastward of the Gulf of Triste, the precipitation is by no means scanty but, as noted above, the peninsulas of Goajira and Paraguana receive less than 500 millimeters of rainfall annually, while the Coro region, at the base of the Paraguana Peninsula, has not more than 250 millimeters. The outer gulf, and the inner, land-locked Lake of Maracaibo, therefore coincide with a north-south section extending from districts of extreme aridity to those of ample rainfall. The water of the so-called lake varies from a brackish solution, near its narrow and shallow connection with the gulf, to water completely fresh toward its inner end. The region should offer a field of particular interest for a study of water birds, but apparently little ornithological work has been undertaken or, at any rate, reported upon.

Platt (1934, 157) describes the Maracaibo Basin as seen with the mind's eye from an airplane in which he had flown eastward from Colombia across the Sierra de Perijá. From the air the whole bowl-like formation seems perceptible —the nearly encircling rim of mountains, the belt of lowlands, and the central body of water. Dense forest on the slopes, broken only by streams, gives way at low levels to scrub woods, spotted with clearings which are increasingly numerous toward rhe lake. These openings indicate "haticos" or little ranches, each with an area partly cleared, a patch of cultivation, a small house, and a water-hole. The district has aspects of semi-aridity consistent with an annual rainfall of about 508 millimeters, falling during a season of seven months, average temperature of over 27° C. for every month, and rapid drainage through the sandy soils of partially consolidated coastal plain sediments. This combination does not necessarily mean desolation. Mistletoe is as plentiful as cactus, and live animals are more in evidence than dead ones. The principal marketable products of such districts are goatskins and dividivi, the latter being pods of the prevalent leguminous tree of the area, valuable for their content of tannic acid.

At Sanra Rosa, an ancient lake village on the neck of water joining Lake Maracaibo with the Gulf of Venezuela, continues Platt, goats and dividivi are almost if not quite supplanred by fish and coconuts. Here the lake water is brackish, and fresh warer is to be obtained only at some distance inland from holes dug in sand. But rhe distinctive form of settlement, wirh dwellings on piles, such as originally gave the name of Venezuela, or Little Venice, to the country, is one befitting local circumstances here where the shore is low, partly swampy, and covered with a tropical tangle ordinarily called jungle. The water of the lake and strait are calm and shallow, and simple pile construction provides a more healthful home on water than could be established on land, with relative security from insect and other enemies.

On the eastern shore of Lake Maracaibo, as about Lagunillos, a sinking of the land and the margins of the lake bottom, attributed to the recent extraction of petroleum, is causing rapid flooding of large areas.

The topography of the floor of the sea north of Venezuela conforms more or less with that of the mainland. Parallel with the coastal cordillera is the submerged ridge upon which the Leeward Islands lie. That these fully share the coastal aridity is evidenced by the following figures on total annual rainfall, from Franze:

	Average	Maximum	Minimum
Aruba	438	942	85
Curaçao	559	1105	265
Bonaire	440	870	164
Margarita	245		

The even greater dryness of the continental shore line is shown by the annual mean precipitation for Coro, given above, that for La Guaira (283 millimeters) and for Cumaná (258 millimeters). The bulk of the rainfall on both mainland and islands comes between the monrhs of October and January, the dry season of northeast trades commencing during the latter month and continuing until July. While many of the above means are based upon figures covering only a few years, they agree well wirh comparable records for periods of thirty years or more.

During the wet season on the Caribbean coast, the country adjacent to the sea is often foggy in early morning, but by sunrise the land breeze (terral) begins, blowing sometimes very strongly through the forenoon. The afternoons are apt to be calm and fair, although a haze, said by the pilot books to resemble the west African harmattan (but nowise akin to it), overhangs the coast much of the time.

The seasonal retraction and extension of the trade-wind border are due, of course, to the swing of the belt of greatest insolation toward and then away from the tropic of Cancer. Toward the end of the northern summer, the region of transient calms and rainfall is gradually reinvaded. From October to April the trade wind blows throughout the day on the shores of Venezuela, to be interrupted nightly by the terral, which is as characteristic of evening during the windy season as it is of morning during the calm season. At the larger islands off the coast there is likewise an alternating régime of land and sea breezes, the nocturnal wind blowing most strongly on the coast which is in the lee of the trades, in other words, where the terral is reinforced by the trade wind.

To westward of the Goajira Peninsula, the trade winds are exceedingly strong, sometimes amounting to gales. The Spanish sailors of early days called these impetuous trades, which differed so markedly from the gentler and more constant winds of the open oceans, "los brisotes de Santa Marta" (von Humboldt, 1852, 1, 127). During the windiest period (January to April), the source of the breeze on this westerly-facing coast lies generally in the *west* in early morning, later veering through northwest and north, and by noon blowing parallel with the shore line. Such "following of the sun" is a tendency of all regular breezes like the trade winds, which should by no means be thought of as keeping a steady northeasterly course at all localities and during all seasons. The trade winds are readily deflected by the meteorological system of a continental coast, and as a rule they tend to blow perpendicularly toward the shore when the latter is in the direction of the sun.

The same principle applies to the annual as well as to the daily cycle, and many correlations can be observed in the West Indies. For example, winds from north of east prevail from November to March; April and May, the most tranquil months of the year, are characterized by easterly breezes; winds from south of east prevail from June to October. The latter part of the summer is a time of feeble trade winds, leading to the hurricane months of August, September and October.

As explained heretofore, no part of the continent of South America lies within the path of hurricanes, although these storms frequently sweep through the length of the Caribbean, parallel with the Venezuelan coast, spreading devastation from the Lesser Antilles to Yucatán. The South American mainland, however, as well as Trinidad and the chain of coastal islands, is all but free from their direct effects. Much further information is needed about the "ornithology" of Caribbean hurricanes, particularly with regard to the boobies, frigate-birds, flamingoes, song birds, etc., sometimes vaguely reported by newspapers as being seen buffeted about near a ship in the vortex.

In the central part of the Venezuelan coast, near Puerto Cabello on the Gulf of Triste, the mountains turn northward toward the sea. Thence eastward the range hugs the shore, and at many places toward Point Peñas on the Paria Peninsula or, indeed, quite to the northeastern tip of Trinidad, the waves of the Caribbean break against the foot of the mountains themselves. The green aspect of the heights is due to constant precipitation which does not affect the aridity of the lowlands except where streams descend through forested ravines to sea level. Between La Guaira and the Gulf of Cariaco much of the immediate shore is low and dry (save for mangrove swamps). Of this district, which is reminiscent of the coast of Peru, Robinson and Lyon (1902, 136) write:

This northern coast of Venezuela is noted for its heat. The tropical sun beats upon it without mercy, and where water fails the aspect of the country is that of a desert. The littoral plain near La Guaira, where not watered by the *acequias*, or irrigation trenches, which bring the water from high up on the courses of the mountain streams, is parched and dusty, and given over to Agaves, Cacti of various kinds (*Opuntia*, *Cereus*, *Melocactus*), and to a sagebrush-like plant (*Lantana*) of characteristic odor. But wherever water can be obtained the plain assumes a most fertile and flourishing character. Such is the condition at Macuto, three miles east of La Guaira. Still farther to the east, some seven miles from La Guaira, a large stream comes down a fair-sized valley. Before debouching upon the plain, its water is all carried off to the right and left by the *acequias*, and used to operate sugar mills and afterwards to irrigate wide fields of cane.

Close to shore in this broad bight of the coast are eleven small islands, comprising two clusters, which were passed and described by von Humboldt and Bonpland during a voyage from Cumaná to Caracas at the end of the eighteenth century. They write:

We found ourselves at midnight between some barren and rocky islands, which uprise like bastions in the middle of the sea, and form the group of the Caracas and Chimanas. The moon was above the horizon, and lighted up these cleft rocks which are bare of vegetation and of fantastic aspect. The sea here forms a sort of bay, a slight inward curve of the land between Cumaná and Cape Codera. The islets of Picua, Picuita, Caracas, and Boracha, appear like fragments of the ancient coast, which stretches from Bordones in the same direction east and west. . . . Several of the islands are visible at Cumaná, from the terraces of the houses, and they produce, according to the superposition of layers of air more or less heated, the most singular effects of suspension and mirage. . . .

As we came near this group of mountainous islands, we were becalmed; and at sunrise, small currents drifted us toward Boracha, the largest of them. As the rocks rise nearly perpendicular, the shore is abrupt; and in a subsequent voyage I saw frigates at anchor almost touching the land. The temperature of the atmosphere became sensibly higher whilst we were sailing among the islands of this little archipelago. The rocks, heated during the day, throw out at night, by radiation, a part of the heat absorbed. As the sun arose on the horizon, the rugged mountains projected their vast shadows on the surface of the ocean. The flamingoes began to fish in places where they found in a creek calcareous rocks bordered by a narrow beach. All of these islands are now entirely uninhabited; but upon one of the Caracas are found wild goats of large size, brown, and extremely swift (von Humboldt, 1852, 365).

Of the Gulf of Cariaco, and the country on either side of it, Lowe (1909, 305, 321) writes:

To one steaming up the Gulf of Cariaco nothing indeed could be much more striking than the strange contrast which is exhibited on the one hand by the Peninsula, with its arid, desolate, and schistose rocks only scantily clothed with cactus and mimosa scrub, and on the other by range after range of tall mountains, luxuriantly forest-clad, which mark the Secondary limestone formations of the mainland. . . .

Once inside, the voyager finds himself on an irregular sheet of deep still water of the deepest blue, studded here and there with small islets. Surrounding it on all sides, in the fashion of a Scotch loch, are high hills. They present a series of colours which vary from rich deep red to deep yellow-ochre. In the distance the iron-tinted soil seems in places to be frosted with old silver, an effect produced by the patches of silvery-toned cactus-scrub. Along the shores, stretches of bright golden sand alternate with the deep green of the mangrove-belts. Here and there on the lower slopes patches of acacia-trees and the candelabra-like inflorescence of the agaves relieve the more sober tones of the cactus-scrub.

When von Humboldt embarked at the town of Cariaco, in late September, 1799, for a boat journey to Cumaná, he encountered a morning torrent of rain, accompanied by lightning and heavy thunder. "Swarms of flamingoes, egrets, and cormorants," he wrote (1852, 289), "filled the air, seeking the shore, whilst the alcatrás, a large species of pelican, alone continued peaceably to fish in the middle of the gulf."

The mountain ridge forming both the Paria Peninsula and the backbone of Trinidad, against which the full strength of trade wind surf beats, is breached by the Bocas de Dragos. Issuing here into the Caribbean is a powerful current made up of Orinoco waters combined with that part of the equatorial ocean stream that has found a way through the funnel of the Serpent's Mouth into the Gulf of Paria. The tidal range in the gulf is greater than in adjacent parts of the coast, and during the rainy season the outflowing current, augmented by an ebbing tide, sometimes attains a velocity of about 10 kilometers per hour. The difficulties of the islet-studded passage were commemorated by Columbus in the name which it still bears ('Dragon's Mouths'), but with the advent of steamers the term has lost some of its old significance.

Here, at the extreme eastern end of the Caribbean coast, there begins to be a more copious rainfall at sea level than is found in northern Colombia and Venezuela. .The northeast trade wind season holds from November to May, the wet season during the remainder of the year, with the heaviest precipitation in July and August. At Trinidad, May is the warmest month of the year, with a mean temperature of 33.5° C., and February the coolest, with 19.4° C.

The occasional remarks made on the Caribbean mainland water birds and shore birds, in this chapter, may be concluded with a brief record of Mr. G. H. H. Tate's observations at Cumaná, Venezuela. Between May 16 and 24, 1925, after an American Museum expedition to Mt. Turumiquire, Tate made headquarters at the port of Cumaná, which is separated from the main town by a stretch of sandy, salt-encrusted plain.

One morning he set forth long before dawn in a rowboat, with the object of reaching some extensive growths of swamp vegetation to eastward of the port by the hour that the marsh birds would leave their roosting places for the feeding grounds. Approaching mangrove-covered Punta Erga just after daybreak, he could see the pale pinkish glow of a flock of Roseate Spoonbills in the earliest rays of the sun, together with a scattering of egrets and several other sorts of herons. Vast numbers of plovers and sandpipers were feeding on expanses of mud flats left bare by the tide. Flocks of skimmers were already coursing up and down the channels. Toward solid land, a wall of taller mangrove trees evidently served as a nightly roosting place for more herons and for hundreds of cormorants. As Tate stepped out of his boat, to wade shoreward through alternating stretches of mud and shallow water, groups of gorgeous Scarlet Ibises flew out of the low mangrove thickets and circled around the visitors before disappearing behind the trees.

Mr. Tate collected in the territory close to Cumaná about twenty-five species of water and shore birds. The Limicolae naturally included many migrants, presumably bound toward North America, such as phalaropes, turnstones, curlews, stilts, willets, knots, plovers and sandpipers, in addition to such resident forms as the tropical American Oyster-catcher. Local birds belonging to a more distinctly salt-water aggregation included the Brown Pelican, Man-o'-war Bird, Least Tern, and the estuarine Large-billed Tern (*Phaetusa*). He noted that birds of the last-named species often circled at night around the powerful electric light on the pier of the port. The Bigüá Cormorant occurred, as might be expected, in every sort of damp habitat—fresh, brackish, and salt, forested or exposed.

Such birds as those listed are substantially what one would expect to see in suitable places along the entire length of the Caribbean mainland shore, from Trinidad to Panama. The Man-o'-war Bird is the only one that might not normally penetrate far into fresh-water districts, such as the Lake of Maracaibo. However, the presence of a fortuitous source of food, such as a slaughterhouse on the shore, or a place where fish are gutted in large quantity, is sufficient to draw Man-o'-war Birds from their usual salt-water foraging grounds a long distance up inland waterways, including even forested rivers.

Strictly marine birds, like boobies, can be observed from the mainland shore only in the straits between the continent and their nesting islands. To westward of the Goajira Peninsula, and particularly along the jungle-bordered coasts of the Gulf of Darien, oceanic birds of all sorts are scarce. The ubiquitous cormorant is present, however, not only in the flats and swamps of Urabá, but even along the Stygian course of the Atrato. According to Todd and Carriker (1922, 131), the Brown Pelicans probably nest on some of the remote insular beaches between the mouth of the Magdalena and the town of San Juan de Ciénaga, Colombia.

Turning now to the chain of Caribbean islands, which are the main center for the oceanic fowl of this littoral region, it must be pointed out that the conditions for bird life have naturally altered enormously during several centuries of European occupancy or interference. Even on the islets that have never been the permanent home of men, the introduction of new plants and of domestic animals has changed the pristine state to an extent hard to conceive. The present appearance of some of these islands would no doubt put them beyond the recognition of one who had known them only in primitive times. The changes referred to include many phases of human activity, from the removal

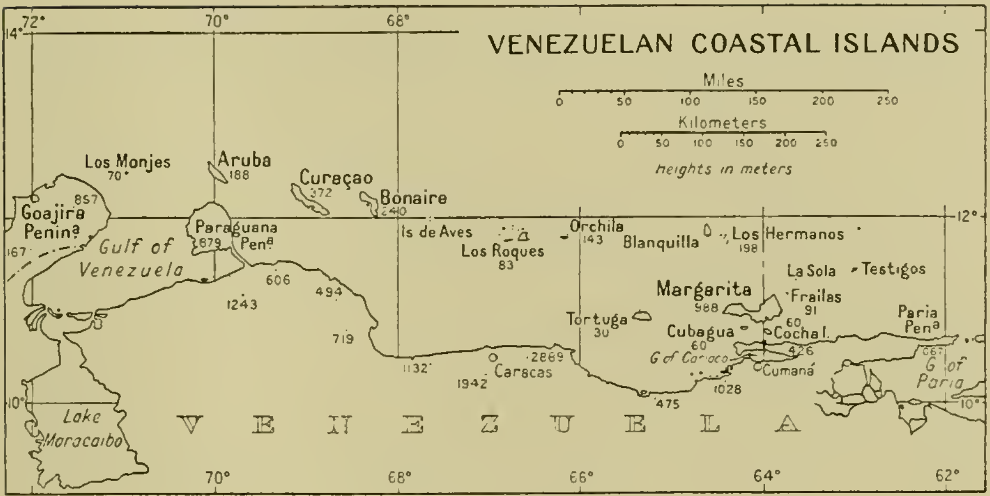


FIG. 16.

of old guano beds from such sites as Little Curaçao and El Roque to the establishment of ostrich farms on Aruba!

The larger and higher islands epitomize the opposite mainland coast, with xerophytic plant life and semi-desert types of birds near sea level, and tropical rain forest, with a correlated avifauna, near the summits. The rainfall in high altitudes is to be associated with adiabatic cooling of the sea winds, exactly as on the continent. Mountain torrents are numerous, combining to form streams that reach the sea, at least during the rainy season. Margarita, the largest member of the chain, is thus described, with its land birds, by Clark (1902, 259):

> The island has three well defined life zones; first, the flat and hot coast region, sandy, and with scant vegetation, consisting of post and melon cacti, with the dreaded 'tuña' and thorn-trees. This extends all around the island, and occupies a strip averaging about three miles in width, in which the Burrowing Owl (*Speotyto*) is exclusively found, while the Troupial (*Icterus*), Scaled Dove (*Scardafella*), Buzzard (*Buteo*), and Parrakeet (*Conurus*) prefer it to any other region. The chief towns of the island, Asunción, Juangriego, and Porlamar, are situated here. Next comes the intermediate region, of rough, hilly country, with a large amount of scrubby growth, and many varieties of cactus, forming the home of the Tawny Cuckoo (*Diplopterus*), the Spinetail (*Synallaxis*), and the Honey Creeper (*Coereba*). The interior of the eastern part of the island is a heavily wooded mountain, with its summit 3240 feet above the sea level, and always hidden by clouds. Here occur such forms as the Yellow-billed Thrush (*Platycichla*), Manakin (*Chiroxiphia*), Guan (*Ortalis*) and Parrot (*Amazona*).
>
> Some birds, such as the Creeper (*Dendroplex*) and the Antshrike (*Thamnophilus*), occur everywhere.

The three westernmost islands, namely Aruba, Curaçao, and Bonaire, have a small proportion of purely West Indian forms among their birds, in addition to the larger continental element (Hartert, 1893, 308). Margarita, however, which is much nearer the Lesser Antilles, has, according to Richmond and Robinson (1895, 653), an avifauna wholly derived from Venezuela, 27 kilometers distant.

The islands closest to the coast have the largest variety of water birds.

Thus the islets and reefs of Aruba, the driest of the three Dutch islands off Venezuela, harbor such species as *Larus atricilla*, *Phaetusa simplex*, *Thalasseus maximus*, *Thalasseus eurygnatha*, *Sterna hirundo*, *Sterna dougalli*, *Sterna albifrons antillarum*, *Sterna fuscata*, *Sterna anaethetus*, *Phalacrocorax olivaceus*, *Pelecanus occidentalis*, *Fregata magnificens*, and *Phoenicopterus ruber*. Margarita shares many of these, and has also the skimmer (*Rynchops nigra*).

It will be noted that practically all of the above are species that also frequent the bights, beaches, coves, and lagoons of the continental shore. No one of them, except the Sooty Tern, is a cosmopolitan, blue-water type of bird. Most of them are of the American tropical and sub-tropical coastal assemblage, to which an island is preferable to a continental breeding and feeding ground solely because of its relative safety. Doubtless flocks of flamingoes, for example, were once as familiar on the Caribbean flats of Venezuela as they have since been on the "salt-pans" of Bonaire (Hartert, 1893, 335). Certainly pelicans prefer to nest as close to the mainland as possible. One of their largest colonies within the region is among the mangroves of Tortuga Island, which lies on the broad shallows of the coastal shelf, while the distant outlying groups, such as Islas de Aves and Los Hermanos, are without pelicans (Cory, 1909, 252).

It is at such islets as the last named, together with the Roques cluster, that we find the stronghold of the oceanic birds *par excellence*. They are mostly small, scattered cays, though some are relatively high, and some are of sufficient size to enclose lagoons around which thrives a variety of low, halophytic vegetation. Certain of the islets at which boobies nest in greatest numbers, such as Orquilla of the Hermanos, are covered with granite boulders interspersed with dense growths of tall cacti which render human penetration exceedingly difficult. Lowe (1909, 312) thus describes the main island of the Testigos, which lie on the line between Margarita and Grenada:

> Testigo Grande is of greater extent than is given in the sailing directions. We put its length at from three to three and a half miles, but its shape is very irregular, and in the short time at our disposal we had no opportunity of taking more accurate measurements. Its greatest height is (roughly) 400 to 500 feet.
>
> Scattered round it are other smaller islands or rocky fallarones [= farallones]. The group is periodically inhabited by fishermen, who go there from January to April, but we were informed that one family now lived there all the year.
>
> Testigo Grande is thickly wooded and covered with very varied vegetation, in spite of the waterless condition in which we found it. Many of the trees attain quite respectable proportions, and there seemed to me to be an unusual variety. Besides many that were unknown to me, I noticed Logwood, West-Indian "Birch," Guaiacum, Acacia, Tamarind, and Manchineel. Various kinds of Cactus grow on the lower slopes and on the smaller islets, and there is a great profusion of flowering bushes and even flowering plants. Wild cotton grows in abundance. Except for the few miserable huts erected by the fishermen, and a modest plot or so of cultivated ground in their immediate vicinity, these islands remain as they have existed through the ages. Geologically they consist of masses of a coarse-grained granite (hornblende), enormous fragments of which, much weathered, may be seen here and there amid the surrounding vegetation. On the weather side of one of the smaller islets this granite is overlaid by a layer of shaly rock. The general colour of the soil and exposed rocks in the lower parts of the island is deep ferruginous. I was much struck by the number of butterflies that we saw. Progress anywhere on the large island is laborious, owing to the thick bush and the excessive heat.

Localities of this sort are no doubt the least changed of the sea bird breeding stations in the Caribbean, and yet the ravages of goats and other introduced creatures may still have had an important unperceived effect.

Most of these islands experience a concentrated, moderately heavy rainfall during the northern-hemisphere summer season, but they endure a long parched period afterwards. The breeding time of the majority of the sea birds seems to rise to a peak shortly after the end of the rainy season. Thus boobies of three species, man-o'-war birds, and tropic-birds are nesting in great numbers at Orquilla during January (Lowe, 1909, 324; 1911, 205). Noddies and Sooty Terns, which are evidently migratory, come to the island for the same purpose during February (Cory, 1909, 226). But the boobies, at least, breed during later months of the year as well, and it is likely that the nesting season for the population of any one species is protracted, if not practically continuous. At any rate, the offshore water of the Equatorial Current is of a character that suits the requirements of the boobies and certain other species throughout the year. It probably rarely or never falls below a temperature of 25° C., and it supports an abundance of the pelagic flying fish and cephalopods which are important, respectively, for the Blue-faced Booby (*Sula dactylatra*) and the Red-billed Tropic-bird (*Phaëthon aethereus*). These two species, as well as the Sooty Tern and the Noddy, cling mostly to waters beyond the coastal shelf. The Brown and the Red-footed Boobies, on the other hand, may in part follow the pelicans, man-o'-war birds, cormorants, and such species of terns as possess shore proclivities, toward yellower waters close to the continental beaches. Alexander von Humboldt (1852, 333) writes of "the bank abounding with fish, which surrounds the islands of Coche, Margarita, Sola, and Testigos; a bank of more than four hundred square leagues, extending east and west from Maniquarez to the Boca del Draco." Clark (1902, 260) states that both of the lesser boobies occur along the coast from Trinidad to La Guaira, and that the Brown species is as abundant in fishing grounds of the channel inside Margarita Island as it is around the islets farther from shore.

At Aruba, Hartert (1893, 308) found Least, Roseate, and Bridled Terns all laying eggs during June, which would be after the close of the verano, or dry and windy season, and at the beginning of the rains.

Petrels seem to be missing from the resident sea bird fauna of the Venezuelan islands. Audubon's Shearwater nests as close to the region as Barbados and the Grenadines, but has yet to be recorded from the Venezuelan coast or islands. Wilson's Petrels, however, enter this part of the Caribbean on their migrations, and Clark (1902, 260) reports a flock of a score or more, between Margarita and the mainland, on July 2.

Belcher and Smooker (1934, 572; 1935, 279) have recently published a comprehensive list of the birds of Trinidad and the neighboring Antillean island of Tobago, which forms part of the same British colony. The waterfowl which they list, with the status of each, are as follows:

Puffinus lherminieri. Tobago, resident.
Oceanodroma leucorhoa. Winter visitor.
Phaëthon lepturus catesbyi. Tobago, resident.
Pelecanus occidentalis. Resident, both islands.
Sula sula. Tobago, resident.
Sula leucogaster. Resident, Tobago and rocks off Trinidad.
Phalacrocorax olivaceus. Visitor to Trinidad.
Fregata magnificens rothschildi. Tobago, resident.
Haematopus ostralegus palliatus. Tobago, resident or visitor.
Larus atricilla. Resident, both islands.
Phaetusa simplex. Trinidad, resident.
Gelochelidon nilotica. Winter visitor.
Sterna hirundo. Winter visitor. (Banded Massachusetts birds recovered in Trinidad.)
Sterna dougalli. Winter visitor. (Banded Massachusetts birds recovered in Trinidad.)
Sterna fuscata. Resident, both islands.
Sterna albifrons antillarum. Trinidad, resident.
Thalasseus maximus. Winter visitor.
Thalasseus eurygnatha. Resident, probably at both islands.
Anoüs stolidus. Resident, both islands.
Anoüs minutus. Trinidad, possible resident.
Rynchops nigra. Visitor to Trinidad, either from North America or Guiana.

During the middle of the nineteenth century, Caribbean guano from many of the lesser Leeward Islands assumed considerable commercial importance. Centinela, El Roque, Los Monjes, and Los Testigos were among the hundred or more sites worked, and "myriads of waterfowl" are mentioned in the ships' logs and other contemporary accounts. The product was a phosphatic guano of rocky type, with a laminated outer surface, often characterized by a high polish. It was therefore not similar to typical Peruvian nitrogenous guano, but rather resembled the "guano glass" found, along with a better grade, at the northernmost of the Peruvian islands, such as Lobos de Tierra, where rain occasionally falls (Taylor, 1857, 91).

2. The Atlantic Coast, Trinidad to the Shoulder of Brazil

The western side of the Gulf of Paria, and the coast that stretches southeastward toward the main mouth of the Orinoco, is low, heavily forested, and flooded during at least part of the year. The delta of the great river begins in the southern tip of the gulf, and to the eastward and southward of this point the shore has never been thoroughly explored nor more than approximately charted. The coastal waters are shallow and there are no towns or centers of trade to attract shipping toward the land between the few branches of the river that serve navigational needs. Even off the Boca Grande, the principal channel into the delta and the inland waters of the Orinoco, it is said that vessels have not infrequently grounded out of sight of land. The territory about the entrance is not only low, but is all so evenly covered with forest that it presents few distinctive marks to the eye of a visitor.

Simpich (1931, 41), who took part in an air reconnaissance here, writes:

Up yellow and brown estuaries of the dismal Orinoco Delta we flew, crossed intervening green jungle wastes, and returned to the muddy coastal tide flats by some other wandering stream in this swampy labyrinth. Except for two or three widely separated grass huts of savages, we saw no sign at all of human life.

This is "The Land of a Single Tree" (the mangrove), as called by the Beebes (1910, 9) in a chapter from which the following passages are taken.

One of the most astonishing things about the mangrove forest is the apparent diversity of its plant life. Until one actually comes within reach of trunk and leaves it is impossible to believe that all this forest is composed of a single species of plant. The foliage of some of the trees is light, of others, dark; here stands a clump of pale beech-like trunks, there a dark, rough-barked individual is seen. The manner of growth of the young and old trees is so different that a confusion of mingled trees, shrubs, and vines seems to confront one. But everywhere the mangrove reigns supreme. It is the only vegetable growth which can gain a footing in this world of salt water. In fact, it makes its own footing, entangling and holding mud and débris about its stems, and ever blindly reaching out dangling roots, like the legs of gigantic spiders.

Far out on the tip of a lofty branch a mangrove seed will germinate, before it falls assuming the appearance of a loaded club from eight to fifteen inches in length. One day it lets go and drops like a plummet into the soft mud, where it sticks upright. Soon the tide rises, and if there is too strong a current the young plant is swept away, to perish far out at sea; but if it can maintain its hold, roots soon spring out, and the ideal of the mangrove is realized, the purpose for which all this interesting phenomenon is intended: the forest has gained a few yards, and mud and leaves will soon choke out the intervening water.

The mangroves have still another method of gaining new territory. Aërial roots are thrown out from branches high in air, swinging downward and outward with a curve which sometimes wins three or four yards ahead. Like hawsers thrown from a vessel to a wharf these roots clutch at the mud beneath, but where the current runs swiftly they swing and dangle in vain, until they have grown so heavy that they touch bottom some distance downstream. . . . Throughout all this great region there is not a foot of solid ground. In one place we pushed a tall shoot some eight feet in height straight down through the mud, and it went out of sight. A man falling on this mud, out of reach of aid, would vanish as in a quick-sand. . . .

More wonderful even than the coral polyps are these mangroves, for by this plant alone all this region has been rescued from the sea and built up into land. In future years, as the mud banks become higher and are fertilized by the everfalling leaves, other growths will appear, and finally the coast of the continent will be thus extended by many scores of miles of fertile soil.

But the gain is specious; it is a case of robbing Peter to pay Paul. On the Atlantic coast of Venezuela and in parts of Guiana the land may, indeed, be extending its borders with wreckage from the interior of the continent, but nearer the Amazon it is probably being eaten away by the sea at least as fast as it is built up by fluvial detritus and plant growth. Agassiz (1868) regarded it as very remarkable that the Amazon, largest of rivers, has no delta—unlike any of the other streams we call great. By investigation he satisfied himself that most of the islands in the estuary are detached portions of the mainland, that in fact the sea at this point is breaking down the shore much faster than the river can build it up. There are, of course, a few small transiently growing islands of mangrove-covered alluvium, but in the main the process is one of disintegration.

Von Humboldt (1852, 373) gives the following description of the plant and animal association of the mangrove thickets, and of the extension and eventual annihilation of the latter.

Wherever mangroves grow on the sea-shore, the beach is covered with infinite numbers of molluscs and insects. These animals love shade and faint light, and they find themselves sheltered from the shock of the waves amid the scaffolding of thick and intertwining roots, which rises like lattice-work above the surface of the waters. Shell-fish cling to this lattice; crabs nestle in the hollow trunks; and the seaweeds, drifted to the coast by the winds and tides, remain suspended on the branches which incline towards the earth. Thus, maritime forests, by the accumulation of a slimy mud between the roots of the trees, increase the extent of land. But whilst these forests gain on the sea, they do not enlarge their own dimensions; on the contrary, their progress is the cause of their destruction. Mangroves, and other plants with which they live constantly in society, perish in proportion as the ground dries and they are no longer bathed with salt water. Their old trunks, covered with shells, and half-buried in the sand, denote, after the lapse of ages, the path they have followed in their migrations, and the limits of the land which they have wrested from the ocean.

The Atlantic Ocean along this stretch of Amazonian, Guianan, and Venezuelan shore line receives a relatively enormous proportion of the earth's river water. This coast is the chief sluice-way of the wettest of continents. Heilprin (1906, 544) writes:

Lest the geographer becomes too thoroughly impressed with the notion that the great rivers of the globe are only those that serve as trade-carriers or have played a familiar part in childhood's study of geography, it may be noted that in this distant forest-land are rolling waters that would shame the rivers of Europe—that would put to a long test even the "Father of American Waters." The great sweep of the Corentyn and Essequibo, rivers that 60 miles or more above their estuarine mouths measure from three to four miles in width, and which for yet a further hundred miles may still carry two miles, is an object-lesson in geography which impresses with more than ordinary force.

The outpourings of one river overlap and mingle with those of the next one to northwestward, as all tend to fall in with the general course of the equatorial ocean current. Sometimes even the special source of river water may be told by its color far from the mouth through which it issued. According to Smith (1879, 1), Amazon water, discolored by suspended particles of yellow clay, is determinable as greenish bands, parallel with the coast but from 300 to 500 kilometers away from it, and over deep soundings, as far as latitude 10° N.

Farther south, near the equator, and still a hundred miles from land, the sea is much more strongly tinged; in April and May, indeed, it has nearly the clay-yellow hue of the Amazons itself, and furious currents struggle with each other until the surface boils and seethes as below a cataract. The flood of turbid waters, after this first battle with the ocean, gives way before the yet stronger equatorial current; its flank is turned, and it sweeps away northward, staining the sea with the blood of its defeat, littering it with débris, madly rushing into the heart of the enemy's country, until its last forces are exhausted and it sinks to annihilation, six hundred miles from the field of battle (Smith, 1879, 2).

The experience of Pinzon, who reported a "fresh-water sea" off the northeast coast of South America after filling his casks out of sight of land, during the

Amazon flood season of March, 1500, has been repeated many times. It is probable that much of the continental shelf, which is widest off the mouth of the Amazon, gradually narrowing toward Trinidad, has been built up of the countless cubic kilometers of silt carried into the ocean by the Amazon, the Orinoco, and many lesser but still mighty streams. The action of the long-shore current is recognizable in old beachlines and spits, which are now obstacles to the direct flow of fresh water toward the sea, so that the smaller rivers tend to turn westward in the lower parts of their courses and to run for some distance parallel with the shore line. Off the mouth of the Essequibo, the pelagic water of the equatorial current, as distinguished from the mixed and turbid littoral water, has been detected within 40 kilometers of shore, in a depth of as little as 18 meters. Along most parts of the coast, however, the landward edge lies farther out. The offshore limits of the current are reputed to be in the neighborhood of 400 kilometers from land, and the axis of greatest velocity at a little less than half that distance.

To return to the Orinoco delta, Boca Grande, the main mouth of the river, lying between Cangrejo Island and Barima Point, is about 16 kilometers wide. The approach is obstructed by an extensive bar which projects so far seaward that only in clear weather are the trees on the eastern side of the entrance visible from deep water. In windy weather there is a heavy and dangerous sea on the bar, which grows and sloughs away in such a manner that its depth is little affected by the height of the river, notwithstanding the great seasonal amplitude of the latter.

The front of the Orinoco delta extends for about 260 kilometers along the coasts of the open Atlantic and the Gulf of Paria, and through numerous mouths, great and small, the river waters escape to the sea. Only the routes of the Boca Grande, the narrow Pedernales, and the Macareo are of commercial importance. Through the last named a steamship company operates its vessels on the most direct course between Port of Spain, Trinidad, and the inland city of Ciudad Bolivar, on the Orinoco. This route greatly reduces the distance, eliminates a voyage through the open sea, and so permits the use of river steamers and avoids the strong currents and troublesome waves of the Boca Grande bar. The seven or more other mouths are mostly little known. Several of them join at Barrancas, about 180 kilometers up the main stream.

After our consideration of such sister rivers as the Atrato and the Magdalena, it is hardly necessary to add that the delta of the Orinoco is not the home of birds that can be called marine. Petrels and boobies cleave to clean and saline water. Even Brown Pelicans and man-o'-war birds show no penchant for the shores of regions in which the sea water is excessively turbid. Occasional short files of pelicans may, indeed, be seen entering the estuaries of the dark delta channels, but the observer may be reasonably certain that they are wanderers and that their nearest breeding grounds are on islets of the bluer Caribbean. Only our adaptable old friend, the Bigüá Cormorant, seems as much at home in one place as the other.

The avifauna, in fact, is made up of the characteristic assemblage of marsh birds which form fixed or transitory associations with the mangroves. Let us imagine the coming of evening in the Orinoco delta.

Where were the myriads of water-fowl of which we had heard? We had seen nothing—not a single feather. But now the scene slowly changed. The tide was falling rapidly, swirling and eddying past the boat, and the roots of the mangroves began to protrude, their long stems shining black until the water dried from them. Mud-flats appeared, and suddenly, without warning, a living flame passed us—and we had seen our first Scarlet Ibis. . . . Before we could recover from our delight a flock of twenty followed, flying close together, with bills and feet scarlet like the plumage. They swerved from their path and alighted on the mud close to the mangroves, and began feeding at once. Then a trio of snowy-white Egrets with trailing plumes floated overhead; others appeared above the tops of trees; a host of tiny Sandpipers skimmed the surface of the water and scurried over the flats. Great Cocoi Herons swept majestically into view; Curlews and Plover assembled in myriads, lining the mud-flats at the water's edge, while here and there, like jets of flame against the mud, walked the vermilion Ibises. Terns with great yellow bills flew about the sloop, and Skimmers ploughed the surface of the tide in endless furrows. Macaws began to pass, shrieking as they flew, two and two together—and then night closed quickly over all. From the zenith the sun had looked down upon a stream as quiet as death; it sank upon a scene full of the animation of a myriad forms of life (Beebe, 1910, 6).

By the end of March the waters of the Orinoco begin their vast annual rise, attaining greatest height in July or August and gradually falling away again to a minimum in February or March. The ordinary range in water level amounts to as much as 18 meters. A range only slightly less is known even at Ciudad Bolivar, 367 kilometers upstream. With the flood, the current of the river increases, and the ocean surface off the Boca Grande is said to become quite fresh 30 kilometers from land. At the time of heaviest rains the northern parts of the delta, where the outlets run into the Gulf of Paria, are covered with water that has overflown from the channels, and the human inhabitants take to dwellings built in trees.

The block of territory extending from the scarp just south of the River Orinoco to that just north of the lower Amazon is collectively known as Guiana. It is one of the geologically ancient plateaus of the continent. Historically it is divided into Venezuelan, British, Dutch, French, and Brazilian sections. The foreshore from near the Boca Grande of the Orinoco to the Oyapock River at the Brazilian border continues generally low, being formed of alluvial matter brought down by very numerous rivers. To a considerable extent the land close to the sea is slightly below spring tides, which flood wide areas; at low water the shores of many estuaries appear as inaccessible banks, while at high water they are inundated. Certain settlements, such as Georgetown, are diked to meet this condition.

The submarine slope of the muddy coast is so gradual that depths of 50 meters may sometimes be found almost as many kilometers from the land. Barely submerged mudbanks extend offshore in places as far as 15 kilometers. Such banks are constantly shifting under the influence of river and ocean currents. Clumps of vegetation carried down during the rainy periods not infrequently become established after stranding on shallow parts of the banks, with a resulting growth that alters the features and even the direction of the coast. The pilot books are filled with references to points of land in Guiana that can no longer be made out. Moreover, owing to the monotonous uniformity of the coast, every ephemeral feature, such as a clump of burned trees, is seized upon as a landmark.

Schomburgk well described these shifting shallows nearly a century ago. The mudbanks, so dangerous to coastal navigation, he writes, are the nuclei of ever-nascent formations along the Guiana coast. Their magically rapid birth and disappearance has something mysterious about it. Where a few days before was a smooth surface of water, there abruptly appear soft mudbanks which, after a short time, may be as quickly washed away. Frequently, however, they are pushed bodily against the shore where, out of reach of the general drift, they come to form part and parcel of it through the agency of mangroves and related plants. The whole coast line is thus subject to constant change, and many a settler who could formerly look from his windows out to sea now finds the view shut off by a forest. Further confirmation of the continual increase of foreshore is indicated by the successive tiers of coast vegetation which, according to their respective ages, rise one above the other inland like the seats of an amphitheatre. The alluvium cannot come in large part from Guiana, the streams of which are bright and translucent except in the relatively narrow coastlands. If the latter had been the source, they would have been all washed into the sea ages ago, for the littoral ocean is so chock full of mud and mire, along an area at least 240 kilometers in length and 16 out from shore, that in some places the very waves resemble soft thin ooze (Schomburgk, 1847, **1**, 187).

The pilot books make much of the "dark suspicious hues" of the coastal water of British Guiana, which is due to a combination of the silt, the shoal and muddy bottom, and the vegetal staining of the river increment. During a coastwise trip out of Georgetown, Beebe (1910, 134) noted the inhibiting effect of suspended matter upon wave movement: "The water along the coast," he writes, "is very shallow and is so filled with sediment that even in a heavy gale the waves break but little."

Schomburgk (1847, **1**, 252) has further described the egress of the muddy Essequibo through an estuary 20 kilometers in width.

The grand spectacle of the ocean was increased by the sight of the mighty Essequibo. Although the mouth of this river was still several miles away, we could already see the powerful waves of the stream flow like a dirty ribbon out to the sea, without mixing with the waves of the ocean. Still more lively and impressive this became when at high tide the two immense water forces met in a wild fight and stirred up the surface to an incredible tumult—but the proud river proved its superiority and soon conquered the power of the tide; the high foamy waves and whirling calmed down, and the glorious ribbon of the victorious river extended before our eyes again, and was only lost to view far away at the horizon.

And Heilprin (1906, 539) carries on, in the following pleasant introduction to the country, the references to the earthy cargo of the littoral waters which, indeed, few visitors to that part of South America have failed to note.

Most travellers receive their first impressions of British Guiana on their arrival at the capital city, Georgetown (more commonly designated from the country in which it is situated, Demerara), but before this, and for many miles out to sea, he will have noted a characteristic of the land in the yellow-brown waters that lie outside, the sediment that rolls out in floods or is gathered in from the discharge waters of the Orinoco. The Amazon seems to have little part in this discoloration; for, if my information is correct, much of the off-shore of French Guiana and the land lying still farther to the eastward are bathed by a clear sea. Back of the fringe of muddy water the eye follows the low contour of a bordering grove of mangrove, and beyond it in some places, or replacing it elsewhere, the glass may resolve a somewhat loftier growth of willow-like bushes, or even trees, the courida (*Avicennia nitida*). In the distance, less lofty than the occasional chimney that tells where the sugar-cane is being grown, or where it was cultivated until competition with the sugar-beet broke the back of the most important, albeit steadily falling, industry of the colony, are a few specimens of the royal and cabbage palms (*Oreodoxa regia*, *Oreodoxa oleracea*), and the landscape is virtually complete. There is not a rise in the land that even remotely suggests a hill, and it is in faith only that the mind constructs the landscape of lofty mountains in the far interior.

The muddy water of this coast is, in my opinion, the factor that limits the southeastward extension of the Brown Pelican's distribution so abruptly in the neighborhood of Trinidad. On the west coast of South America pelicans have taken advantage of continuously favorable littoral conditions, and have pushed their specific range southward to central Chile. Much of the eastern coast of the continent appears to offer an even better habitat for pelicans, despite the fact that none are present. To southward of Cape São Roque, in particular, inlets like Bahia, the Bay of Rio de Janeiro, and the straits behind the shelter of islands such as São Sebastião and Santa Catharina, have every appearance of places in which pelicans could find an abundance of food, clear and bland water, and a climate admirably suited to their welfare. Furthermore, the Abrolhos Islets would seem to offer breeding sites to suit every need. Rocas Reef and Fernando Noronha are doubtless too far from the continent to be equally available. In every other respect, however, they too would make ideal "pelican islands"; neither should it be forgotten that this same species of bird has at some time in the past established itself upon the much more remote Galápagos.

I would hazard the guess that if fifty adult pelicans from the West Indies were set free along the coast of southern Brazil, the birds would take to their new home as rabbits did to Australia, and would quickly found a flourishing colony. But the ever-present and insuperable barrier to their natural distribution into this region is the mud and silt that fills so much of the coastal ocean between the Gulf of Paria and the mouth of the Amazon. In this turbid water there are either no schooling fish in numbers sufficient to support a population of pelicans, or else the water itself is so nearly opaque that the pelicans are unable to see and capture their prey.

A critical reader may object to this that the boobies and the man-o'-war bird, which have succeeded in rounding the eastern tip of South America, might presumably have been thwarted by the same unfavorable conditions off the Guianas. The answer is that birds of both these groups have more pronounced pelagic inclinations than pelicans. Perhaps it would be more correct to say that the boobies and man-o'-war birds have less pronounced inhibitions against leaving the immediate neighborhood of the coast; probably, indeed, a man-o'-war bird would voluntarily fly 50 kilometers from shore more readily than a pelican would fly 10. It is likely that for such reasons the West Indian forms of *Fregata* and *Sula* have crossed or circumvented the barrier of silty waters, to reappear as nesting birds at Fernando Noronha and in the blue-water paradise along the southern tropical coast of Brazil.

For a number of reasons the man-o'-war bird would be much more at home than the pelican on the coast of Guiana. Among these are the following: (1) Although it roosts by night in the mangrove forest, it is ready and willing to fly a considerable distance out to sea in search of favorable fishing waters; (2) it is not wholly dependent upon prey captured by itself, but feeds in part upon food which it forces other birds to disgorge; (3) it does not dive for its food and is therefore not limited to transparent water—the fish it captures for itself are mainly forms which come to the surface, or which even leave the water to make short glides in the air. Little seems to be known about breeding stations of the man-o'-war bird between the Caribbean and Cape São Roque, but it is probable that the species nests, or formerly did so, on some of the islets off the coast of French Guiana where, it is said, the water over the continental shelf is prevailingly more clear than that to westward.

Boobies and tropic-birds are all scarce, if not quite unknown, along this section of the South American coast. Tropic-birds would, of course, entirely avoid muddy, or even discolored, water. The same is true, though perhaps to a lesser extent, of the boobies. Moreover, only one species of the tropical Atlantic group of boobies is known to roost consistently in trees. The tropic-birds and boobies are, however, sufficiently pelagic to have worked around the outer edge of the turbid coastal zone, so that they reappear farther southward.

Finally, there is another consideration to be mentioned which has a bearing upon the foregoing hypothesis, without invalidating its application to the pelican. The Atlantic members of *Fregata*, *Sula*, and *Phaëthon* are all, to a greater or less degree, birds of cosmopolitan type, and there is no reason to believe that they have originated in the West Indian region, thence to spread into other parts of the world. It is rather more likely, on the contrary, that they originally reached the Caribbean by invasion in the direction towards which the converging trade winds blow. The Brown Pelican, on the other hand, either originated in the Caribbean-West Indian district or else it has been extirpated elsewhere. In either case the opportunities for it to spread southeastward, toward suitable waters on the Atlantic coast of Brazil, are greatly lessened by the same natural forces which once made "rounding Cape São Roque" a difficult feat for sailing vessels, namely, the constant opposition of winds and a strong ocean current. When we add to these obstacles the presence of a band of muddy water, and the Pelican's congenital disinclination to pass out of sight of the coast, the limits of its present range in this direction are not hard to comprehend. Brown Pelicans have, of course, been reported from the coast of the Guianas and even from inland waters of the Amazon. All such records, however, appear to be based upon wandering individual birds. The species is not mentioned in most lists of residents of the region, and Schomburgk states that it does not nest anywhere southeastward of the Venezuelan coast.

Between the mouths of the Orinoco and the Essequibo the low coastal region is filled with large lagoons and marshes, the resident Indians constructing their dwellings on posts well above the ground, and travelling about largely in "woodskins," as the Guianan canoes are called. On the open shelving sea beaches a heavy though sluggish surf is usually in force, especially during flood-tide, which augments the current and the run of the waves. In places, as at the Waini and Moruka beaches, there are conspicuous beds of shells, which are a commercial source of lime, but owing to the breadth of the shallow flats only small vessels can come inshore close enough to load. Shells of mollusks are more or less mixed with the littoral mud all along the coast of Guiana and have been made the basis, by Schomburgk and others, of speculations regarding the source of the growing foreshore.

The coastland bird life of the common border of British and Dutch Guiana is thus described by Young (1929, 751) who, it is interesting to observe, mentions neither the pelican nor the man-o'-war bird in his account:

> The littoral and riparian area embraces the bog-land of the Corentyne Coast, the mangrove swamp-jungle through which the rivers flow and which also occurs at intervals on the shore, and the wide spaces of mud exposed at low tide and bordered on the landward side with arrow-grass and shrubby trees. The swamp-jungle consists typically of the two mangroves (*Lagunularia* and *Rhizophora*), the courida (*Avicennia nitida*), which lends its name to this type of jungle, known to the creole as "courida bush" and the impenetrable "bunduri pimpler" (*Drepanocarpus lunatus*), the name "pimpler" being applied to any plant with thorns. Where this bush has been felled by man the exposed mud becomes covered by the giant swamp-fern (*Achrosticum aurem*), which grows in clumps five or six feet high. The only species of bird peculiar to this swamp-jungle is the Hoatzin (*Opisthocomus hoazin*), which spends its whole life within a comparatively small area. . . .
>
> The Corentyne Coast bogs constitute the hunting-ground of the Brazilian Cormorant (*Phalacrocorax vigua*), and here, as well as on the open flats, the migratory Waders disport themselves—Spotted Sandpipers (*Actitis macularia*) in clouds, and others less abundant, such as the Solitary Sandpiper (*Tringa solitaria*) and Ringed Plover (*Charadrius wilsoni*). Occasionally companies of White-faced Tree-Duck (*Dendrocygna viduata*) paddle about on the water's edge, and groups of the beautiful pink-legged Stilts (*Himantopus mexicanus*) may also be met with. This is a fascinating region, and the enjoyment of watching the most varied assemblages of shore- and water-fowl is often the reward of anyone who braves the prospect of struggling up to the knees in ooze, stabbed mercilessly by arrow-grass and subjected to the undivided attention of clouds of mosquitoes and sand-flies.

Quelch (1896, 258) likewise refers to the great flights of North American migrants in the marshlands, especially during former times when the Golden Plovers (*Pluvialis dominica*) began to arrive in force during August, increasing thereafter until October, and then diminishing until the last stragglers departed southward in November. During the dry season, according to Quelch, the native waders are mostly confined to the stream courses or to isolated ponds, but after the wet season begins, the "Negrocop" or Jabiru, the Spoonbill, and other marsh birds disperse over the flooded savannahs of British Guiana, where they feed upon aquatic creatures spread abroad by the floods or upon insects and reptiles driven out of the undergrowth.

The climate of British Guiana approaches the sub-tropical, despite the proximity of the equator, the sun's heat being to a large extent tempered by the fresh northeast sea breezes, which blow practically daily for the greater part of the year. There are two wet seasons annually, a longer one from April to July and a shorter one in December and January. At these times a southwest or land breeze is often experienced, bringing with it the heaviest falls of rain.

In Dutch Guiana, according to the Penards (1908), the long rainy season begins slightly later—in May or June. The savannahs become bogs and the creeks swell into terrifying torrents. Toward August, the rain slackens and sunshine quickly follows the showers. This is the time of year when young ibises, herons, flamingoes, and other native waders spread in numbers along the coast. By September relatively fair weather prevails; the ground dries and cracks; temperatures are high; easterly or northeasterly winds blow during the afternoons. This is the short dry season, to be succeeded about the middle of November by a short wet season, during which there are heavy morning fogs and comparatively low temperatures.

The annual precipitation increases toward the eastern end of the region, reaching a maximum in French Guiana. There the so-called dry seasons scarcely deserve the name, judging by rainfall records, except that September and October have little rain at the coast, while August and November are at least drier than the remaining months of the year. To this extent we see an approach toward the rainfall pattern of the northeastern tip of Brazil and the island of Fernando Noronha.

Along the coasts of British and Dutch Guiana there is a dearth of outlying islands as well as of eminences on the mainland. In French Guiana the same condition holds as far eastward as the Iracoubo River. At this point, however, the hills of the same name become visible from the ocean, and farther eastward isolated peaks or low ranges are much in evidence. Likewise, small groups of islands begin to appear, most of them being similar in formation to the fringing mud flats of the coast. Cayenne Island, however, rises to 255 meters above sea level. It is lined on one side with bold rocky coves and steep islets, presenting a strong contrast with the ports of the neighboring Dutch and British colonies. This prominence is essentially a mainland spur, but offshore in the same region are the Salut Group, with its notorious Devil's Island, the Battures, the Connétables, the Père and Mère, and l'Enfant Perdu, the last so called because it is a long way to leeward of its parents and seems as if it had strayed hopelessly from home (Waterton, 1839, 94). Bellin, in 1743, spoke of these islets as "sterile rocks," but recent photographs (Simpich, 1931, 45, 46) show that several of them now have good growths of palms and other vegetation. One of the Connétable Islands is said to be worked for building stone and guano. It would be interesting to learn the source and nature of guano which has accumulated in so humid a region. As to the abundance of birds, however, there seems to be no doubt, for Barrere, another French chronicler who, like Bellin, published in the year 1743, says that the Great Connétable is known also as Bird Island, and that frigate-birds and boobies occupy it. It has remained a sanctuary for sea fowl, he continues, because the strong tides and currents make it hazardous for sailing craft to reach it. Waterton (1839, 95) adds the following:

Considerably to windward of Cayenne, and about twelve leagues from land, stands a stately and towering rock, called the Constable. As nothing grows on it to tempt greedy and aspiring man to claim it as his own, the sea-fowl rest and raise their offspring there. The bird called the frigate is ever soaring round its rugged summit. Hither the phaeton bends his rapid flight, and flocks of rosy flamingos here defy the fowler's cunning.

If boobies and tropic-birds are, indeed, present at the offshore islands of French Guiana, it would tend to confirm Heilprin's statement, quoted above, that the littoral ocean is here clearer than the waters either to eastward or to westward. Barrere remarks, furthermore, that this coast is particularly rich in fish, and Waterton that it offers "by far the sublimest scenery on the seacoast from the Amazons to the Oroonoquo."

The Oyapock River, at the Brazilian boundary, has a funnel-shaped estuary about 20 kilometers wide. Beyond the more or less swampy lowlands to westward of the entrance, the terrain rises into picturesque hills and mountains that appear from a distance like islands.

The country between the French border and the Araguary River, at the mouth of the Amazon, is the sea front of Brazilian Guiana. Behind the uniform-looking coast, with nothing to indicate the position of most of the rivers, there are many large lagoons lying between shore and highlands. The whole region is more or less inundated during part of each year, and is covered with mangroves which can be seen at a distance of not over 15 to 20 kilometers. Being exposed to the scouring action of waters discharged by the Amazon and other rivers, the outline of the coast undergoes continual change. Soft mud flats formed by the sediment of the rivers extend off in many places considerable distances. These the mangroves invade rapidly during the dry season, often to be torn up again by the violent action of currents when the period of freshets ensues. Moreover, the high tides, advancing up the streams far into the country, smear the banks with an enamel of slimy, fine-grained mud.

Goeldi (1896, 97) describes a boat journey during the month of October from Pará to the River Counaný, which lies about midway between French Guiana and the Amazon. The coastland, he writes, looked from sea like a narrow blue-green ribbon, surprising in the apparent regularity of its breadth. The ocean water was entirely of a muddy brown hue, even though the date was half a year after the Amazon flood season. When he reached the mouth of the Counaný, the tide was out, and even his very small steamer was unable to enter until it had risen, carrying with it toward shore many reddish brown jellyfish. Even with the flood-tide, progress was difficult because of bars and uprooted trees, all hidden by water which the author describes as little more than fluid mud. The forest on either bank was of the typical Guianan sort—siriúba, with occasional couridá trees, tall palms of two species, clumps of bamboo, and many lianas.

After an hour and a half the coastal or navigable stretch of the river had been passed, and Goeldi continued his voyage by means of a dugout. Subsequently he ascended a neighboring stream, the Amapé, where conditions were equally muddy, dreary, and devastated, with piles and tangles of tree trunks along the banks, wreckage of the terrible "pororóca" or bore. For a proper conception of the "miles of giant forest trees, uprooted and scattered like matches" by rivers of this coast, the reader should refer to a photograph from the air, published by Simpich (1931, 47).

In this part of the coast, and southeastward, the tidal bore is perceptible in the estuaries of most of the shallow rivers. In the Calsoene River spring tides rise 7 meters, and at Maracá Island 9 meters. The Calsoene is incidentally characterized by a curious tidal phenomenon, called the "doucin" because the water in the estuary becomes entirely fresh. After heavy rains there is no longer a flood current; even though the tidal level rises and falls as usual, a vessel at anchor remains constantly swung to the ebb.

The mouths of the Amazon extend along about 290 kilometers of ocean front. Despite the amount of silt carried by the great river, far larger in the volume of its water than any other, it has built up no projecting delta like those of the Mississippi and the Nile. Its deposits appear to be carried away continuously by the action of currents flowing in a northwesterly direction along the coast and attaining, offshore, a maximum speed of 5 to 6 kilometers per hour. Much sediment is evidently dropped, at least temporarily, at the northwestern border of the estuary for here, off Cape North, a vast shoal stretches seaward, the 10-meter contour being in some places as far as 80 kilometers from shore.

A certain mixing of river and ocean waters also takes place on the southeasterly or up-current side. Agassiz (1868) noted that when he approached the mouth of the Amazon from the south the first indications of the river were yellowish patches staining the sea here and there. Presently the patches were replaced by broad streaks, after which the fresh waters began rapidly to supersede the salt, while the steamer was still several hours' journey to southeastward of the Pará estuary.

The dark water of the Amazon discolors the ocean for 80 kilometers or more from its mouth. The annual inundations in the lower part of the basin occur chiefly between January and May, the rise of the river amounting in some places to as much as 15 meters. Tidal effects are extremely varied and confusing in the complicated waterways of the estuary, the powerful bore sometimes occurring in the shallow waters of the western mouths and elsewhere, at or near spring tides. In maritime instructions the bore has been characterized as "a head of water five to twelve feet in height, with a breaking front, advancing at speeds which range from ten to fifteen knots." Under such circumstances, the entire tidal rise along the shores of the northwestern channel is said to occur within the short space of ten minutes.

Smith's (1879, 12) description of the Amazon bore is somewhat less spectacular and is doubtless more factual.

> Near the mouth this wave is very apparent. The tide is forced, so to speak, into a funnel, over shoals and against the descending current; it rises in a great solid mass three or four feet high, uprooting trees along the banks and breaking canoes that may happen to be in shallow water. This is the celebrated *pororóca*, a phenomenon which is best seen on the northern side of the river,

and during the spring tides. Travellers have had much to say of the *pororóca*, and some of them, no doubt, have multiplied it in their fancy. However, the tidal wave is really formidable, and much dreaded by the canoemen, who keep in mid-channel to avoid its force.

It is largely because of the presence of the bore that the western or main entrance to the Amazon is little used for commerce, the usual maritime route being by way of the channel leading toward Pará. Alfred Russel Wallace (1853), however, refers to formidable manifestations of the "piroróco," as he spells it, even in this branch of the river. On one occasion during his youthful field work in Brazil, he had gone ashore at a sugar estate to wait for the incoming tide, when the agent told him to take the boat out into the stream in order to avoid the pororóca. Just as the party was expecting the tide to turn, a great wave came rushing along and broke at the place where the canoe had been previously moored. When the wave passed, the water was as quiet as before but flowed up with great rapidity. In winter when the spring tides are highest, the bore breaks with terrific force, according to Wallace, often sinking boats or dashing them to pieces if they are left in shallow water. His explanation is that when a body of tidal water in rapid motion is of sufficient depth to come in contact with a shoal, a great wave is formed which continues for a long distance beyond. For a day's journey or more up the great river, the onrushing tidal wall causes the waterfowl, and the marsh birds on the banks, to take precipitant flight.

Stretching across the main mouth of the Amazon is a chain of islands, of which the two largest are Caviana and Mexiana. The latter is the most southern and seaward of the group, and is separated by the Canal do Sul from the much more extensive Ilha Marajó, which is really to be considered as part of the riparian mainland, despite its separation on the western side by a complicated web of creeks. Mexiana has been visited, and reported upon, by a number of naturalists, including Wallace in 1853, Hagmann in 1908, and Müller in 1914. Since it is inhabited by all of the water birds of the coastal region, as well as by a rich variety of land birds, we may pause to picture it as a typical example of Atlantic equatorial lowland fronting on the ocean.

Mexiana is oval, about 50 by 30 kilometers in dimension, and is bisected by the equator. Despite the fact that its northern and eastern sides face the open Atlantic, it is surrounded only by fresh water; neither saline nor brackish water is noticeable at any point, even when the Amazon attains its lowest level during drought periods. The greatest elevation is only a meter or two above mean sea level, and the very highest points comprise little mounds called "tesos," which are covered with tall growth and which thus dot parts of the interior grassy campo with "islands" of forest, in which the brilliant yellow blossoms of the knotty carobal trees come into bloom during August.

The general level of the island is highest near the shores and falls away toward the middle, this being due to the fact that during flood seasons the larger part of the overflowing load of sediment is deposited around the borders. Because of this same annual enrichment the principal belt of marshy forest, containing palms, latex-producers, and other lofty trees, as well as an abundance of bamboos and lianas, is likewise marginal, the whole center of the island being grassy or shrubby campo. In a few places this breaks through the forest girdle to extend as open glades down to the muddy or sandy beaches, which at high tide are mostly submerged. Numerous small meandering creeks or "igarapés," which are without sources on the island, receiving all their water from the Amazon, penetrate inland from various parts of the coast. These have dense gallery-forest along their lower reaches. They are all subject to tidal rise and fall, and many of them lead to fair-sized lagoons in the interior sinks of the island. Toward the end of March such bodies of water greatly enlarge with the floods. Thereafter some of them dry up, or remain only as swamps or "mondongos" during the relatively long dry period. As a rule no rain falls from about the middle of August until early January.

Mexiana is all thoroughgoing alluvial land, mostly clay and sand, with no pebbles or other stone. The variety in the soils and the forest vegetation in different parts of the terrain led Müller (1914, 35) to the opinion that the island has originated through the consolidation of several smaller estuarine islands, and that the principal igarapés are the last remnants of former dividing channels.

On the whole, Mexiana gives a much more tropical impression than Marajó, although the two are separated by only 8 to 9 kilometers of river. Mexiana is locally celebrated for the abundance of its alligators, ounces, and birds. Among its forest trees live many cuckoos, anis, paroquets, hummingbirds, woodpeckers, tanagers, cotingas, and birds of prey. There is also one species of toucan (*Rhamphastos toco*), and the Black Vulture is common. Flocks of Muscovy Ducks fly with a noisy rush of wings toward the lagoons as long as any water remains in them. Cormorants plunge in the deeper, surrounding channels. Sun-bitterns and Spur-winged Plovers feed in the igarapés, especially along their jungle-bordered stretches, and a host of marsh birds, such as Limpkins in search of snails, Spoonbills, Scarlet Ibises, Jabirus, Wood Ibises, and several species of herons appear in great numbers with the coming of the showers, about New Year, and remain throughout the wet season until July, when many of them retire to more permanent watery fastnesses of the mainland. In the coves and canals around Mexiana one can usually see flocks of river terns of several species, as well as Skimmers (*Rynchops nigra cinerascens*). The Gull-billed Tern (*Gelochelidon nilotica*) is also said to nest at the island.

There is thus no resident sea bird fauna. On the offshore side one might see an occasional man-o'-war bird in pursuit of a skittering "balao" (*Hemirhamphus* or a related fish), but the Mexiana assemblage as a whole is rather of the sort with which we have already become acquainted in delta and marshland regions along the Caribbean. In short, with the notable absence of the Brown Pelican, it is the standard avifauna of humid tropical coastlands in South America, not very different from what we might find along waterways of the Gulf of Guayaquil, on the opposite side of the continent and close to the same latitude.

That the waters off the mouth of the Amazon are, nevertheless, a favorite region of sea bird concentration within the tropical Atlantic is clearly indicared by observations of the 'Meteor' Expedition referred to above (p. 89). Hentschel's chart (1933, 117) shows seven stations, between the mouth of the Rio do Pará and a point nearly a thousand kilometers to northeastward, in which the oceanic bird count is relatively very high, as compared with neighboring parts of the tropical ocean. Birds were less common near the land than well offshore; at five of the pelagic stations between 10 and 19 individuals per watch period were observed. Hentschel does not record the species of birds observed within this oceanic tongue, which is enclosed by the parallels of 0°–6° N., and the meridians of 40°–48° W. In the same neighborhood during April, however, I have seen numerous storm petrels (both *Oceanites* and *Oceanodroma*), Greater Shearwaters (*Puffinus gravis*), unidentified terns (perhaps *Sterna paradisaea*), boobies, tropic-birds, and a skua (*Catharacta*). Examples of the petrels were collected. The skua flew between the masts of the brig 'Daisy,' in latitude 5° 54′ N., longitude 40° 30′ W., on April 30, 1913. Simmons (1927, 75) likewise reports skuas between the equator and the West Indies during mid-May.

Ocean waters receiving such a vast discharge as that of the Amazon should, of course, offer favorable conditions for a rich neritic and high-seas life, since they possess at least three of the environmental advantages which Hentschel has listed at the conclusion of his report on oceanic biology (1933, 164). In this region, for example, there are extensive areas of reduced salinity and of enormous terrigenous additions to the ocean. There are also local zones of sinking and of upwelling, caused by differences in temperature and density. And, finally, there is a very active mixing of waters, due to the penetration of the ocean by a sustained flow from the greatest of rivers. All such circumstances, as pointed out heretofore, tend to stimulate a succession of life in the sea.

That offshore currents sometimes show pronounced temperature differences even in the equatorial Atlantic is shown by the following observation made by Ball (1887, 356) on the evening of July 30, in a latitude a little to southward of the mouth of the Amazon.

> With the thermometer standing about 82° [F.], the passengers naturally preferred the upper deck to the close air of the saloon, and were resting in their ship-chairs between nine and ten P.M., when suddenly there came an outburst of coughing and sneezing, followed by demands for muffling of every kind. There was no sensible movement in the air, but I found that the thermometer had fallen to 79° Fahr., and there was a feeling of chilliness which was not easily explained by that slight fall of temperature.
>
> The mystery was explained on consulting the chief officer, who throughout the voyage paid much attention to the temperature of the sea. Since leaving Pernambuco, the thermometer in a bucket brought up from the surface had varied only between 82° and 83°. On this evening we had abruptly encountered a relatively cold current, with a temperature somewhat below 76°, and the effect of being surrounded by a body of cool water when the skin was in the condition usual in the tropics was felt by nearly all the passengers.

The estuary of the Pará, which is in reality the mouth of the Tocantins rather than of the Amazon, is so wide (about 55 kilometers) that from a mid-position the wooded banks on either side are out of sight. Mud and mangroves, flats and narrow waterways mark all the shores, and the river craft produce a certain resemblance to a Chinese stream. Vast extents of territory, such as part of the great pasture land on Marajó Island, are flooded during the rainy season which, as explained in the section on the Amazonian climatic district, is between December and April. From here eastward toward Cape São Roque, however, the peak of the wet period comes later and later in the year until, from February at Belem, it reaches June at the shoulder of the continent.

All of the northerly coastland of Brazil is low, except in the vicinity of Ceará. East of the Amazon the broad continental shelf, studded with green islands close to shore and with small shallows farther out, narrows only gradually toward the east. Behind the beaches are many sandhills visible from the coastwise steamship routes. They present a similar and monotonous aspect, although occasionally interspersed with small reddish cliffs and with clumps of mangroves on the western banks of the rivers. Because of wind and current trends, it is characteristic that the western or leeward side of the mouths of the streams should be covered with vegetation while the eastern sides are sandy and barren. Sometimes the lower sand dunes look like breakers; again, as at Salinas Falsas Bay, they rise in such a manner as to resemble the white sails of schooners. Still farther east are stretches of coast on which the sandy areas look like gigantic pieces of white linen laid out to dry. Northwest of Maranhão, for example, are the islands known as Lençöes Grandes and Pequenos, or the Big and Little Sheets, names likewise repeated on the mainland farther eastward.

Behind the wave-built ridge of the actual beach, which in many places serves as the chief coastal highway, lies much broad, green-forested lowland, with countless meandering rivers. The mouths of the latter are for the most part so obstructed by bars that truly navigable streams are few and far between. Most of the outlets, moreover, seem to be progressively shoaling so that ports like Aracaty, formerly frequented by foreign commerce, are today accessible only to small coasters. There are few safe anchorages for vessels along the open seacoast, and even boat-landings can be made only where spits or reefs extend out from shore, thus forming on their western sides a shelter from the constant swell. Vessels have been detained inside the bar of the River Jaguaribe for months, for want of sufficient water to float them across. A large part of this coast is imperfectly surveyed, but at any rate changes are so rapid that constant revision of charts would be necessary. Between São Luiz do Maranhão and Cape São Roque the only good harbor is Tutoya Bay.

Studies of this part of Brazil—its physiography, vegetation, and bird life—have been made by Snethlage (1917, 41), Reiser (1926, 107), and Hellmayr (1929, 241). In northern Pará and Maranhão most of the hinterland is still covered with majestic primeval forest, which verges into "campo" toward the east. Close to the seashore and along the larger rivers, wooded swamps or "igapós" prevail in even the generally open districts of these states. According to Hellmayr, the coastal forest can be traced as far east as Miritiba, but somewhere between here and the Rio Parnahyba the woodland gives way to an open or at least cleared terrain. Gallery forest naturally continues to extend inland along the rivers well into the otherwise treeless country.

Hellmayr lists, as characteristic of rivers or other waterways along the coast, the Pied-billed Grebe, Bigüá Cormorant, Anhinga, Laughing Gull (doubtless a migrant from the north), the large and small river Terns (*Phaetusa simplex simplex* and *Sterna superciliaris*, respectively), and the southern race of the Black Skimmer (*Rynchops nigra intercedens*), of which the type locality is São Paulo. Inhabiting the beaches during northern-hemisphere winter months are such migrant shore birds as the Hudsonian Curlew, Spotted Sandpiper, Sanderling, Least and Buff-breasted Sandpipers, Robin Snipe, Semipalmated Sandpiper, Dowitcher, Wilson's Plover, Black-bellied Plover, and Ruddy Turnstone.

For some distance to eastward of the Amazon the coastal waters retain a yellowish tint, due to the sediment of many rivers, but toward Ceará they become progressively clear and acquire a greenish aquamarine hue which is famous. The change is due both to greater clarity and to the replacement of dark and silty bottoms by sand. It becomes most pronounced near the point where the relief increases, and where the streams consequently wind through less marshland on their course toward the ocean. It is a short distance east of the delta of the River Parnahyba that the first highlands become visible from the sea and shore—the northern end of the Ibiapaba Mountains, which loom a thousand meters above a sandy foreground. Lesser hills along the coast overlook a great expanse of plains and swamps and a cluster of peaks reaches the shore at Fortaleza.

A heavy sea and a powerful westward-setting current prevail almost constantly along this part of the coast. A frequent haze, and the embarrassing uniformity in the appearance of the land, add to the trials of navigation. The heart of this district, in Rio Grande do Norte, is the Brazilian "Job of the North," discussed in the meteorological section. Southeastward from Fortaleza, the low sandy hills behind the beach have scarcely a trace of vegetation that remains green through the drought periods, but between the mouth of the Assu and Cape Calcanhar lies a coast with groves of coconuts around its numerous villages. Midway in this stretch the great Lavandeira coral reef begins, a certain indication that the control of muddy river water no longer takes precedence over the blue and saline water of the tropical ocean. Not far beyond Cape São Roque, in fact, and from that point southward almost to the tropic of Capricorn, the area of richest, high-sea, ultramarine surface water comes closer to the continental coast than anywhere else in America.

The mouth of the Assu is close to the center of the most arid strip, with rainfall of less than 500 millimeters a year. Over a considerable stretch of coast on either side, it is still less than 1000 millimeters, a feeble precipitation when the high average temperature and rapid evaporation are considered. Throughout northeastern Brazil the rains are all concentrated within one season, the inverno, which alternates with the dry verão. But the months of the rainy season are not everywhere the same. Recife receives 58 per cent of its rainfall during the four months between April and July; Fortaleza, 82 per cent during the five months, February to June; Joazeiro, 99 per cent during the five months, November to March. Thus we find three distinct régimes: autumn rains on the north coast; winter rains on the east coast; summer rains in the interior. The winds of the neighboring parts of the Atlantic explain these differences. The northeastern coast depends upon the southeast trade which here, as elsewhere, is a dry wind. It normally blows from July to December, sometimes continuing until February. Even when its rude squalls beat high against an inhospitable shore, the sky remains uniformly serene. The calms, which follow when the zone of the trade wind has withdrawn toward the south (February-May), bring the storms and rainfall. The rainfall system of Ceará recalls that of Pará, with the exception that the inverno is shorter and later. The zone of calms, advancing from north to south during the southern summer, reaches Pará in December or January, Maranhão in January or February, Fortaleza in February or March. As one goes inland, the rains are earlier. The persistence of the essentially marine trade winds in the coastal region retards the formation of such barometric depressions as appear to announce the coming of summer in the interior. As for the east coast region of winter rains, it has, as on the east coast of Africa, a monsoon system. In summer (November-February) the southeast trade wind is warped to an entirely different quarter by the monsoon winds, and when it strikes the coast of Pernambuco, blowing from the *northeast*, it carries no rain. In winter, on the contrary, the high pressure of the continental air in northeastern Brazil causes the monsoon wind to blow from the opposite direction, that is from the south or southwest, more or less parallel with the coast. This brings heavy rains, though storms are unknown. The monsoon penetrates but a little way into the interior, which explains why the narrow, well-watered coastal zone passes abruptly into the semi-arid region (Denis, 1927).

At Cape Calcanhar the northeastern corner of Brazil is turned, and the coast begins the south by east trend which extends almost to Recife. The greater part of the shore line here, and all the way down to Bahia, is a succession of white beaches and dunes, interspersed with dark green brush, clumps of coconut palms, and occasional lines of reddish bluffs. Villages are numerous, especially at the mouths of the many streams from the plateau, and there is a surprising number of relatively large towns and cities, with populations of 30,000 or more. The following three paragraphs are freely transcribed from Maull's (1930, 9) description of the coast southward from Parahyba do Norte, a little north of Recife.

From the ocean, the country seems to stretch along as a level, forested tableland, broken here and there by comparatively broad valleys. The interrelationships of land forms on the continental border are, however, more complicated than they appear. From the sea, the cultivated lowland is easily overlooked, not because there is little of it but because it presents no surface extensive enough to be conspicuous.

Here and there one notes a line of light sandy beach. Elsewhere the dark wall of woodland is interrupted by brightly colored cliffs. In front of the forest, in some places, stands a second and lower level of vegetation, constituting the mangrove zone. Finally, a reef runs along at a good distance from the beach, sheltering a lagoon behind a fringe of white foam. This resulting belt of quiet water has lured the inhabitants of a coast that is poor in natural harbors not only to take to the sea but even to make long voyages in their extremely primitive craft, the "jangadas." The latter are mere rafts, rigged with a sail and a bench. Under way they are a strange sight, with the lower structure buried in the waves, so that the boatman seems to be standing upon the water and gliding along its surface. It is said that northeastern Brazilians have gone as far as Rio de Janeiro in their jangadas, with the object of attending the Centenary Exposition.

Considerable topographic variety is not lacking on this coast, for at several places the scarp of the plateau retreats inland and a broad foreland opens up. Such is the case at Pernambuco, for example, where the highlands of Olinda draw away from the shore, making room for the plain, which is a mangrove-grown, silted-up lagoon, shut off from the ocean by a tongue of land projecting from the hills.

Historic Cape São Roque is only a slightly projecting point of white sand, about 55 meters high, with a few tufts of brush. It is visible to a distance of about 30 kilometers, and is ringed by reefs. A landing can easily be made northwest of the cape in quiet weather, and even in a fresh breeze the native jangadas run back and forth through the waves. The channel between the cape and the outer reefs is much used for local navigation. The winds at Cape São Roque blow generally from between southeast and east. During the southern monsoon season, that is from June to August, they are most southerly, and since the northwestward current then attains its greatest strength, this is the hardest time of year for doubling the cape. Between December and March the breeze is more easterly and more moderate, the sea prevailingly smooth and the current weak.

Although the average breadth of both the North and South Atlantic Oceans exceeds 6000 kilometers, the distance separating South America from northwest Africa, on the shortest line from Cape São Roque, is only 2840 kilometers. The New World is here closer to the Old than anywhere else, except in the Arctic. This accounts in a measure for the fact that the tropical Atlantic avifauna is relatively uniform; the pelagic birds of the South American coast are in the main those occurring outside the shore-current zone of the African coast; in any event, there is no such division as we find between the eastern and western borders of the broad South Pacific. Such geographic proximity doubtless has a bearing upon problems even more far-reaching than those concerned with the distribution of sea fowl. For example, two species of inland tree ducks (*Dendrocygna*) prove to have ranges common to both Africa and South America. The same is true of the fresh-water and mangrove-swamp pochard, *Nyroca erythrophthalma* Wied, a duck which has been described under various specific names from widely separated localities in both of the great southern continents.

The reefs that extend almost continuously around the shoulder of the continent, from near the mouth of the Assu to that of the Rio São Francisco, are not all of coral. Perhaps more frequently they are ancient barrier strands con-

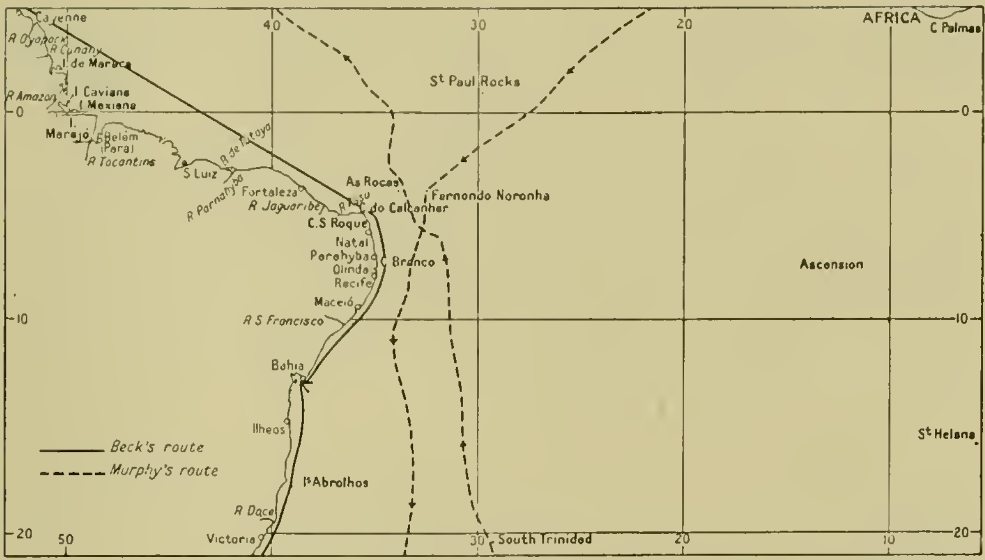


FIG. 17. Coast of eastern tropical South America and the associated oceanic islands. For detailed maps of the latter see figures 18 (As Rocas), 19 (Fernando Noronha), 20 (St. Paul Rocks), 21 (Ascension), 24 (South Trinidad and Martin Vas), 25 (St. Helena). The broken lines in the Atlantic show part of the author's course during the South Georgia Expedition.

solidated by a calcareous cement, and thus forming the famous "stone reefs," which have been investigated by Branner (1904). The extent of limy precipitation at the edge of the ocean is explained by the debility of the coastal streams and the retention of the fresh water in the lagoons for periods long enough for it to become charged with carbonic acid and calcium carbonate.

Such sandstone reefs, which have often been mistaken for coral, accompany the Brazilian shore line, with many interruptions, from northwest of Fortaleza to Porto Seguro, beyond latitude 16° S., a distance of 2000 kilometers. The reefs are mostly straight and they usually lie across the mouths of streams and estuaries, forming natural breakwaters for the harbors behind. Wherever they occur together with coral reefs, the stone reefs are to be found on the landward side. It is possible that there may be buried coral reefs within some of them. Their geologic age is referred to the late Tertiary.

The famous reef at Pernambuco is one of the stone reefs. Viewed from the sea, it looks like a long low artificial breakwater. The outer side is overgrown with seaweeds, barnacles, etc., and is also filled with chitons and sea urchins. At low tide the whole length of the reef is exposed like a black wall.

(1) REEF CORALS IN SOUTH AMERICA

A relationship has been indicated between the Brazilian coral reefs and the temperature, salinity, and clarity or turbidity of the coastal water. The correlations might easily be carried further; for the South American coast as a whole the presence or absence of reef corals is an indicator of certain qualities of ocean water which we have already learned to associate with definite phenomena in the distribution of sea birds. The location and extent of the banks and reefs of corals have been exhaustively studied by Joubin (1912), from whose monograph much of the following information is drawn.

Coral reefs abound on all the islands forming the eastern border of the Caribbean Sea, as likewise on the southern or coastal chain, from Tobago and Trinidad westward to Curaçao and Aruba. The adjacent mainland coast, however, is fringed with reefs in only a few favored localities, chiefly on northerly and northeasterly projections of the shore line, between the province of Sucre, Venezuela, and the Goajira Peninsula, Colombia. Farther westward, there are reefs on either side of the outer Gulf of Darien, to wit, on islets from Cartagena southwards, and along the northerly shores of eastern Panama.

Since mud and corals are incompatible (as well as fresh water and marine corals), the northeastern coast of South America, between the delta of the Orinoco and Maranhão, is absolutely devoid of corals. Off eastern Maranhão there are a few incipient or struggling reefs and more extensive submerged coral beds. Near Fortaleza more substantial fringing and barrier reefs begin, to extend as a more or less broken chain eastward and then southward to a point just north of Cape Frio. The barrier reef along this coast is a sort of miniature of the coral growth of the east coast of Australia, which lies in but slightly more southerly latitudes. On the Brazilian coast, as in Australia, there are frequent breaks in the reef, especially off the mouths of rivers, and the inside channel is navigable in many places. The distance of the Brazilian barrier from the line of white beach is, however, mostly in the neighborhood of two kilometers or less. In places, moreover, the reef is so far submerged that the ocean rollers pass over it to break heavily upon the inner strand. The southernmost coral formation in South America is a small reef on the sheltered mainland shore inside the Restinga de Marambaia, west of Rio de Janeiro and just north of the tropic of Capricorn.

Off Espirito Santo and southern Bahia (16° to 21° S.), where the continental shelf widens, there are extensive coral bank formations, of which the largest is the Hotspur Bank, lying outside the Abrolhos Group. Rocas Reef and Fernando Noronha are fringed by coral growths, but St. Paul Rocks, Trindade, and the Martin Vas Islets are without them.

On the west coast of South America reef corals of any sort are reduced almost to the vanishing point. In the Humboldt Current region, upwelling water produces temperatures too low to be favorable. Joubin reports insular and mainland patches in the Gulf of Panama; a short line of reefs to the northward of Buenaventura, Colombia, and some submerged banks to the southward of the same port; and reefs on the coastal ledges along the northward-facing shore of Esmeraldas, east of Cape San Francisco, Ecuador. Furthermore, he records reefs on Chatham, Charles, and Albemarle Islands, of the Galápagos Archipelago; at Pelado Islet in Santa Elena Bay, Ecuador; at Lobos de Tierra and Pachacamác Islands, San Gallán and the neighboring Paracas Peninsula, Peru. The reefs at San Gallán are doubtless very restricted and, as wherever else they may be present along the Peruvian coast, must owe their existence to special local conditions, such as the warm eddies so often noticeable in Pisco Bay and other indentations of the shore.

3. The Atlantic Equatorial Islands

To what degree the reefs that follow the coasts of eastern Brazil afford nesting sites for sea birds I have been unable to discover. In the absence of any mention of beach vegetation on the barriers of either sandstone or coral, I infer that none possesses soil fully reclaimed from the ocean. We may therefore leave the continental shores for the moment in order to seek a glimpse of important insular bird colonies which are, no doubt, the ultimate source of many marine species recorded from various parts of the southern tropics.

a. Rocas Reef.

Closest of these oceanic islands to the mainland, or at a distance of 222 kilometers, is the Rocas Reef, which is a typical coral island, and the only true atoll in the South Atlantic. Recorded dimensions are at variance, the largest figures indicating that the ring is an ellipse about 8 x 6 kilometers in diameter. On the reef are two small cays, connected at low tide and supporting grass and a little shrubbery. Elsewhere a few knobs of weathered coral project. The highest point does not exceed 4 to 5 meters. The lagoon is shallow, with a bottom of sand and coral, and may be entered by boats during quiet weather through a gap on the northern side.

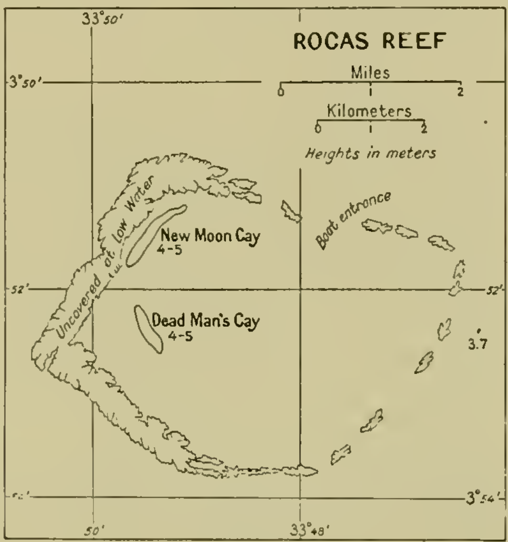


Fig. 18.

Coming northward in the brig 'Daisy,' I passed a short distance to eastward of Rocas Reef at sunset of April 18, 1913. From the masthead we could see one or two tumble-down buildings, the structural support of the automatic light, and a single tall coconut palm, the sole survivor of three which are said to have been planted in 1857. No sign of the island bird life was visible save for a few boobies in the air far off.

Rocas was later visited by the 'Blossom' party, during the South Atlantic Expedition of the Cleveland Museum of Natural History. This was also in April, and Simmons (1927, 71) found hosts of birds breeding. Sooty Terns (*Sterna fuscata*) he estimated to number "hundreds of thousands." They were sitting so close that no indication of the horde was apparent from a distance, but a cloud of birds arose from the eggs when the colony was invaded. On one of the cays Simmons estimated that there were also approximately 1200 nests of the Brown Noddy (*Anoüs stolidus*), 1500 of the Blue-faced Booby (*Sula dactylatra*), and a few of other birds. Furthermore, he observed about the island some 350 individual examples of the Brown Booby (*Sula leucogaster*), 25 of the Red-footed Booby (*Sula sula*), and 15 of the Man-o'-war Bird (*Fregata magnificens*). The last three species may likewise have been breeding, though sites would necessarily be scarce for the Red-footed Booby, which in all parts of the world apparently requires trees or bushes as a support for its relatively well-constructed nest of twigs.

Between the schooner and the reef Simmons saw both Wilson's and Leach's Petrels, the former a northbound migrant from the far south, the other a northern-winter visitant close to the southern limit of its pelagic range.

All in all, the resident avifauna of Rocas Reef is little if any different in character from that of certain offshore islets of the Caribbean, or of outliers of the Antilles.

b. Fernando Noronha.

About 134 kilometers east of Rocas Reef, or 356 from the Brazilian coast, lies the burnt-out volcanic island of Fernando Noronha. It is in reality a group, the lesser islets stretching toward the northeast being called, respectively, Platform, Egg, St. Michael's Mount, Booby, and Rat. Off the southern side is an isolated pinnacle. Although some of the smaller members are partly of sandstone conglomerate, the geological features of Fernando Noronha as a whole are closely akin to those of South Trinidad, which lies more than 1600 kilometers to southward. Clumps of coral grow on some of the rocky shores and on neighboring shallow parts of the sea bottom, though there are no actual reefs.

The main island, which measures about 7 by 3 kilometers, has an undulating plateau rising to 100 meters or so above sea level. Near the middle of its northerly coast there is a bold, overhanging, phonolitic dyke known as the Pyramid, which is upwards of 330 meters in altitude and is the most arresting landmark in the whole South Atlantic Ocean. On the level terrain the soil is thick and rich as a result of the accumulation of humus during a long period.

Fernando Noronha lies in an ocean as warm as the Caribbean. During the season of northern-hemisphere summer it is swept steadily by the southeast trade winds, which are more or less interrupted by doldrum conditions during the northern-winter season. Between February and mid-July the island is well watered; numerous streams form, and waterfalls tumble from the luxuriantly covered cliffs. The mean annual precipitation amounts to 1294 millimeters, but the total is extraordinarily irregular and has varied within a twenty-year period between 460 and 2396 millimeters. Rain is normally scanty during the last four or five months of the year, but the climate is rarely oppressive. It will be noted that here, as on the mainland, the windy season is the dry season. When the trades are strongest, a spectacular surf pounds the windward coasts of Fernando Noronha. During the season of calms, on the other hand, the more sheltered shores are singularly peaceful. Curving beaches of sand run down to

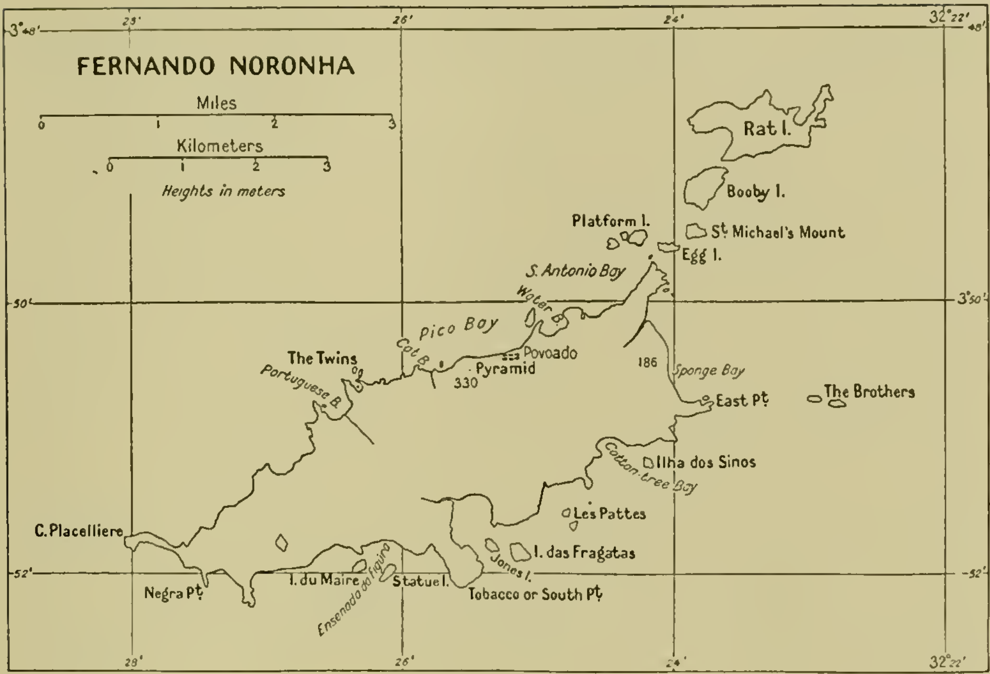


FIG. 19.

quiet, pale green coves, the hue of which is reflected from the white breasts of sea birds flying overhead.

The majority of the oceanic fowl appear to have no fixed breeding season, for the eggs and young of a number of species can be found during any month of the twelve. The Sooty Tern, however, forms an exception to this; here as elsewhere all members of this species apparently lay their eggs together, even though the date of the nesting period may vary somewhat from year to year. The bulk of the sea bird population, particularly the ground-nesting species such as the Sooty Tern, the Brown Noddy, two of the resident boobies, etc., is not on the main island but rather on the islets. The outermost member of the chain, Rat Islet, is upwards of 3 kilometers in length and is rugged and precipitous. It has been worked sporadically for calcium phosphate derived from ancient bird guano. Estimates recorded in the pilot books allege that half a million metric tons of this substance remain to be extracted.

Fernando Noronha was originally heavily forested. At the time of Darwin's visit, in February, 1832, the main island was largely solid woodland, so thickly intertwined with creepers that to crawl through it required great exertion. Darwin was also impressed by the large "magnolias," by trees covered with delicate pink flowers (doubtless *Jatropha gossypifolia*), and by the general beauty of the scenery. He expressed disappointment, however, that the grandeur of the island by moonlight rather faded at dawn, when the hills seemed to shrink under the light of day (Darwin, 1933, 37). He also likened the island (*l. c.*, 341) to the drier parts of the Galápagos, a comparison which seems all the more apt since we now know that the latter archipelago, no less than Fernando Noronha, is characterized by great irregularity in the amount and seasons of rainfall.

The character of the vegetation has been greatly changed through long occupation of the island as a penal colony, and through the introduction of familiar tropical culture plants, such as the banana, coconut palm, maize, etc. Nevertheless, Fernando Noronha still supports a dense and varied flora of indigenous trees, shrubs, vines, and cacti, a number of which are endemic forms, as are likewise several of the insects, lizards, and birds. Most noteworthy among the repriles is the native legless lizard (*Amphisbaena ridleyi*). This animal has been made the prop of far-fetched land-bridge hypotheses, which would make of Fernando Noronha the relict of a continuous terrestrial path between Africa and America. It is, however, closely related to a West Indian form, making a link with the Antilles more notable than any evidence exhibited by the birds. Two of the three resident land birds are endemic. The trio comprises a race of a widely distributed South American dove (*Zenaida auriculata noronha*) which is found in northeastern Brazil as well as on the island, a tyrant flycatcher (*Elainea ridleyana*), and a vireo (*Vireosylva gracilirostris*). The dove forms somewhat odd associations with the sea fowl, particularly when the habits of its continental relatives are taken into consideration. Moseley, naturalist of the 'Challenger,' found it nesting among the boobies and noddies on ledges along the low cliffs of Booby Islet, the eggs and young of the three species being closely intermingled (Moseley, 1879, 83).

Fernando Noronha has been frequently, although scarcely more than casually, investigated by numerous naturalists since early in the nineteenth century. A bibliography of the more important scientific accounts accompanies a report on my own brief visit in 1912 (Murphy, 1915, 46). The following summary of the sea bird fauna is derived from the earlier literature, from my personal observations during a single day's landing in October, and from the subsequent visit of the schooner 'Blossom,' made in March and early April (Simmons, 1927, 60). The breeding species include two tropic-birds, three boobies, one man-o'-war bird, and four terns. They are as follows:

Phaëthon aethereus
Phaëthon lepturus
Sula dactylatra
Sula sula
Sula leucogaster
Fregata magnificens
Sterna fuscata
Anoüs stolidus
Anoüs minutus
Gygis alba

Fernando Noronha appears to mark the southernmost breeding station on an oceanic island of *Fregata magnificens*, which is the characteristic man-o'-war bird of the northern tropical and sub-tropical Atlantic-Middle American zone. Its specific range extends all the way from the Cape Verde Islands on the east to the Galápagos on the west. In north-south extent it stretches from the Bahamas to eastern or southern Brazil, for this same species nests on islets close along the coast of the mainland to southward of Cape São Roque. All the specimens of man-o'-war birds I have seen from Rio de Janeiro and other parts of the southeastern Brazilian coast are *magnificens*. Ribeiro (1919, 186) and Peters (1931, 97) have listed such littoral birds as belonging to the species *minor*, which inhabits South Trinidad, but this appears to be incorrect. Ascension Island, in the middle of the Atlantic and only four degrees farther southward than Fernando Noronha, is occupied by the endemic and highly sedentary, species, *Fregata aquila*, while the larger of the two forms of man-o'-war birds inhabiting South Trinidad, more than fifteen degrees of latitude to southward is a representative of *Fregata minor*, which has a world-wide distribution in the southern tropics and sub-tropics.

Of the other Pelecaniformes resident at Fernando Noronha, the Red-billed Tropic-bird (*Phaëthon aethereus*) has a range most nearly resembling that of *Fregata magnificens*. This tropic-bird is likewise found throughout the Atlantic-American region, from the Cape Verdes to the Galápagos. But it has also penetrated southward to Ascension and St. Helena, in addition to which a race of the species occurs in the Persian Gulf and the northern Indian Ocean. The Lesser Tropic-bird (*lepturus*), the three boobies, and the four terns all belong to species having a more or less world-wide tropical distribution.

Transferring our attention to birds belonging chiefly to the southern tropics, it is highly interesting that Fernando Noronha marks the most northerly and easterly breeding station in the Atlantic of the Fairy Tern (*Gygis*). The resident form is an isolated South Atlantic race, inhabiting only the four islands of Fernando Noronha, Ascension, St. Helena, and South Trinidad. Elsewhere in the milder zones of the southern hemisphere, namely throughout the Indian and Pacific Oceans, the white Fairy Terns have as nearly a continuous distribution as is possible for insular birds which normally do not stray far from their breeding sites, and which consequently, like the man-o'-war birds, tend to become split up into numerous geographic races. Since there are seasons when powerful southeast trade winds blow from Fernando Noronha across the equator almost as far as the mouth of the River Orinoco, speculation offers me no clue as to why *Gygis* has not succeeded in jumping the next gap and establishing itself in the West Indies. Considerably greater distances in the Pacific have been crossed by birds of this genus. Fairy Terns transported to certain islands of the Lesser Antilles would be as assured of a congenial environment as would the previously discussed Brown Pelicans if introduced into southern Brazil.

Finally, Fernando Noronha is noteworthy in that it appears to have no native petrel of any sort. One might assume that its rocks and soil, and the waters of the surrounding ocean, would be well suited to the resident needs of Audubon's Shearwater (*Puffinus lherminieri*), which inhabits the Antillean-Gulf of Mexico region, the Bahamas, and even Bermuda; a distinct race, moreover, is found in the eastern Atlantic at the Cape Verdes. The West Indies have also one or two other native petrels, while no less than six species breed among the islands of the Cape Verde group. Ascension, St. Helena, and South Trinidad each support at least one species.

c. St. Paul Rocks.

Far to the northward and eastward of Fernando Noronha, and at more than double the distance (869 kilometers) from the South American mainland, lies the little horseshoe-shaped cluster known as St. Paul Rocks. The longest axis, from the southernmost to the northernmost rock, is scarcely more than 300 meters, and the highest peak, which is white with the droppings of sea birds, is not more than 20 meters above the level of the sea. Nearer the water the rocks are greenish black. Most of the outliers are more or less mushroom-shaped because the ocean has sapped and undermined them. There is no terrestrial vegetation larger than unicellular algae.

St. Paul Rocks are rare if not unique among oceanic islands in that they are neither volcanic nor coral formations. They are composed entirely of ultra-basic igneous rock of plutonic aspect, and represent perhaps a summit squeezed up by lateral pressure from the floor of the Atlantic Ocean. Darwin (1933, 35) wrote during the cruise of the 'Beagle' that a mile from the islets the lead could not find bottom. Soundings made by the 'Quest' indicate that "at no point is the 100-fathom line distant more than four cables from the rocks, and in places is within 100 feet" (Wild, 1923, 80). More recent sonic measurements by the 'Meteor' show that the rocks represent the pinnacles of a steep-sided mountain no less than 4000 meters in height (Spiess, 1928, 78). They lie in an ocean which is prevailingly stormless and cloudless, except during the brief tempests of the doldrum season. During even calm weather, however, they are usually beset by strong surf, which splashes them with spray to their summits and tends not only to wash away the guano of the sea birds but also to cause it to precipitate its salts in the form of a dense, shining, glassy layer, which has been described by Darwin, Sir James Clark Ross, the 'Challenger' naturalists, and other explorers. According to Moseley (1879, 72) this enamel-like crust is hard enough to scratch glass. It is here given more than passing mention because a similar encrustation is found upon one or more islands off the west coast of South America, to northward of the arid zone.

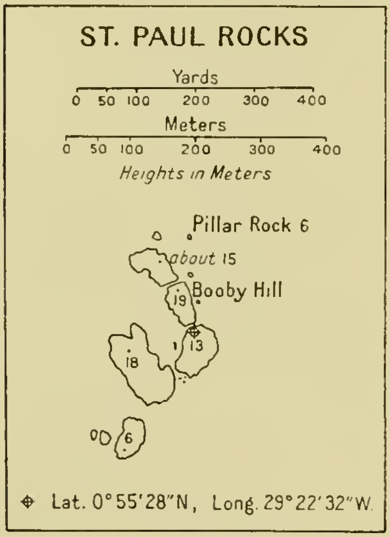


Fig. 20.

Despite the difficulties of landing, St. Paul Rocks have been visited by a considerable number of oceanographic expeditions. It was here that the youthful Darwin, on February 15, 1832, first found himself in the midst of a colony of sea birds and, fired with the enthusiasm of a collector, began to knock down examples with his geological hammer. So far as I can determine, the resident birds are confined to three species, namely, the Brown Booby (*Sula leucogaster*), and both of the Atlantic noddies (*Anoüs stolidus* and *Anoüs minutus*). Boobies thickly cover the higher slopes and summits. Their food consists largely of flying fish, with which visitors have found these birds so crammed that they seemed constrained to disgorge before taking flight. Flying fish brought ashore by the boobies, or inadvertently blown on the rocks by the wind, also supply much of the food of the amphibious crabs which teem on all of the islets. However, the crabs also devour young birds, and Moseley was amazed at the apparent ingenuity of these crustaceans in circumventing their supposedly more intelligent vertebrate rivals.

Of the noddies, the larger and brown species (*Anoüs stolidus*) lays its single egg on bare rock, chiefly in situations lower down than the booby sites. The lesser or Black Noddy has quite different breeding habits. This species is in most places a tree-nesting tern, but at St. Paul Rocks it builds compact, bracketed nests of green seaweed, cemented with dung, on small projections of the slopes and ledges. It is a less abundant member of the island bird life than the other noddy.

A few insects, mites, and spiders complete the terrestrial fauna of St. Paul Rocks. The cove embraced by the islets abounds with sharks and with a great wealth of tropical rock fishes. Among surface species the flying fish have already been mentioned. What kinds of small fry support the noddy population has not yet been reported; perhaps there are enough larval flying fishes to answer the purpose. Noddies do not plunge for their prey in the manner of certain other terns, but rather seize it in mid-air as the tiny, minnow-like fishes leap or sail from the water.

Some of the books on nautical information still give directions, based upon the experience of that redoubtable voyager, Captain Amasa Delano, in the year 1799, for procuring birds' eggs for food at St. Paul Rocks during the month of November. More up-to-date ornithological information demonstrates, however, that these equatorial islets have a characteristic oceanic régime, without a restricted breeding period for the birds, and possibly without even a seasonal peak of productiveness. Moseley, of the 'Challenger,' wrote (1879, 73), "Fitz Roy visited St. Paul's Rocks on February 16th; Ross on May 29th; we on August 29th; on all these occasions eggs and young birds were found. Hence, breeding goes on all the year round." The experience of other parties, such as those of the 'Meteor,' in early May, of the 'Quest' in October, and of the 'Valhalla,' in December (Nicoll, 1908, 2) amply confirms Moseley's deduction.

d. Ascension.

The last of the islands in the Atlantic tropical zone that needs consideration is Ascension, which lies approximately halfway between the shoulder of Brazil and the Lower Guinea coast of Africa. Ascension is a youthful volcanic island, or a "cinder of the sea," nearly circular, with a maximum diameter of 12 kilometers and an area of 98 square kilometers. From the summit of Green Mountain, 859 meters above the sea, about forty lesser hills, representing former vents, may be counted. Most of the natural vegetation of the island is confined to the cap of the mountain, which receives considerably more moisture than

FIG. 21.

the lowlands. The annual average precipitation amounts to only 500 millimeters, the greater part of which falls during the months of March and April. Many species of culture plants have been introduced into Ascension, and are now thriving there, particularly in gardens on the higher slopes of Green Mountain. The introduced animals include a number of birds, such as Guinea fowl and African weavers.

For about a century after the date of Napoleon's exile at St. Helena, Ascension was operated as a British ship of the line and was known and governed as 'H. M. S. Ascension,' but its administration has within recent years been turned over to a commercial cable company.

The ornithological interest of Ascension is largely associated with the fact that the island is the type locality of no less than four species of ocean birds described by three early naturalists. These birds are:

Phaëthon aethereus Linnaeus, 1758	*Fregata aquila* (Linnaeus), 1758
Sula dactylatra Lesson, 1831	*Gygis alba* (Sparrman), 1786

All of these have specific or subspecific representatives in warm seas throughout the globe, and the precise determination of the forms residing at Ascension is the cornerstone of much taxonomic study. As regards the Man-o'-war bird, for example, no other species of this genus was generally recognized by ornithologists for nearly a century after Linnaeus had named *Fregata aquila*. Consequently much of the literature relating to four or more species of *Fregata* is listed under the specific name *aquila*. In point of fact, *Fregata aquila* is now known to be a bird of such restricted distribution that it has never been taken anywhere except at Ascension. Until recently, Ascension was also held to be the type locality of a fifth sea bird, the Red-footed Booby (*Sula sula* Linnaeus 1766). Grant and Mackworth-Praed (1933, 185) have recently shown, however, that this should properly be assigned to Barbados, of the Lesser Antilles.

Ascension has apparently been the home of great colonies of sea birds throughout past ages, for it is reported that a fertilizer company has recently been conducting operations at the northern corner of the island, where the cinder plains come down to the sea. In pits of the lava and volcanic ash there are here quantities of phosphate. As Simmons (1927, 73) remarks, it would be of interest to search for bird bones in these deposits, for the producers of the ancient guano are not certainly known, and they may have been different in part from the modern birds. Even within historic times sea fowl were undoubtedly more numerous on the main island than at present. Thus Darwin (1933, 415) wrote in his diary for July 22, 1836, that he could not imagine the cause of the white patches with which the whole plain was mottled, as seen from the deck of the 'Beagle.' Subsequently he found that "it was owing to the number of seafowl, which sleep in such full confidence, as even in midday to allow a man to walk up & seize hold of them." The description suggests white boobies, although a view of Sooty Terns directly to leeward, with all the birds consequently facing the wind and the observer, might also appear prevailingly white.

The principal present-day headquarters of sea birds are in two places, namely, (1) the Wideawake Fair, which is the famous colony of Sooty Terns at the western corner of the clinker plain; and (2) Boatswain-bird Islet, a short distance off the eastern coast of the main island. Both localities have recently been visited by the 'Blossom' party of the Cleveland Museum of Natural History (Simmons, 1927, 44). Boatswain-bird Islet rises steeply, glaringly white with guano, against the dark volcanic mass of Ascension. Its ledges and talus slopes are occupied by *Sula dactylatra*, and its plateau by both this species and the Man-o'-war bird. In the absence of vegetation, the latter here nests directly upon the ground, as the species *Fregata magnificens* likewise does at St. Michael's Mount, Fernando Noronha. Simmons lists also the Brown and the Black Noddies, the Greater and Lesser Tropic-birds, the Fairy Tern, and a Mother Carey's chicken (*Oceanodroma castro*) as residents of Boatswain-bird Islet, despite the fact that it possesses neither a sprig of green nor a drop of water.

Wideawake Fair has been described by practically every visitor to Ascension. During the breeding season, the eggs of the Sooty Tern or Wideawake, are so thickly distributed that it is difficult to traverse the district without stepping upon them. As many as 10,000 dozen edible eggs have been taken from the colony within a week, but since the robbed pairs of terns immediately lay again, there seems to be no diminution in their numbers from this exploitation. The observations of the 'Blossom' party seem to confirm the time-honored story that the nesting season of the Sooty Terns begins a little earlier in each successive year. The change in time is sufficient to make the birds breed, on the average, four times within three years.

To the sea birds thus far listed as breeding at Ascension, we should add the Brown Booby (*Sula leucogaster*), which nests on Boatswain-bird Rock, where specimens have been collected by members of several expeditions. This makes a total of eleven certain residents, provided the Red-footed Booby (*Sula sula*) can be so regarded. The latter species seems to be invariably a tree-nesting or bush-nesting bird, and arborescent vegetation is altogether lacking at Boatswain-bird Islet and extremely scarce on the main island. Osbeck (1771, **2**, 78), who explored Ascension during April, 1752, when it was still uninhabited, states that it was even then "without woods." However, he adds that the island had "formerly had woods, as appears from several perfect petrefactions of branches of trees, and pieces of wood; but in particular from a large petrified stump" (81). As a further indication of a native flora, Kinnear (1934, 32) has recorded notes and a drawing from the manuscript journal of Peter Mundy to show that an otherwise unknown species of flightless rail inhabited Ascension within historic time, *i. e. circa* 1655.

No specimens of the Red-footed Booby are listed among the birds obtained during many historic British expeditions (Ogilvie-Grant, 1898, 434), nor did the Cleveland Museum party discover the species at Ascension. Nevertheless, Mathews (1915, 216) once designated Ascension as a breeding station of the *Pelecanus Sula* of Linnaeus, upon the apparently sound testimony of Osbeck (*l. c.*, 89), which is as follows:

> *Diomedea Adscensionis* was caught here. It was entirely white, not even the thirteen feathers in the tail excepted; had red feet, formed chiefly for swimming; and only black tips to its wings: for the rest, it is like the *Diomedea piscatoria*

This description could probably apply to no other bird, and we may conclude that the Red-footed Booby was a former resident, whether or not it still breeds at the island. Furthermore, Osbeck first noted the presence of the nesting petrel (*Oceanodroma castro*), examples of which have only recently been collected at Ascension. He writes (89): "We also saw a species of little black sea birds, but only upon the wing."

Finally, there is the dubious case of the southern tern, *Sterna vittata*, which is listed as a breeding bird of Ascension by a number of recent authorities (Alexander, 1928, 169; Peters, 1934, 333). Careful search has thus far failed to yield the source of this record. In other parts of its range the tern is confined to sub-antarctic or to barely sub-tropical islands, and I suspect that the inclusion of the species as a breeding bird of Ascension, or even of St. Helena, is merely an oft-repeated error. Sclater (1924, 149) is more cautious than some of the other compilers; he states only that *Sterna vittata* ranges in the South Atlantic and Indian Oceans from Ascension to Tristan da Cunha and Kerguelen Island, nesting at Tristan. The whole substance of the original association of this tern with Ascension may be sought, perhaps, in a misinterpretation of Reichenow's (1908, 562) statement: "Streicht nordwärts bis zur Gough-Insel, Tristan d'Acunha und ist sogar auf der See zwischen St. Helena und Ascension erlegt."

(1) ROLLERS

Ascension, like several of the other Atlantic islands, is notable for the phenomenon of "rollers," or great waves, which are not related to movements of the surface caused by the prevailing southeast trade wind. They are said invariably to break with particular force on the leeward side of the island. Such waves occur perhaps equally at St. Helena, South Trinidad, and Fernando Noronha. The late Lady Gill, who accompanied her husband to Ascension in July, 1877, before a historic measurement of the solar parallax, wrote as follows of the rollers during October of the same year (1878, 147):

> During the five previous days they had been persistent, and for the first twelve hours their grandeur and power exceeded anything I had ever conceived. I thought I had seen rollers at their worst on the day we landed at Ascension, and again on the night of the eclipse, but these I now found were but baby rollers after all. The full-grown giants shook our little encampment like an earthquake, and the noise of their thunder deafened us. What a sight it was! My pen is quite powerless to describe it.
>
> They fascinate one, too, these mysterious rollers, and, watching them, we enjoyed our evening stroll along the shore more than usual. Yet, each time that a great wave rosé up twenty or thirty feet high, and came thundering along to dash itself to pieces on the beach, I shrank back with a sort of involuntary desire to flee the sight.

According to Meliss (1875, 392, 404) the rollers usually reach Ascension from one to seven days before the same rhythms strike St. Helena. At both islands their direction of progress is southerly or southeasterly, so that they break only against northerly shores. At St. Helena the worst manifestations occur after prolonged lulls in the trade wind, between December and March. The long-remembered rollers of February 17, 1846, appeared during early morning, without other warning than the calm and sultry air, and, by evening of the same day, thirteen ships at anchor in the harbor of Jamestown had been shattered to bits against the rocks.

Waves of this nature take their origin from distant meteorological disturbances, and have nothing to do with winds prevailing locally. In some instances they may represent hurricane waves, such as have been described on p. 55. Their source, on the other hand, may more often be due to much less perceptible stimuli. It is now known, for example, that similar great swells breaking in the neighborhood of Casablanca, on the coast of Morocco, are caused by barometric depressions over the ocean between Iceland and the Azores. The rollers of the South Atlantic islands, and the swells known in the neighborhood of Rio de Janeiro as "resacas," are doubtless equivalent phenomena, as are also the "surf days" which frequently come during calm weather at the Chincha Islands and other historic guano-loading localities along the Pacific coast of the continent. In former times the shipmasters who contracted to transport guano always demanded a special allowance for a certain number of days during which the mysterious and unpredictable rollers from the open Pacific would entirely prevent them from carrying out their accustomed labor. The birds of the Peruvian guano islands, and no doubt the cliff-dwelling sea fowl of the South Atlantic islands, also take unconscious account of the conditions, for rarely if ever are nesting sites selected on ledges exposed to the capricious fury of the rollers.

4. Recife de Pernambuco to the Río de la Plata

To southward of Cape São Roque there are more navigable rivers than to northward and westward, and the entrances to many of the larger inlets possess effective natural breakwaters in the stone reefs. All this part of the coast, however, to a point south of Bahia, lies within the region of anomalous southern-winter rainfall, and the long dry season causes such a shrinkage in the amount of running water that some of the streams can be entered by vessels only during the rainier parts of the year. The point emphasizes merely the unequal distribution of rainfall for, upon the basis of figures, all of this coast should be regarded as well watered. The mean annual precipitation at Parahyba amounts to 1763 millimeters, at Recife 2092 millimeters, at Bahia 1876 millimeters. Nevertheless, away from the river deltas, the flat shoreline strip is generally sandy, and covered, even where moisture is copious, with a somewhat scanty vegetation in which coco palms predominate.

Cape Branco, close to latitude 7° S., from where the coast runs nearly due south, may be taken as the easternmost projection of the continent. To southward of the cape, the reef, which is usually studded here and there with the hulks of wrecks, is particularly fragmentary, or even missing entirely along considerable stretches of shore. For some distance, moreover, the mainland coast is here made up of bold and conspicuous reddish cliffs, visible from far at sea.

Such islands as are found along this part of Brazil are obviously delta or estuarine formations. The largest is Itamaracá, a little north of Recife, and lying in a bight of the mainland from which it is separated by a narrow channel. Its seaward shore is covered with groves of coconut palms, among which are the white dwellings of fishermen, and the fronting beach is constantly pounded by breakers from the open Atlantic. At Recife itself the remarkably artificial looking stone reef, which has given the port its name, thoroughly protects the roadstead from the battering of this same surf.

From the neighborhood of Recife the coast line begins a southwesterly trend that extends to the Bahia de Todos os Santos; likewise it grows more irregular and picturesque. Beyond the mouth of the Rio São Francisco, hills become visible from the ocean; the land is higher and there are many small bays and headlands to replace the monotonous sandy beaches that extend from Maranhão to Recife (Smith, 1879, 1, 448). The significance of this change is that the sedimentary zone has narrowed until the granite massif touches the coast. Between Parahyba and Bahia the table-land rises from 60 to about 200 meters, while the valleys, on the other hand, take on toward the south a more submerged appearance, until their outer parts resemble fiords. Some of them are filled up with mangrove-covered alluvium, while others are blocked off by a continuous barrier beach, behind which is a lagoon or an ill-drained swampy tract with its long axis at right angles to the shore line. Near Maceió, for example, are two such lakes, fed by rivers from the interior of the country and communicating through narrow mouths with the ocean. Such bodies of water are prophetic of the still more extensive lagoons to be found farther southward on the Brazilian coast. The Bay of Todos os Santos at Bahia is itself a drowned estuary which, however, maintains a wide connection with the sea. Wherever along this coast the Tertiary beds of the table-land are worn away by the waves, they form straight cliffs which furnish abundant material for the coastal currents to transport. In favorable places, therefore, flats have secondarily formed in front of such precipices, making young foreshores now grown over with coconut palms.

To northward of Bahia, the original coastal forests have mostly been destroyed, owing to the relative density of human population mentioned above. For a long distance south of Bahia, however, forests practically everywhere cover the eastern edge of the continent. The rounded, tree-clad mountain ranges are visible from the ocean long before the low plains at their bases appear. To northward of Rio de Janeiro such plains are in the main due to breaks in the ranges, which allow the rivers to carry their detritus into the Atlantic. South of Rio, where the maritime mountains are more nearly continuous, narrow coastal plains of this type are mostly lacking.

At Ilheos, a little to southward of Bahia, the southern limit of the region of anomalous winter rainfall is passed, and we reach a part of the coast in which the dry season is little marked. The annual precipitation amounts to 2234 millimeters. The bulk of the rain comes between November and May, but there is a sceondary maximum in September. From this point southward the predominance of summer rainfall becomes more definite. The six months of southern winter account for only 22 per cent of the total annual rainfall at Campos, inland from Cape São Thome. At Rio de Janeiro the annual rainfall of 1118 millimeters is more equally divided, 36 per cent being received during the six winter months.

From Bahia the coast runs nearly southward for 400 kilometers, or as far as the vicinity of the Abrolhos bank and islands. It is a fertile and well-settled stretch, with numerous modern Brazilian towns as well as villages still inhabited by the aborigines. Broad sandy beaches alternate with wooded hillocks, the latter sometimes carved into reddish cliffs toward the sea. The mountain barrier is not high along this part of the shore, the peaks ranging up only to about 600 meters. Mouths of rivers can be distinguished by the breakers on the reefs that protect most of them but, owing to the general absence of striking landmarks, many impermanent objects, even such as conspicuous trees, have come to receive more than ordinary recognition from mariners.

Along parts of this coast coral growths run close to the shore; elsewhere deep water extends to the very base of the continental scarp. The northern edge of an extensive submarine plateau, upon which lie the Abrolhos Islands and reefs, begins at about latitude 17° S. The bank measures roughly 250 by 200 kilometers, is as shallow as 30 or 40 meters over wide areas, and yet rises abruptly on its offshore side from abyssal depths. Between the Abrolhos and the outlying Rodgers Bank, for example, the 'Meteor' obtained echo-measurements of 3800 meters, and along the southeasterly side of the main bank found a very steep slope descending to 2000 meters (Spiess, 1928, 233). Along the margins, soundings of 60 to 600 meters are in many places in close proximity, and no less than ten or twelve small banks, separated from the principal plateau by deep water, approach close to the surface. Thus the Abrolhos Bank and the outlying fragments really form a considerable chain of mountains under the sea, with five peaks of no great extent projecting into the atmosphere.

The islets are constructed of the familiar Brazilian reef lime, rather than of coral, but they are fringed and surrounded by coral formations. There are four principal members and two smaller ones, arranged in an irregular ring, and lying approximately 65 kilometers from the nearest point of the mainland. The five named islets are called Santa Barbara, Redonda, Siriba, Southeast, and Guarita. Santa Barbara, the site of the lighthouse, is in latitude 17° 57′ 31″ S., and is 33 meters in maximum altitude, with a length of slightly over a kilometer. The vegetation comprises only cactus, and small shrubs. All of the Abrolhos Islets are said to be covered with the nests of innumerable sea birds about which, however, little appears to be known. The only specimen that I have been able to find among many collections of oceanic birds is an example of *Sula dactylatra*. Doubtless other species of boobies, frigate-birds, Sooty Terns, and one or both of the Atlantic noddies make up a good proportion of the resident sea bird population.

Darwin (1933, 46) gives a record of a landing from the 'Beagle' at the Abrolhos Islets on March 29, 1832. This was marked by a larder-raid upon the sea fowl, of which such an enormous number were slaughtered by the aid of guns, sticks, and stones, that the victims were more than the ship's boats could hold. Unfortunately, no examples appear to have been preserved, nor are the kinds named. On the sea at a distance from the islets, or around the borders of the bank, Darwin reports that the only birds seen were Mother Carey's chickens. The latter were probably *Oceanites oceanicus*, numerous specimens of which were collected by Beck close to the Brazilian coast at the same season of the year but nearly a century later.

The Abrolhos are the seat of an extensive fishing industry carried on by the inhabitants of the neighboring coastal villages. Everywhere about the islets the water is shallow, warm, and clear, and the coral reefs of both the fringing and the barrier types harbor multitudes of rock-dwelling and bottom fishes, besides which flying fish and other surface species come close inshore from the Brazil Current. While the upper waters of the open ocean in this region are in general too warm to support a teeming marine life, the very presence of such islets as the Abrolhos has an enriching local effect. This may be due in part

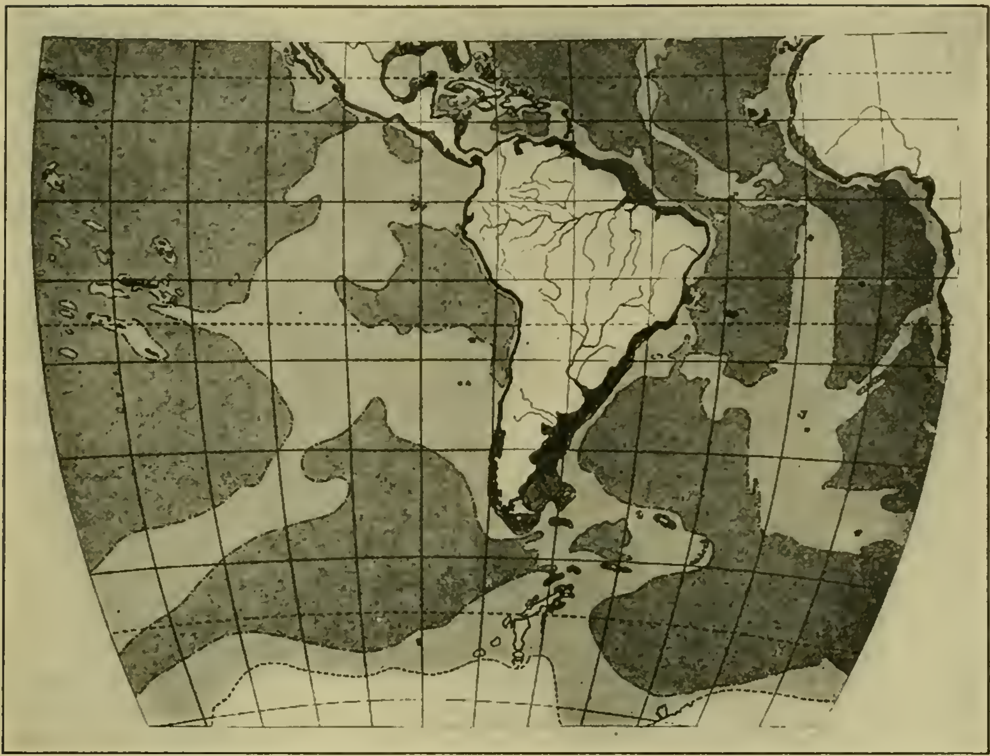


FIG. 22. Bathymetric chart showing the continental shelf (to 200 meters), the oceanic ridges and plateaus bounded by the 4000-meter contour (light areas), and the deeper basins of the South Atlantic and eastern South Pacific Oceans. Note that the Whaleback Ridge connects the African and mid-Atlantic plateaus.

From the American Museum homolographic base map of the world (1931).

to the forcing upward of deeper and cooler waters by the slope of the bank. According to Schott (1926, 109), both the ocean waters and the surrounding land of what he terms the "Brazilian Basin" are prevailingly cooler than the water and atmosphere of the same latitudes on the African side of the Atlantic. In the western bed of this ocean there is nothing corresponding to the Whaleback Ridge, which bars the cold and deep polar waters out of the African Bight. The northern limit of the Brazilian Basin extends from St. Paul Rocks west-southwestward, by way of Fernando Noronha and the Rocas Reef, to Cape São Roque. Thus only an interrupted line of submerged mountains corresponds with the Whaleback off the African coast.

In the neighborhood of the Abrolhos Islets there are interesting coral structures differing from the several types of ordinary reefs and banks. Most notable among these are the clumps or coral-heads, which the Brazilians call "chapeirões." These are small patches in the open sea, which rise like pillars from depths of 15 or 20 meters or more, their tops sometimes attaining the level of low water. Occasionally they spread out aloft, like mushrooms. The Parcel dos Abrolhos, on which many vessels have been wrecked, is a cluster of such coral structures to eastward of the archipelago and several square kilometers in area. In quiet water, and especially when viewed from a distance, the surface of the sea over the chapeirões appears to be flecked by shadows, each of which marks the position of a coral column.

To southward of the Abrolhos Islets the coast of Espirito Santo is generally low, with spits and sandhills dividing the sea from the lagoons and marshes that extend inland 40 kilometers or more to the base of ranges parallel with the shore. The Rio Doce, notable among Brazilian rivers for the fruitfulness of the land it traverses, enters the Atlantic at 19° 37′ S., with very extensive banks, formed by river detritus, off its mouth. The flotsam includes trunks of large trees, many of which stick at various angles in the changing bars, while during the rainy season others may be encountered floating at sea, far off the mouth of the stream.

To southward of the Doce the ocean encroaches still more closely upon the elevated crustal block of the continent, which is bounded by scarps. The foreland is higher, with increasing slopes and cliffs, and peaks with an altitude of 1000 meters or so are visible from the ocean. Rounded islets, with brushy or wooded tops, become more and more common close to shore toward Cape Frio and Rio de Janeiro. Evidence of a double geological shift here begins to be indicated. The first movement involved a recent slight uplift, shared with more northerly sections of the Brazilian coast, as well as with Patagonia; the second a still more recent and more pronounced submergence, increasingly marked toward the south. The sunken bays of Rio, Santos, and Paranaguá all testify to this depression of the immediate shore.

The great bend in the coast just to eastward and northward of Rio is formed by two salients, of which Cape São Thome, the more northern, is low and sandy, with a vast swampy plain behind it, while Cape Frio is bold and double-summited, with wooded slopes and an altitude of about 500 meters. Cape Frio is often the first landfall for ships bound toward Rio from the north and east, and here clouds of butterflies, or bewildered land birds perching in the rigging, are likely to extend a welcome to tropical lands. From Cape Frio, the shore, rising steadily westward from strands to bluffs and cliffs, leads to the harbor of Rio de Janeiro. The best general view of the beautiful site of the city is to be obtained from the ocean to southward. Thus seen, the peculiar and much-described topographic formations within the metropolitan area form a united picture with the Organ Mountains rising behind. Within the harbor is an island called Cagarra, a word suggestive because in Old-World Portuguese settlements, such as the Azores, Madeira, and the Cape Verde Archipelago, it is the name given to a large shearwater (*Puffinus*). However, the term connotes merely the conspicuous defecations of sea birds on the rocks, and the islet at Rio is more likely to be an ancient breeding place of the Brown Booby than of any species of petrel.

Along the southward-facing coast on both sides of Rio de Janeiro there is an eddy-like countercurrent, called the São Sebastião after the large island between Rio and Santos. This flows eastward toward Cape Frio, for the name of which it is doubtless responsible, the current being considerably cooler than the average littoral water in these latitudes. There it meets and mingles with the main stream of the Brazil Current, which flows southward from the direction of the Abrolhos Islands. The relatively low temperature of the São Sebastião may be due in part to upwelling from intermediate depths close along the steep shore. At certain times of year, especially in midwinter (June-July), morning fogs hang above the adjacent coast, completely concealing the land, but these usually dissipate early in the day under the power of the rising sea breeze. The effect of the São Sebastião is therefore, in miniature, like that of the Humboldt Current along the coast of Peru. Its meteorological and oceanographic consequences illustrate objectively the great influence of even very slight mean differences of temperature within the tropics. From the subjective angle, as pointed out by von Humboldt (1852, 1, 178) at the end of the eighteenth century, atmospheric variations of only six or seven Centigrade degrees in tropical South America are sufficient to produce in human beings the opposite sensations of heat and cold.

The vicinity of Rio marks the beginning of a far more rugged type of coast than is to be found to northward. Here the eastern scarp of the Brazilian horst closely parallels the sea. Steep, rounded, rocky hills, of the type known as ilsenbergs, rise from the narrow lowlands. There are numerous sharply incised bays and, for the first time since leaving Trinidad, lofty islands represent separated portions of the continent. Ilha Grande (1000 meters), nearest to Rio, still has a relatively scanty human population. São Sebastião (1339 meters) is as high as the adjacent mainland shore, and as thickly populated. Santa Catharina, 48 kilometers in length and 600 meters in altitude, is the site of the capital city of the State of Santa Catharina, and has a population of close to 100,000. Santo Amaro, Ilha do Mar, Cananéa, and Ilha do Cardozo are other members of this chain of high continental islands, which are forested except where the land has been cleared for cultivation. In this respect they entirely resemble the mainland terrain and present a marked contrast with lower islands a little farther offshore. The latter, having no opportunity to benefit by the adiabatic cooling made possible by long and steep slopes, suffer from the characteristic "trade wind drought," which has been mentioned so often before. For instance, the Alcatrazes Islets, about 24 kilometers southwest of São Sebastião, and at a considerably greater distance from any point of the Brazilian shore, are exceedingly barren even though the highest member of the cluster attains an altitude of 268 meters. The islets of Castilho and Figueira, to southward of Santos, are still better examples of arid spots not far from shore but too low to be effective in the local condensation of water vapor. Amaral (1921, 41) has given a description of a number of the small islands in this region, including particularly Queimada Grande, which lies about 64 kilometers southwest of the Bay of Santos and has an area approximating one square kilometer. Although in part well covered with small trees, Queimada Grande has a generally parched appearance and receives relatively little moisture when compared with the opposite mainland. It is surrounded on all sides by great rocks, and is quite inaccessible except when the sea is calm. It is inhabited by a number of species of small land birds and by an extraordinarily large number of bird-eating snakes, the curious habits of which Amaral has described in detail. The resident sea birds of the region are identified by this author only as "mergulhões" and "gaivotas," but one of his plates fortunately shows a group of what appear to be Brown Boobies, perched upon a large boulder. Doubtless the neighboring Alcatrazes Islets take their name from this same species. In most parts of Hispanic America pelicans are the first choice for the name alcatráz; wherever pelicans are lacking, the word is applied to boobies.

Bryce (1912, 371) has called the scenery of the richly wooded eastern side of the Brazilian plateau, where it breaks down steeply towards the Atlantic, as beautiful as can be found anywhere in the equatorial regions. He had approached this coast from the south, and when his steamer,

> . . . rounding a lofty cape, turned her prow shoreward to enter the harbour of Santos, . . . here at last were the tropics. Here was the region of abundant and luxuriant vegetation, a soft, moist air and a sea of vivid blue, with the strange thin-bodied, long-winged frigate birds hovering above it. As we came near enough to see the waves foaming on the rocks, an amphitheatre of mountains was disclosed, surrounding the broad, flat valley through which a river descends to form rhe port of Santos. To the north there ran along the coast a line of lofty promontories against which the surges rose. The mountains behind, all densely wooded, were shrouded with heavy mists, but the sun bathed in light the banks of the river, covered with low trees and flowering shrubs, and the gaily painted houses of the suburb which stretches out from the town of Santos, embowered in palm groves, to the white sands of the ocean beach.

The coastal region is here low and narrow, and is sharply separated from the high interior by the Serra de Paranapiacaba, as it is farther northward by the Serra do Mar. The land is once again crossed by many rivers, all of which are characterized by an extremely rich aquatic life. In addition to the abundant resident birds native to the shore and the country behind it, there are also many snipes and plovers which migrate from the northern hemisphere, as well as visitors from southern South America, such as the Black-necked Swan, which comes to São Paulo to escape the rigors of the Patagonian winter season (Koenigswald, 1896, 332).

The drowned character of the coast line increases southward. At Cananéa, for example, the coast is slit by narrow, branched straits, more or less parallel with the shore, which widen out to southward to form the inland sea known as the Mar de Tarapande. The Ilha do Cardozo and the Ilha Comprida lie on the ocean side of these waterways, which extend as sheltered natural canals all the way up the coast to Iguapé. Off the main entrance into Cananéa lies the small islet of Bom Abrigo, the welcome sight and name of which guide vessels through the channel between dangerous bars. Even more submerged is the appearance of the Bay of Paranaguá, which cuts far into the state of Paraná with numerous fiord-like arms, and makes a practicable approach to a broad valley rich in tropical vegetation. Two large islands in the mouth of the bay furnish shelter from the prevailingly strong surf and currents but, after entering, one finds a quiet, land-locked harbor, with steep-sided inner coves extending in several directions ("N," 1860, 327). Still farther southward, as at Pelotas, the Tertiary rock of the plateau is buried under a hundred meters of recent gravels and clays.

From Cape Santa Martha Grande, south of Santa Catharina Island, the coast trends southwestward for nearly 500 kilometers, or as far as Rio Grande do Sul, in the form of long sandy beaches or "praias." The mountains are here far inland and, since they draw away from the ocean still farther toward the south, where great lagoons lie behind the beach barriers, the shore is prevailingly arid for the same reasons noted as applying to low islands. Beyond the white beaches are dunes and flat sandy hills, with a scanty cover of stunted vegetation. The largest of the many fresh lagoons, lying in faults of the coastal terraces, is the Lagoa dos Patos. Does this body of water take its name from true "ducks," or from the vast numbers of cormorants (*Phalacrocorax olivaceus*) that frequent it? Grafted on to its northern end is the deep bay of Porto Alegre, which is itself the drowned estuary of the Rio Jacuhy. The flood-head of the river has been sufficient for the Lagoa to maintain an egress through the barrier beach, in the form of the Rio Grande, which is a strait between lake and ocean rather than a river.

The prevailing winds along this stretch of coast are northeasterly, but the southwesterly pamperos, which blow with great violence, are not uncommon during the winter, their effect sometimes reaching northward to Santos. At the latter city the annual rainfall amounts to 2083 millimeters, with the dry season lasting only from June to August. A little to southward we meet the region of even rainfall régime, which extends down the coast beyond the estuary of the Río de la Plata. Thus at Porto Alegre and Pelotas the rains are almost equally divided throughout the seasons. The mean annual temperature naturally lowers gradually from north to south in the coastal region. At Santos it is 21.9° C., at Porto Alegre 19.1°. However, in drawing away from the tropic of Capricorn the summer temperatures are reduced only slightly, those of winter much more markedly. Thus at Santos the means for the warmest and coldest months, respectively, are 25.5° C. and 19.1°; for Porto Alegre the corresponding figures are 24.6° and 13.6°. The cultivation of characteristic tropical culture plants, such as sugar-cane and coconuts, can be carried on along the coast about as far south as Porto Alegre (30° S.).

As regards native seashore vegetation, we reach in the vicinity of Santos the southern limit of mangrove-growth along the east coast of South America. These plants, which have been mentioned so often in the account, comprise several species, of which the most important are the true mangrove (*Rhizophora manglier*) and the black mangrove or couridá (*Avicennia nitida*). The first of the two grows mainly on flats overflowed by tidal rivers, while the second fringes more or less open seacoasts wherever the topography is favorable. The chief factors determining the distribution of the plants seem to be sufficiently saline water and a minimum annual temperature of about 10° C. That they are an excellent index of average climatic conditions is evidenced by their very dissimilar distribution on the easterly and westerly sides of South America.

On the Pacific coast they extend southward only as far as the Peruvian border of the Gulf of Guayaquil (about latitude 3° 30′ S.). At this point the absence of estuaries, together with climatic conditions associated with the Humboldt Current, impose an abrupt bar to their extension. Along the Caribbean and Atlantic coasts they are characteristic, as we have seen, of suitable localities as far southward as latitude 24° S. or a little beyond. It is rather curious that whereas the southward growth of reef corals falls short of that of the mangroves on the east coast of South America, the same organisms have contrived to find at least a feeble development for a long distance south of any mangrove-growth on the western side of the continent. In general the range of mangroves may be said to be substantially similar to that of tropical jungle vegetation in well-watered low country immediately behind the shore. It is not very different, moreover, from the present range of feral coconut palms along the coast. The latter plant is, of course, strongly halophytic. It attains its greatest vigor and luxuriance at the seashore, and is usually the first tree to become established upon newly exposed tropical beaches and coral reefs. Humboldt (1852, 290) reports that when these palms were planted in the inland missions of the Orinoco, it was customary to put half a bushel of salt into the hole receiving each nut.

The several organisms, both plant and animal, just mentioned as examples of tropical distribution are confined to either the land or the sea side of an attenuated geographic zone of torrid coastal lowlands. With only brief interruptions, this extends for more than 11,000 kilometers along the borders of South America, or from near the southern boundary of Peru northward and eastward around the continent, and then southward to about latitude 27° S., or to the neighborhood of the island of Santa Catharina, Brazil. In most places this coastal belt is very narrow; only in the region of the Amazon estuary does it extend inland as much as 500 kilometers. From southern Brazil around the southerly tip of South America, and thence up the west coast to the northern end of Chile, such flat or undulating coastal country as has just been referred to is replaced nearly everywhere by mountainous regions, or by plateaus of considerable height which are steep along the edges facing the sea so that the inland limits of the coastal strip are at least very clearly marked.

The two types of coastal topography, in combination with the distinct character of the littoral water found along each region, correspond in the main with the grand division between the pan-tropical and the sub-antarctic realms of ocean and shore life. Latitudinally the two parts are highly asymmetrical, each tending to center about its respective pole of an axis that crosses the continent of South America from northeast to southwest. Allowing for certain variations in ranges due to local conditions, particularly to Humboldt Current phenomena on the west coast, we may say that the northeasterly moiety of the South American coastal outline, from southern Brazil to Peru, lies within the range of reef corals and mangroves; of the Portuguese man-o'-war (*Physalia*), flying fish, dolphins (*Coryphaena*), and other tropical pelagic creatures; of frigate-birds, tropic-birds, and equatorial types of boobies. Its beaches, more-

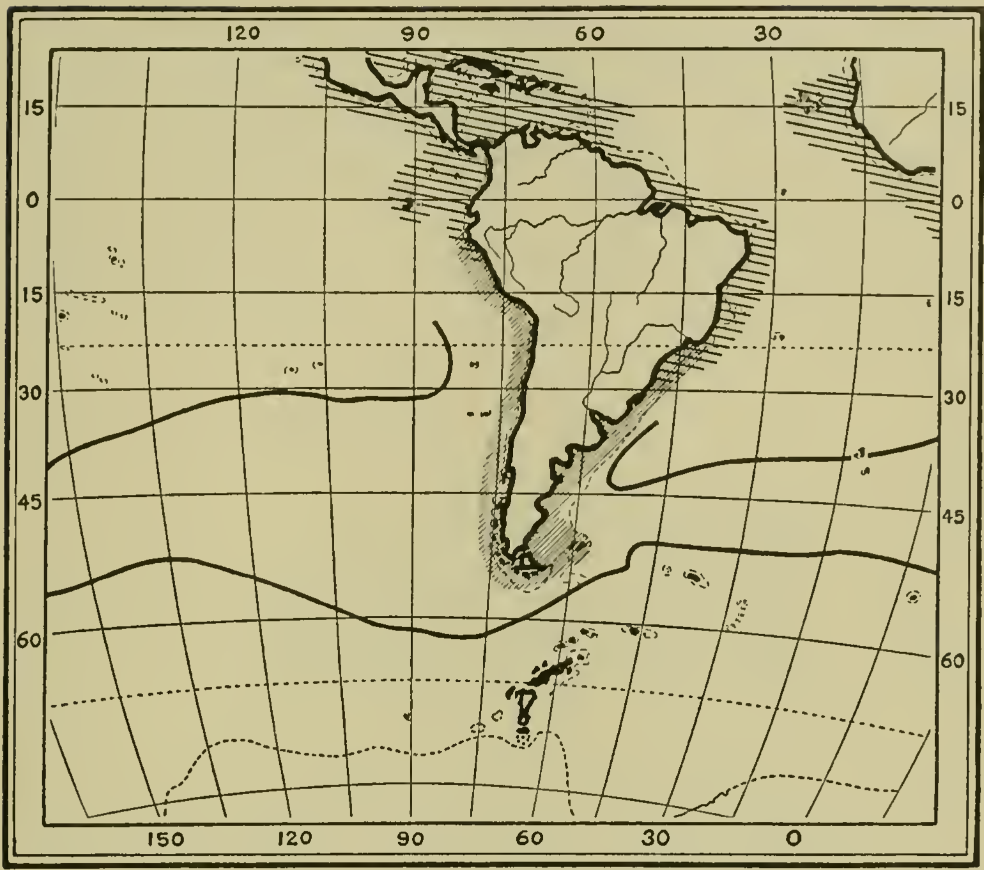


Fig. 23. Complementary examples of oceanic distribution in South America, as correlated with surface temperatures. Coarse shading shows the range of a pan-tropical man-o'-war bird (*Fregata magnificens*), fine shading that of a sub-antarctic tern (*Sterna hirundinacea*).

The heavy, transoceanic lines mark the approximate mean positions of the Antarctic and the Sub-Tropical Convergences, the course of the latter being very uncertain in the Pacific.

over, are the breeding sites of sea turtles. On the other hand, the southwesterly part of the continental circumference, from southern Brazil to Peru by way of Cape Horn, comprises the totally different and supplementary zone of the giant kelp (*Macrocystis*); of sub-antarctic seals and sea-lions; of penguins, white-breasted cormorants, Wandering Albatrosses, Cape Pigeons (*Daption*), and other birds which are at home in cold seas. The respective assemblages of life should be thought of in relation to the oceanic zones discussed above in the section on hydrology.

In the northeasterly, or generally tropical, section of the South American coast, many kinds of inland marsh birds, some of which have already been given passing mention, reach the ocean shore. Other species, such as the West Indian Flamingo and a number of Limicolae, are almost wholly confined to beaches and flats washed by salt water. Examples of both of these aggregations of tropical or sub-tropical birds, which can by no means be called oceanic but which are useful, nevertheless, as indicators of oceanic climatic influences, are listed below. In some instances the coastal range is typical or exclusive; in others it is merely a coastal contact dependent upon mangrove-growth; in still others, the species concerned inhabit treeless swampland, or even beaches lying in front of arid plains. The assigned limits of coastal range are to be regarded as only approximate. Probably in no instance, moreover, is the littoral distribution continuous throughout the range indicated; rather, its pattern is determined by various local ecological factors. In the following list, subspecific discrimination of the birds is omitted.

WATER-TURKEYS

Anhinga anhinga. Ecuador to southern Brazil.

HERONS

Ardea cocoi. Peru to Argentina.
Butorides striatus. Colombia to Uruguay.
Florida caerulea. Peru to Argentina.
Leucophoyx thula. Northern Chile to Uruguay.
Hydranassa tricolor. Ecuador to eastern Brazil.
Nyctanassa violacea. Peru to southern Brazil.
Botaurus pinnatus. Colombia to southern Brazil.

WOOD IBISES

Mycteria americana. Peru to Argentina.

IBISES

Mesembrinibis cayennensis. Ecuador to Argentina.
Guara rubra. Ecuador to southern Brazil.

SPOONBILLS

Ajaia ajaja. Peru to Argentina.

FLAMINGOES

Phoenicopterus ruber. Galápagos Islands to Guiana.

RAILS

Rallus longirostris. Peru to southern Brazil.
Aramides cajanea. Peru to Uruguay.

PLOVERS

Charadrius collaris. Peru to Argentina.

Somewhat similar to the coastal distribution of the foregoing sixteen species is that of the two most characteristic terns of South American tropical rivers. These are *Phaetusa simplex* and *Sterna superciliaris*, a large and a small species, respectively, both likely to be found along almost any part of the coast between eastern Colombia and Uruguay or Argentina. These two terns, like the marsh birds named above, are to be regarded as eminently continental rather than oceanic. Since they belong to the fauna of great rivers, they are confined almost altogether to the slopes of Caribbean and Atlantic drainage, and have not occupied the narrow western side of the Andean watershed. The Large-billed Tern (*Phaetusa*), however, has been at least once or twice recorded from western Ecuador, where the River Guayas alone simulates a fluvial system worthy of comparison with those that bear water toward the Atlantic. In the estuaries of the Caribbean and Atlantic rivers, and along the shores between, both of these terns reach salt water.

The Red-billed Tern (*Thalasseus eurygnatha*) has likewise practically the same coastal range, but this species is typically littoral rather than fluviatile. It inhabits many of the Caribbean islands, and others along the Atlantic border of the continent.

Let us for the moment leave the pan-tropical birds, whether of continental or pelagic affinities, and consider the waterfowl of the Atlantic west wind belt. We may say that Cape Frio, washed by the cool São Sebastião, represents at certain seasons of the year the threshold of the south. It is along this part of the Brazilian coast that we begin to encounter sea birds from the pan-antarctic zone in watery territory more properly belonging to tropical species and to widely distributed continental water birds. Perhaps the cool coastal current has much to do with the regular occurrence of southern species in the bight of the coast that stretches from Cape Frio to Cape Santa Martha Grande. At any rate, here the breeding ranges of a southern tern (*Sterna hirundinacea*) and of the Kelp Gull (*Larus dominicanus*) overlap that of the Brown Booby. Penguins, Cape Pigeons (*Daption*), and an occasional albatross, moreover, visit waters within the regular beats of the man-o'-war bird and of tropical terns.

The von Iherings (1898, 113; 1904, 345; 1907, 1) have discussed the birds of São Paulo and the states to southward, and Luederwaldt (1929, 1) those of the island of São Sebastião. The following sea birds of southern Atlantic affinities are reported:

Spheniscus magellanicus. Frequently caught in the nets of fishermen; often dies in great numbers during midwinter (August) along the beaches between Rio Grande do Sul and Paranaguá. Reported from Ilha de São Sebastião, Santos, Iguapé, and Guarujá.

Diomedea melanophris. Rio de Janeiro, Santos. Also an albatross, listed by Luederwaldt as "*Thalassogeron* sp.," has been found dead on the beach of the Ilha de São Sebastião.

Daption capensis. Ilha de São Sebastião, Iguapé, Rio Grande do Sul. Spix and Martius (1824, 1, 119), moreover, report *Daption capensis* and *Phaëthon aethereus* seen together in latitude 18° S., longitude 35° 20′ W., close to the Abrolhos Islands. There could hardly be a better example than this of the meeting of extremes!

Pachyptila. Whale-birds, under several different names, have been recorded from Ilha de São Sebastião, Iguapé, Santos, and even from Bahia. The specific determinations, however, do not inspire confidence.

Procellaria aequinoctialis. Iguapé, Bahia.

Pterodroma macroptera. Dead on the shores of Ilha de São Sebastião.

Oceanites oceanicus. Many points along the coast of Brazil.

Von Ihering and Luederwaldt furthermore list the Manx Shearwater (*Puffinus puffinus*) as a migrant petrel from the northern hemisphere which has been collected along the São Paulo coast. Among resident and breeding species of water birds they name the following:

Sula leucogaster.

Phalacrocorax olivaceus. "Lives equally on the coast, in lagoons, and along rivers of the interior" (H. von Ihering).

Fregata magnificens. (Listed by these authors under the names *aquila* and *minor.* All specimens I have seen from southern Brazil, however; prove to be *magnificens*).

Larus dominicanus.

Phaetusa simplex.

Sterna hirundinacea.

Sterna superciliaris.

Sterna trudeaui.

Thalasseus eurygnatha.

Rynchops nigra intercedens.

The skimmer and several of the terns are, of course, chiefly birds of the bays, estuaries, and lagoons. The mixture of tropical and southern species is a further indication of the overlapping avifaunas of southern Brazil. Von Ihering states that tropic-birds (*Phaëthon*) are not found along the coast of São Paulo. This is interesting in view of the presence of both the Atlantic species as breeding birds at Fernando Noronha and Ascension. Since neither *Sula dactylatra* nor *Sula sula* is mentioned as occurring in these waters, it is highly probable that these two distinctly tropical boobies, as well as the tropic-birds, do not pass to southward of the clear and warm littoral ocean that ends somewhere in the vicinity of Cape São Thome, or not far from the tropic of Capricorn. Hentschel (1933, 121) speaks of the tropic-birds as reaching a maximum limit of "40° S. latitude" in the South Atlantic. The statement, however, is probably a slip of the pen, for the same author's accompanying distributional chart (pl. VII) shows that during the cruise of the 'Meteor' no field observations of tropic-birds were made even as far south as latitude 20° S.

Southward from Rio Grande do Sul, the Brazilian coast continues of the same general character as described above, all the way to the Uruguayan border. A little north of Point Palmar, which is the first of several salients that turn progressively toward the estuary of the Río de la Plata, are the Coronilla Islands, where there are seal rookeries under the jurisdiction of the Uruguayan government. Smith, who has investigated these and neighboring islets, writes (1927, 287):

> The most northern islands on the coast of Uruguay are the Coronilla group, lying in latitude 33° 56′ S., about 17 kilometers to the southward of the Chuy River which marks the boundary

between Uruguay and Brazil. These islands are resorted to by both fur seals and sea-lions, and are the northern limit of the range of these animals on the east coast of South America. The group consists of two main islands and several islets, and lies about 2½ kilometers offshore, off a promontory sometimes designated as Punta de los Loberos.

With reference to the northernmost breeding stations of southern pinnepeds in South America, it is worth noting that "lobo" is the Brazilian, as well as the Spanish-American, word for sea-lion, and that there are two small islets called Lobos—Grande and Pequena, respectively—at about latitude 26° 30′ S., just south of the Ilha de São Francisco. Perhaps in former times the sea-lions or fur seals, or both, ranged somewhat farther toward the edge of the tropics than their reduced population now extends.

South American seals of all sorts graphically reflect by their distribution the same kind of oceanographic phenomena which we have attempted to interpret through the distribution of sea birds and of many other marine and neritic organisms. The southern sea-lion (*Otaria byronia*), for example, ranges from these small islands, just north of the estuary of the Río de la Plata, southward along the Patagonian coast to Cape Horn. It reaches the Falklands, but not South Georgia; neither does it cross Drake Strait into truly antarctic waters. From islets off Tierra del Fuego the range stretches continuously northward along the western coast of the continent as far as the Humboldt Current is in contact with the shores. The northernmost "loberías," or sea-lion rookeries, are in the neighborhood of the westernmost projection of South America, at Punta Pariñas, Peru (4° 45′ S.).

Before the destructive advent of white men, the so-called antarctic fur seal (*Arctocephalus*) and the sea-elephant (*Mirounga*) each had a very similar distribution. The former animal has now been largely decimated, and the sea-elephant wholly exterminated, within the South American field. Just as the three species of seals thus far mentioned marked the cold waters of high southern latitudes, or zones of cool upwelling within the tropics, so the nearly extinct West Indian seal (*Monachus*) was once a symbol of the warm Caribbean. Incidentally, the southeastward extension of the West Indian seal seems to have been limited by the same physical attributes of the ocean water which have prevented the Brown Pelican from invading the northeasterly segment of the South American coast. I can see no other reason, at any rate, why both pelican and seal should not have reached or rounded Cape São Roque.

Off Cape Polonia, Uruguay, which is a conspicuous rectangular promontory flanked by broad sandy beaches that merge into high dunes, are the Castillos and Torres groups of seal islands. Farther westward, near the famous "East Point" of the estuary, are the larger and more important Lobos Islands.

The Lobos Islands, lying 10 kilometers off Punta del Este, Department of Maldonado, are usually cited in works of reference as located in the mouth of the Rio de la Plata. The trend of the coast from Montevideo to Maldonado is in general a continuation of the left bank of the estuary of the Plata, but it does violence to the physical and biological facts to regard the Lobos Islands, with their typical marine littoral fauna and surrounded by water of high salinity, as being in the mouth of the Plata.

The Lobos group consists of a main island, an outlying low islet, and a number of small detached rock masses over which the surf breaks. Lobos Island proper is about one kilometer long and half a kilometer wide, with a maximum height of 20 meters, and is composed mainly of exceedingly rugged granite ledges, boulders, and cliffs, in places left in fantastic shapes by the volcanic upheaval of which evidences remain in small smooth laval areas and outcropping honeycombed laval rocks in the interior of the island. A shallow soil of sand, shells, and humus supports a sparse stunted vegetation of which conspicuous elements are a harsh brake and a diminutive cactus. Sandy beaches are few in number and of limited extent, the principal beach, at the northwest end, being the only safe boat landing and having determined the location of government houses connected with the sealing industry, a lighthouse, and a wireless station. There are no harbors, and landing is at times difficult, if not precarious, owing to the heavy swell and strong currents. The southern part of the island has the most elevated and broken shore, a striking feature being a huge, semi-detached castle-like buttress, with precipitous sides and numerous ledges and crevices to which the seals resort, the base being surf-beaten (Smith, 1927, 279).

Smith notes, furthermore, that the waters about all of these essentially temperate islands are infested with ravenous sharks of sufficiently large size to prey upon the seals. His remarks upon the resident bird life, in the following description of the main island of the Coronilla group, is particularly important for our purposes (287):

The larger island is landward and eight-tenths of a kilometer long. The low northern end is composed of granite ledges and boulders, with a considerable soil-covered area planted with cane and oats about an abandoned sealing plant. The higher southern end is very rugged, with extensive fissured granite ledges and huge boulders. The shore has no landing places but inside the surf-washed boulders there are half a dozen flat sandy or shelly areas. In some places the shells, washed in by the storm waves, are in great variety and of exquisite beauty and are in beds several meters thick. Wherever there is vegetation and in and about the abandoned buildings, there exist untold thousands of large land snails, including two edible species introduced into Uruguay from Europe many years ago and now found all over the country. Conspicuous birds resident on the island were a black-backed gull, abundant and nesting, a few eggs observed, many downy young running about; a small tern, nesting; the teru-tero, or lapwing, a number of old birds observed and several young caught by the Uruguayan sailors who stated that the birds are easily tamed and make interesting household pets; the black oyster-catcher, several adults seen and a nearly grown bird and two downy young brought aboard the vessel; a black cormorant, numerous; a red-breasted grebe, a nearly full-grown young of the year caught in tall grass; and a colony of orioles nesting in the cane-brake.

The gull mentioned is *Larus dominicanus;* the tern probably *Sterna hirundinacea;* the lapwing *Belonopterus chilensis lampronotus;* the black oyster-catcher *Haematopus ater*, here doubtless at the extreme northern limit of its breeding range on the Atlantic coast; the cormorant *Phalacrocorax olivaceus*, with which we have already become acquainted in a wide variety of climatic and edaphic environments; the grebe, presumably *Colymbus chilensis*. Also, Wetmore (1926, 134) tells us that the Brown-hooded Gull (*Larus maculipennis*) nests in abundance on rocky islets along the coast of the Department of Rocha, Uruguay, which can mean only the Coronillas, the Lobos, or neighboring groups.

The list of residents has a prevailingly southern stamp, which is heightened by Smith's reference to the annual appearance in large numbers of penguins about the northern seal islands of Uruguay (*l. c.*, 292). Every winter (July–August), he writes, penguins resort by thousands to the islands and to the extensive sandy beaches at Cape Polonia. Then, as the season advances and the air and water become warmer, they sicken and die. "Not one penguin survives until the next fatal migration occurs." As many as 3000 have been known to succumb at Cape Polonia during a single season. From the skins of many the local sealers make up various articles of wearing apparel.

Smith is certainly incorrect in identifying these penguins as *Pygoscelis papua.* They are undoubtedly the Magellanic Penguins (*Spheniscus magellanicus*) undertaking the normal winter exodus from nesting grounds along the Argentine coast, as described hereafter in the biography of the species.

5. The Atlantic Sub-Tropical Islands

Leaving the continent once more, we may now visit several oceanic islands which I have already designated as sub-tropical both because of their climatic position and the constituency of their bird life. South Trinidad, with the neighboring Martin Vas group, and St. Helena comprise the entire list of these. St. Helena has, of course, even less claim than Ascension to be called a South American island; nevertheless, it is a link in the distributional chain of South Atlantic sea birds. While Tristan da Cunha lies, as heretofore stated, on the convergence between sub-tropical and sub-antarctic waters, its zoölogical associations are mostly with the latter zone, despite the presence of breeding noddies. The Tristan group may therefore best be discussed in conjunction with Gough Island, which, like the Falklands, is thoroughly sub-antarctic.

a. South Trinidad and Martin Vas.

South Trinidad or, in the Portuguese spelling, Trindade, is 1207 kilometers from the continent, with dimensions commonly recorded as about 6.4 by 3 kilometers, and an altitude of about 600 meters. Although geologically rather similar to Fernando Noronha, having peaks of phonolite associated with basaltic lavas, Trindade differs from the less lofty equatorial island in that it nearly everywhere rises steeply from the ocean; there is almost no strand, and very little coastal fringe of any other sort. Coral reefs are mentioned by Simmons (1927, 28) but by none of the earlier visitors; their presence needs confirmation.

The geographic position of the island is toward the southerly edge ot the trade wind zone. Rainfall is sufficient to support a wealth of tree ferns and other evergreen vegetation on the upper windward slopes, but the northerly sides of the mountains are barren. Owing to the porosity of the volcanic soil and the absence of stratified rocks, most of the precipitation is absorbed beyond redemption; the brooks and waterfalls are transient even if torrential, and the few springs are untrustworthy. One stream, flowing through a cluster of ruined stone huts on the northern shore, may perhaps be perennial. Trindade has more than once been occupied by resident human beings, but can hardly be said ever to have supported a permanent settlement. However, Rockwell (1932, 434) infers that it has been again used within the last decade as a place of detention for Brazilian political prisoners.

So much that is romantic and eerie is associated with the history and appear-

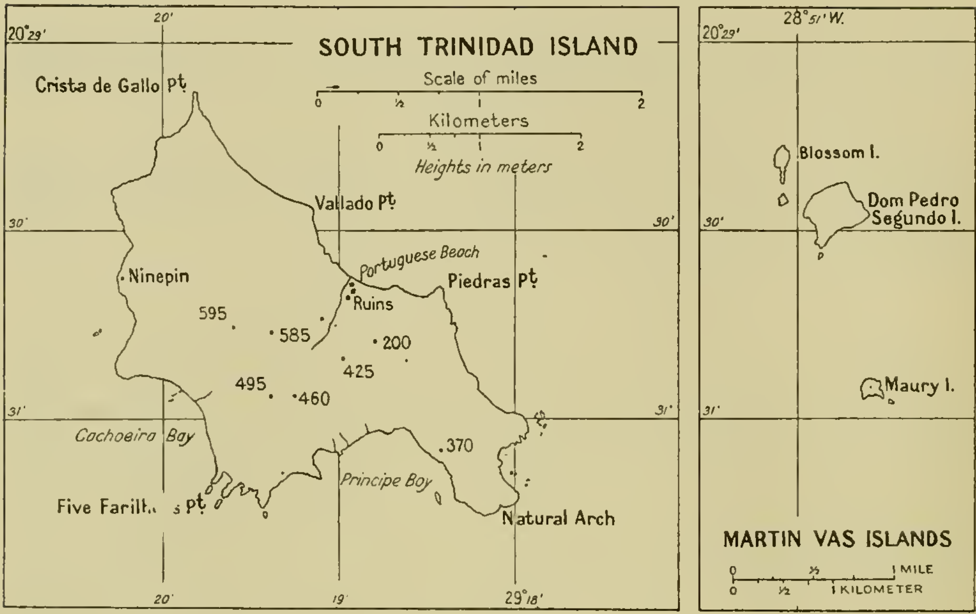


FIG. 24.

ance of Trindade that it would be unfair, even in a scientific discussion, to give no suggestion of this. The following paragraph is from a report made after my own youthful visit to the island in April, 1913. In the paper referred to, incidentally, I have cited a bibliography of 19 titles, dealing with the principal visits of naturalists to Trindade up to that date.

East of the coast of Espirito Santo some seven hundred miles lies a fairy island. Alone in the tropical ocean, piled up in peaks as fantastic as tossing waves, and overhung with pennons of torn clouds which seem to flutter from the summits, Trinidad has exercised a strange charm upon the imaginations of all who have but seen its silhouette on the borderline of sky and sea. During four centuries it has been a landmark in the trade routes of the South Atlantic, often sought by sailing vessels as a check upon their nautical reckonings. Before the days of steamers it was a veritable signpost at a crossroads of the sea, yet few indeed are the travelers who have set foot upon its crumbling shore. Pirates in the old times, whalers, treasure-seeking adventurers, ill-fated colonists, in their turn have come to Trinidad and gone; the island seems unfalteringly to forbid the encroachment of permanent habitation. None who have felt its presence can speak or think of it unstirred; even the prosaic pages of the 'South Atlantic Pilot' become alluring at the account of Trinidad, and the Director of the British Antarctic Expedition of 1901, though he surveyed the islet with the critical eye of science, was deeply impressed by "the dream-like appearance of this remarkable cluster of volcanic peaks in the early tropical dawn" (Murphy, 1915, 332).

All over Trindade the brittle, standing, residual rock structure has assumed grotesque forms through extreme weathering. The summits of the ridges are a succession of needle-like pinnacles. The island has given many visitors the impression that through erosion and landslides it is fast crumbling to bits. Needless to say, the crossing of the mountainous ridge, or an ascent to the highest point, is a relatively formidable undertaking, although both have been many times accomplished. During my own single day on the waters about Trindade, we found it impossible to land because of the heavy swell. Twice since that date, however, the island has been exhaustively investigated, first by a Brazilian scientific expedition (Ribeiro, 1919, 171), and later by the 'Blossom' party of the Cleveland Museum of Natural History (Simmons, 1927, 28), the members of which spent nearly six weeks at the island during 1925. For a month of this period Messrs. R. H. Rockwell and Alan Moses dwelt in a cave on a hillside, just out of reach of the furious surf, while collecting and preparing a comprehensive series of the fearless resident birds (Rockwell, 1932, 435).

In the destiny of its vegetation, Trindade may be going the way of Ascension, although its current stage is several centuries later than that of the latter island. When the astronomer Halley landed at Trindade in April, 1700, its windward coast was well covered with forests of large Brazilwood trees (*Caesalpinia*). These trees subsequently all died, the last mention of living examples in the groves harking back to the eighteenth century. There has been a good deal of speculation as to the cause of such destruction, the explanations offered including an emanation of volcanic gases, a sharp decline in the amount of rainfall, and the activities of goats liberated by Halley (Copeland, 1882, 269). In view of the history of St. Helena forests, discussed below, it is likely that the goats offer an adequate explanation for the destruction of the trees of Trindade. The creatures would first feed upon the undergrowth, while increasing enormously in numbers, and would take next to the leaves and bark of the trees. As food became used up, the goat population would in turn decline, until a natural balance had been attained. The goats of Trindade, long thought to have died out completely with the passing of the Brazilwood trees, have been observed, together with hogs, on the secluded upper slopes of the island as recently as 1925 (Simmons, 1927, 28; Rockwell, 1932, 436). Simmons reports that they still appear to subsist entirely upon vegetation, while the feral hogs feed chiefly upon land crabs.

The novelist Captain Marryat includes a picturesque and factual account of the dead forests of Trindade in his first work of fiction, "Frank Mildmay, or the Naval Officer," which was published in 1829. His words are as follows:

> Here a wonderful and most melancholy phenomenon arrested our attention. Thousands and thousands of trees covered the valley, each of them about thirty feet high; but every tree was dead, and extended its leafless boughs to another—a forest of desolation, as if nature had at some particular moment ceased to vegetate! There was no underwood or grass. On the lowest of the dead boughs, the gannets, and other sea-birds, had built their nests in numbers uncountable. Their tameness, as Cowper says, 'was shocking to me.' So unaccustomed did they seem to man that the mothers, brooding over their young, only opened their beaks in a menacing attitude at us, as we passed by them.
>
> How to account satisfactorily for the simultaneous destruction of this vast forest of trees was very difficult: there was no want of rich earth for nourishment of the roots. The most probable cause appeared to me, a sudden and continued eruption of sulphuric effluvia from the volcano; or else, by some unusually heavy gale of wind or hurricane, the trees had been drenched with salt water to their roots.

During the voyage of the 'Terror,' McCormick (1884, 23) landed twice on

Trindade in January, 1840. At that date the upper slopes were still covered with great numbers of dead trees, barkless and blanched, mostly fallen and scattered about in wild confusion, but with here and there one standing erect in the soil. After the beginning of the present century, Knight (1907) added the following account, which describes the contemporary status of the Brazil-wood forests:

> The mountain slopes were thickly covered with dead wood—wood, too, that had evidently long since been dead; some of these leafless trunks were prostrate, some still stood up as they had grown. . . . When we afterwards discovered that over the whole of this extensive island, from the beach up to the summit of the highest mountain—at the bottom and on the slopes of every now barren ravine, on whose loose-rolling stones no vegetation could possibly take root—these dead trees were strewed as closely as it is possible for trees to grow; and when we further perceived that they all seemed to have died at one and the same time, as if plague-struck, and that no single live specimen, young or old, was to be found anywhere—our amazement was increased.
>
> . . . . Looking at the rotten, broken-up condition of the rock, and the nature of the soil, where there is a soil—a loose powder, not consolidated like earth, but having the appearance of fallen volcanic ash—I could not help imagining that some great eruption had brought about all this desolation; . . . . I think this theory a more probable one than that of a long drought, a not very likely contingency in this rather rainy region.

The very recent notes and photographs of the 'Blossom' party give a similar picture, except that still more of the dead boles have fallen, while the branches and the prostrate logs have progressed several stages nearer final dissolution. The condition of this rotting vegetation has a very important effect upon the history and future of the resident sea birds, a subject to which I shall return below.

Simmons collected about thirty species of plants on Trindade, making a considerable addition to the previously known flora. The tree fern, so conspicuous on the plateaus and higher slopes, is an endemic species (*Cyathea Copelandi*). The lower limit of its growth was determined by the naturalists of the 'Discovery' to be at an altitude of about 335 meters. In addition to the vascular plants, there are a number of species of mosses and lichens, including a tree-infesting *Usnea*.

Before discussing the bird life of Trindade, it will be well to set down a brief description of the neighboring Martin Vas Islets, which lie about 50 kilometers to eastward. The altitude of the highest of these has been variously given as from 90 meters to twice that. At any rate, the cluster is high enough to be visible from the shore of Trindade. There are three main islets, lying along a north-south line, the two northern ones close together, the southern member about 4 kilometers from the other end of the chain. All are relatively inaccessible, the middle and tallest island, in particular, towering abruptly from the sea toward its flat plateau, which is covered with luxuriant grass or sedge. Round about are many fantastic rocks, some in the form of spires, others domed and arched. The geological composition is evidently similar to that of Trindade.

The Martin Vas group was briefly visited by a whaleboat party from the schooner 'Blossom' in December, 1924 (Simmons, 1927, 27).

The bird life of Trindade and Martin Vas differs from that of the Atlantic islands to northward in the apparent absence of the two large intertropical boobies (*Sula dactylatra* and *S. leucogaster*). Positive and more significant differences are found in the presence of the Lesser Frigate-bird (*Fregata ariel*), and also of a species of Greater Frigate-bird (*Fregata minor*); we have not previously encountered either of these during our circumnavigation of South America. Still more important among the new elements is a petrel (*Pterodroma arminjoniana*) which is a member of a group widely distributed in the Sub-Tropical Zone of the southern hemisphere. The fact that neither of the Atlantic tropic-birds (*Phaëthon*) has yet been reported from Trindade or Martin Vas need not be emphasized until it becomes certain that no member of the genus is to be found there. The islands have thus far been investigated at haphazard seasons of the year, and it is worth noting that for a long period both the Noddy and Sooty Tern were overlooked. There seems to be no longer any doubt, however, that the islands do not harbor a single species of native land bird. The resident avifauna, as known to date, comprises the following eight species:

Pterodroma arminjoniana. A petrel of several puzzling plumage phases, no less than four of which have been described under as many specific names. It is related to *P. neglecta* of the sub-tropical South Pacific and may be regarded, indeed, as the Atlantic representative of that species. Like its close relatives, the Trindade petrel is a surface-nesting bird, laying its eggs in hollows and niches of the rock. It inhabits both Trindade and the Martin Vas Islets in vast numbers.

Except for *Oceanodroma castro* at St. Helena and Ascension, *P. arminjoniana* is the only petrel certainly known to breed in any part of the Atlantic between Tristan da Cunha and the West Indies.

Sula sula. An abundant species which appears to be the only resident booby of Trindade. It is a bird of critical interest because of its dependence upon vegetation for its nest and nesting sites.

Everywhere in the world, so far as I have been able to determine, this booby constructs its nest of twigs and places it among the branches of shrubs or trees, upon the fronds of palms, or upon stumps or fallen logs. Curiously enough, it lays but one egg, as do the frigate-birds and fairy terns, whereas the ground-nesting boobies usually lay a complement of two or more eggs. The fairy terns, however, are content to nest upon either wood or rock, and the frigate-birds can at least be forced by circumstances to abandon their shrub-nesting habit and to build upon ledges or even upon bare ground close to the edge of a plateau above the sea. But in the case of the Red-footed Booby, I have thus far found but a single instance (reported upon in the biography of the species) of a nest that is not supported upon some sort of plant-growth, dead or alive. The disappearance of suitable vegetation from any island means, indeed, that *Sula sula* will cease to reside and breed upon it. No doubt the practical abandonment of Ascension Island by this species took place long ago with the dying off and eventual disintegration of the original trees. Trindade seems to be following the same course, except that there is a considerable amount of arborescent vegetation in addition to the blighted and vanishing groves of *Caesalpinia*.

The 'Blossom' expedition photographs show the Red-footed Boobies of Trindade invariably nesting on weather-beaten and decaying wood, however small the fragments may be. Mr. Rockwell tells me, moreover, that during his visit of a month he never saw a nest, egg, or chick of the booby in any other situation. Most of the nests were of small size for this species, a result which might be expected in view of the difficulty the birds would have in finding a ready and abundant supply of small sticks, such as they ordinarily use.

All of this leads one toward an interesting speculation regarding the future of the Red-footed Booby at Trindade. As the remnants of the Brazilwood become reduced to dust, will the boobies tend to confine themselves to cramped nesting sites in the bushy growths on the heights of the island, or will they make the seemingly simple yet unprecedented transition from wood-nesting to rock-nesting? Fortunately, the answer to this question can be learned within a measurable length of time, and a marked reduction in the booby population of the island would probably mean that the history of the species at Ascension is by way of being repeated at Trindade.

At the Martin Vas Rocks, where there is no woody growth, the Red-footed Booby does not nest.

Fregata minor. At Trindade we find this large species of man-o'-war bird at its northernmost breeding station in the Atlantic. The statement would need modification if it should become known that the man-o'-war bird formerly residing at St. Helena belonged to the same species. In other oceans *Fregata minor* is very widely distributed, extending its range into the North Pacific as far as the Hawaiian group.

As previously noted, the Trindade form apparently does not reach the Brazilian coast, where it is replaced by *F. magnificens*.

Fregata ariel. The Lesser Frigate-bird is another new species in our list, finding at Trindade its sole breeding station in the Atlantic. Like *Fregata minor*, it appears to be highly sedentary. Both forms of frigate-bird were observed about the Martin Vas Rocks by the 'Blossom' party.

Sterna fuscata. The Sooty Tern nests in December and January, its breeding areas being rather restricted. One colony occupies rocky platforms around tide-pools of the northern islet of the Martin Vas group, and a second certain islets known as the Tents, off Trindade.

Anoüs stolidus. Abundant at both Trindade and Martin Vas.

Anoüs minutus. The Black Noddy inhabits Martin Vas but, so far as known, not Trindade. Nicoll (1906, 673) obtained one specimen. The 'Blossom' records refer to it as a species "breeding in nests plastered against an almost perpendicular cliff" at the main islet of Martin Vas (Rockwell, 1932, 434).

Gygis alba. Abundant at both Trindade and Martin Vas.

b. St. Helena.

St. Helena is 2897 kilometers from South America and only 1835 kilometers from the nearest point of the African coast. It is larger than any of the oceanic islands we have yet considered, being 16.5 kilometers in length and nearly as

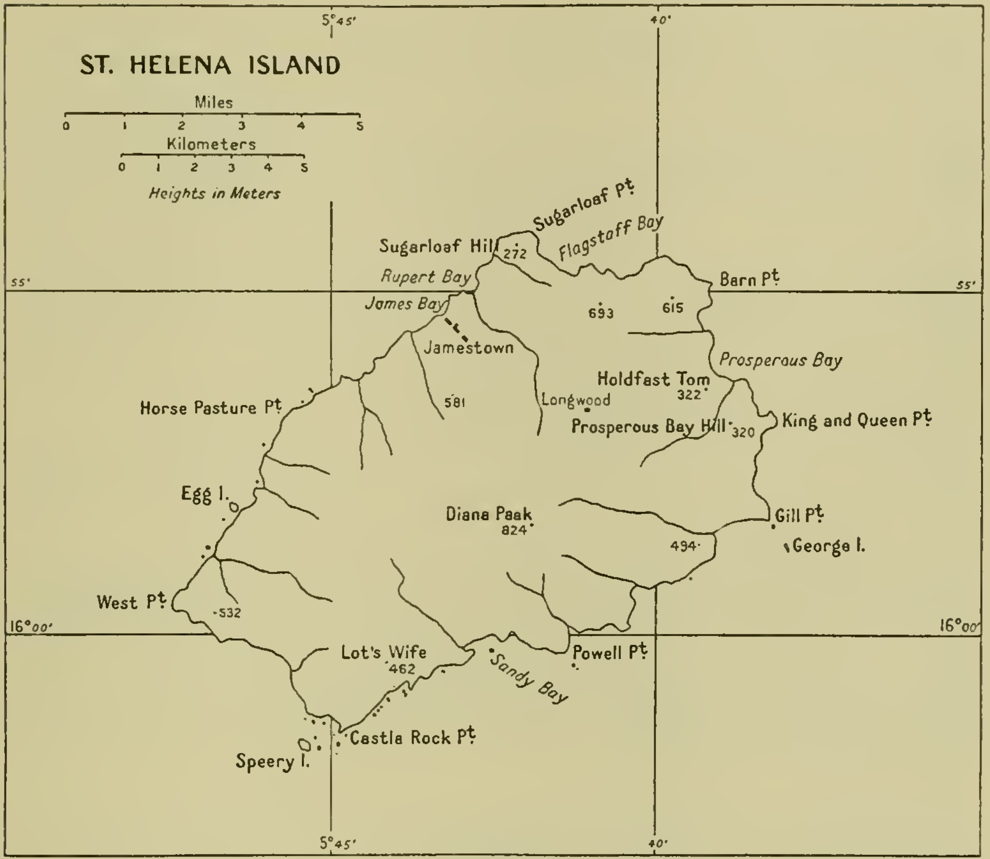


Fig. 25.

broad, with an area of about 122 square kilometers. It is wholly of volcanic origin, although the surface is much altered through erosion and redeposition, and on all sides except the southerly it has wave-cut cliffs ranging up to 600 meters in height. The curved mountainous ridge of the island is part of the rim of a great crater, characteristically breached toward the southerly or windward edge. It culminates in Diana's Peak, which is 824 meters above the sea. In the words of Darwin (1933, 409), the island looms like a huge castle from the ocean, with a wall built of successive streams of black lava around its whole bold coast. Near the shore the lava is entirely destitute of vegetation, but in the higher and central parts the rocks have decomposed into a clayey soil of many colors, which in the rainy seasons produces a singularly bright green pasture. At an altitude of 500 meters the modern vegetation possesses a decided British aspect, due to the fact that the introduced plants are tenfold more numerous than the indigenous, which number fewer than sixty. Of the thirty-eight species of native flowering plants, many of which have become extinct, all but one are endemic.

At St. Helena the southeast trade wind blows nearly continuously, the condensation causing a canopy of clouds to hang during much of the time at the level of the peaks. The condition accounts for a significant local expression concerning "covered days." Strong trades, such as hold particularly during September and October, are the nearest approach to a storm that the island experiences, thundersqualls being all but unknown. As Meliss (1875, 387) observes, it is remarkable that when the trade winds "blow with fury round the coast, even driving ships to sea from the snug anchorage on the leeward side, a perfect calm exists on the mountain ridge at Diana's Peak." The usual shallowness of the trade wind layer over the oceans is, indeed, a point that deserves stressing. The 'Meteor' party encountered days during which the whole moving body of atmosphere extended upwards not more than 50 meters above the surface of the Atlantic, with the thermometers recording 27° C. at the foremasthead and only 19° on deck (Spiess, 1928, 302).

St. Helena, like all steep, high islands, is a center of other curious vagaries of the winds, some of which doubtless have an important effect upon the selection of nesting sites by sea birds. Darwin (1933, 413) writes:

> The only inconvenience I suffered in my walks, was from the impetuous winds. One day I noticed a curious fact; standing on the edge of a plain terminated by a great cliff of about a thousand feet elevation, I saw at the distance of a few yards, right to windward, some Tern struggling against a very strong breeze, whilst where I stood the air was quite calm. Approaching close to the brink I stretched out my arm, which immediately felt the full force of the wind. An invisible barrier of two yards wide, separated a strongly agitated from a perfectly calm air. The current meeting the bold face of the cliff must have been reflected upwards at a certain angle, beyond which there would be an eddy, or a calm.

While long droughts occasionally occur at St. Helena, rainfall is usually moderately plentiful. There are both summer and winter peaks of precipitation, the summer rains being relatively heavy, but the winter rains (March to August) more continuous. The annual rainfall in the highlands amounts to 990 millimeters, or about double that of Ascension, while the coast always feels more or less of the "trade wind drought." Streams are very numerous, and there are said to be no less than 212 springs of fresh water. There are a few records of floods that have carried away trees, cottages, and stone walls, and have washed down surface soil in such quantity that the sea around the island looked like mud. Such phenomena, and even the normal run-off from the island, account for an enormous increment of terrigenous materials in the surrounding ocean waters, with a consequent direct and secondary enrichment of the neritic life (Hentschel, 1933, 165). The 'Meteor' naturalists were impressed with the abundance of both fish and terns at St. Helena (Spiess, 1928, 231).

It is but natural that in so long-inhabited an island man and his creatures have wrought an overwhelmingly destructive effect upon the original biota. In 1683, St. Helena had a human population of 500; it has since risen to a maximum of between 4000 and 5000. It requires considerable faith on the part of the modern traveller to realize that this prevailingly barren island was once densely forested, but the testimony of Sir Joseph Hooker, as quoted by Meliss (1875, 221), leaves no possible doubt of it. When St. Helena was discovered, in 1502, it was entirely covered with forests, the gumwood, ebony, and other native trees even drooping over the tremendous precipices that overhang the sea. Hooker writes:

> The destruction of the Madeira forests . . . was by fire. A much more insidious agency has operated with tenfold greater effect in St. Helena—viz., goats. These were introduced in 1513, and multiplied so rapidly, that in 1588 Captain Cavendish states that they existed in thousands, single flocks being almost a mile long.

In the year 1709, trees still abounded, though in greatly reduced number, and the governor regarded the goats as of more value than the remaining lumber and firewood! Just a century later another governor reported the final destruction of the forests by the goats which, according to Hooker, "greedily devour the young plants, and kill the old by browsing on their leaves and bark."

St. Helena had no native land mammals, and the widely accepted tradition that manatees formerly came to its coast, and that they were captured up to the year 1810, or thereabouts, is erroneous. Mortenson (1933, 417) and Hatt (1934, 560), who have reviewed the evidence, conclude that the alleged manatee was some form of pinneped, such as a fur seal. Fraser's (1934, 33) text and drawing from the manuscript journal of Peter Mundy (*circa* 1655) suggests that the creature may have been the sea-leopard (*Hydrurga leptonyx*), although Fraser himself identifies it with the sea-elephant.

The bulk of the island's peculiar fauna is made up of land shells and beetles. Many of the latter are wood-boring weevils, an excellent correlation with the former woodland cover. The fact that there is but a single species of native grass may also be considered an indication that forest once covered the terrain on which many introduced grasses now thrive so well.

Land birds of African, Oriental, Australian, European, and American origin have been carried to St. Helena by calling ships, and an extraordinary assortment is now acclimated. There is, however, but one endemic form, the "Wire Bird" or plover (*Charadrius sanctae-helenae*) which the latest reviewer (Peters, 1934, 252) regards as specifically distinct from its nearest relatives in Africa.

Together with the almost incredible change in the original cover and appearance of St. Helena, the native marine birds have suffered a vast reduction, both in number and variety. Part of the process has taken place under a vague degree of human observation; the man-o'-war bird, for instance, has disappeared within recent historic time. Much more we can infer only from plentiful remains in the form of bird bones, which have never yet been critically studied. Speaking upon the basis of slight objective evidence combined with zoögeographic likelihood, it is safe to say that in its pristine glory St. Helena was occupied by hordes of shearwaters and other Procellariiformes; by frigate-birds and Red-footed Boobies which nested not only close to the brinks of precipices but also throughout the woodlands, along with the Fairy Terns which still seek sites remote from the sea. Both of the Atlantic tropic-birds doubtless made the island their home, the larger species (*Phaëthon aethereus*) filling the niches of the sea cliffs with crowded colonies of the sort now to be found in few parts of the world, notably at Razo Island of the Cape Verdes. What other birds made up a part of this teeming avifauna we shall perhaps never know in full; the tradition that albatrosses once made headquarters of the heights of this sub-tropical island may be discounted.

Seale (1834, 10) states that in an extensive amphitheatre of St. Helena, between Holdfast Tom and Prosperous Bay Hill, the precipitous sides of which still furnish nesting retreats for sea fowl, there are innumerable ancient bird skeletons buried at various depths in the soil. These bones he ascribes to the Red-billed Tropic-bird and the "Wandering Albatross." The "ossuary, in which these fragments are found, extends about a mile in length from the water's edge, . . . and is from ten to ninety feet deep. Remains of a similar description are found near Sugarloaf Hill."

According to Blofeld (1852, 195), bird bones are associated with fossil mollusks in various lofty parts of the island. He obtained specimens near Longwood, at an elevation of 520 meters, on a hillside worn into numerous ravines by heavy rains. The surface, to a depth of two meters, consisted of dark mould. Beneath this was a stratum of grayish brown, friable earth, in which were the bird bones and shells. Owen identified these bones merely as pertaining to "marine birds," but others from Turk's Cap Bay he ascribed to Pleistocene age and stated that they were of the "petrel kind," some representing the genus *Puffinus*. Lambrecht (1933, 732) lists the latter under *Puffinus lherminieri*, a step for which he does not give the evidence. The presence of this cosmopolitan, pan-tropical shearwater at St. Helena would, to be sure, be not surprising, and would help to explain its present-day distribution in the Atlantic.

Meliss (1875, 90) likewise refers to remains of extinct birds at St. Helena, and adds, "It is difficult also to account fully for the almost total disappearance of some species which once were abundant, such as the Frigate-bird."

Many sea birds characteristic of the Antarctic Zone sometimes follow the winds and the cool surface drift to the vicinity of St. Helena. Examples of the Antarctic Fulmar (*Priocella antarctica*), for example, have been caught on fish-hooks off Speery Island during the month of October, and additional records of species captured or sighted in the vicinity are referred to in the biographies that succeed this section. The resident species, omitting such as the *Puffinus* which are known only as fossils, are the following, the list being based in part upon collections obtained during the recent expedition of the Cleveland Museum of Natural History.

Oceanodroma castro. This petrel nests, according to Meliss, in November. Specimens were collected during the visit of the schooner 'Blossom' during October, 1925.

Phaëthon aethereus. Once very abundant along the windward coasts of St. Helena, but now greatly reduced in numbers, partly because of former plume-hunting and still more because of the ravages of rats and feral cats.

Sula sp.? There seems to be no exact record of the booby which, according to Meliss (1875, 97), frequents the neighborhood of the island, although seldom coming to land.

Fregata sp.? The man-o'-war bird has long since abandoned Sr. Helena, and it is possible that the specific identity of the form once common there can never be determined. I have thus far failed to locate any record of a St. Helena specimen.

The natural inference would be that *Fregata minor*, which inhabits the sub-tropical island of Trindade, was also the form of St. Helena. However, Ascension is very much nearer than Trindade, lying only 1152 kilometers northwestward from St. Helena, and it is at least within the bounds of possibility that *Fregata aquila* once occupied both islands. Meliss wrote in 1875: "Although there is a part of the southwest coast designated Man-of-War Roost, deriving its name from this bird, and there is still living evidence of its having once frequented even the landing-steps at Jamestown, it is seldom now to be met with, nor is it easy to assign a reason for its disappearance from the Island."

Sterna fuscata. A migrant species, locally known as the egg-bird, which is said by Meliss to arrive at St. Helena toward the end of the calendar year, and to nest after New Year on some of the outlying islets, such as George's, Speery, and Egg. The Cleveland Museum party, under Simmons, however, collected examples at George's Island and in the harbor of Jamestown, during September and October.

Anoüs stolidus. The commonest sea bird at St. Helena, often seen resting on the shipping in the roadstead, and nesting in large colonies on Egg Islet and elsewhere. The 'Blossom' party collected specimens during October.

Gygis alba. Next to the Noddy the "White Bird" is the most numerous species at St. Helena. It nests largely in the higher and more inaccessible parts of the main island, occupying ledges of rocky cliffs, and the weathered columnar dikes such as the structures known as Lot's Wife, etc. Specimens were collected by the 'Blossom' party during October.

6. Southern Coasts, Gulf of la Plata to the Strait of Magellan

In the broad funnel of the Gulf of la Plata, we find a meeting-place between the life of rivers proceeding from the tropics and an oceanic life that suggests the cool south. The great stream pours forth the mud of hot lands, and carries on its brown surface innumerable blue-spiked rafts of "camelotes," the South American, bladder-stalked relative of the pickerel-weed (*Pontederia*). During March, April, and May, the flood season of the Paraná, large trees are scattered among the flotsam of lesser plants. It was in May that the 'Meteor' encountered remains of such vegetation, as well as yellow water, "hundreds of miles" off the mouth of la Plata (Spiess, 1928, 82).

On the other hand, the sea birds that congregate offshore in the wide fringe of mixing water are anything but tropical. Here we find in abundance all of the pan-antarctic petrels, albatrosses, and penguins which have already been listed as sporadic visitors to the coast of Brazil. On the night of July 21, 1832, when the 'Beagle' was well to eastward of the estuary, in dirty, squally weather, she was so surrounded by clamorous penguins and seals that the watch was startled into believing the vessel to be driving toward a shore lined with lowing cattle (Darwin, 1933, 80).

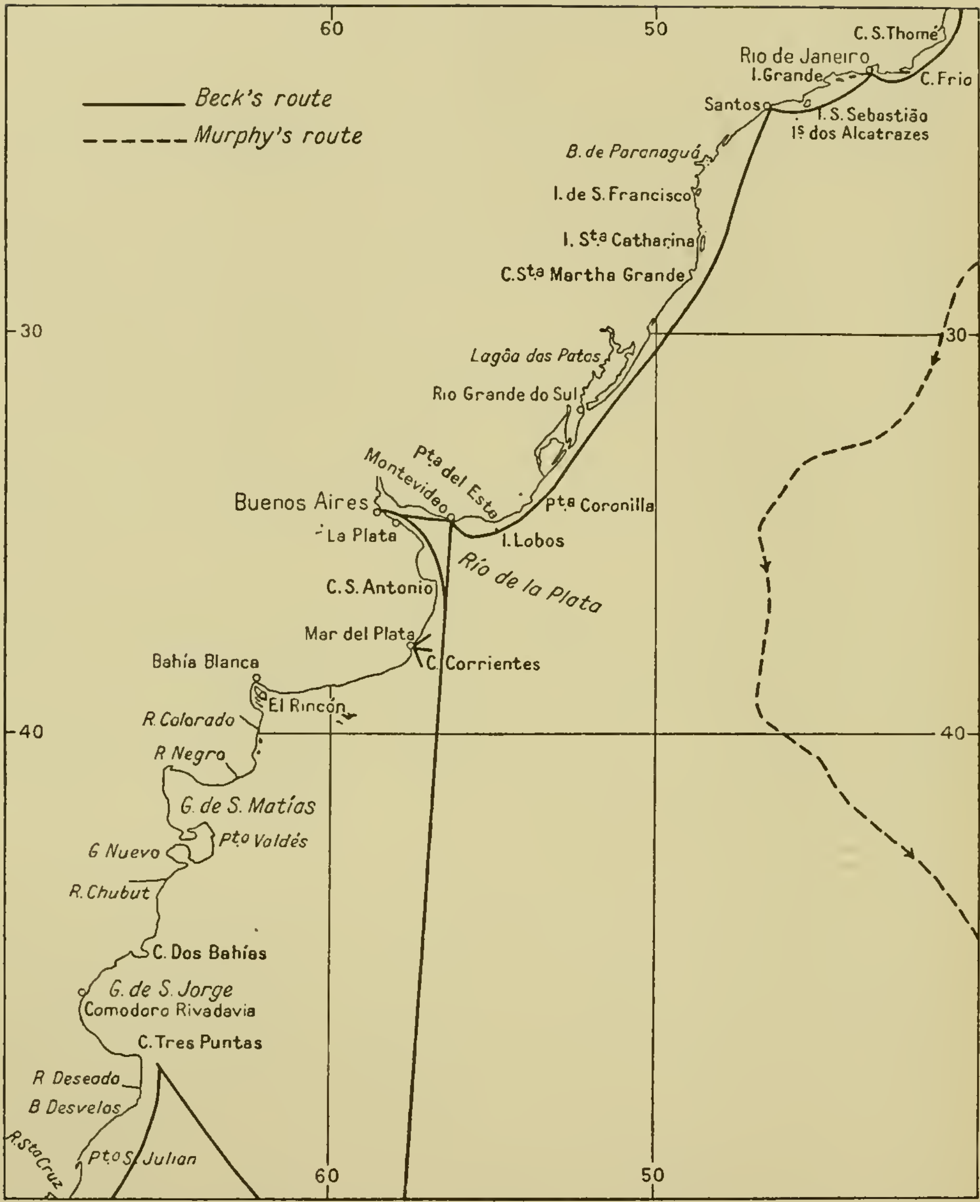


FIG. 26. Southern Atlantic coast of South America, with courses of Beck's cruises and local field work during the Brewster-Sanford Expedition, and of the author's voyage in the brig 'Daisy.'

Both sea and atmosphere in this region are peculiarly subject to strange and violent, and often spectacular, phenomena. The following description of the coastal water just to southward of the gulf is from Darwin's unrevised notebook entry for October 24, 1832, as recently published by Mrs. Barlow:

> The night was pitch dark, with a fresh breeze. The sea from its extreme luminousness presented a wonderful & most beautiful appearance; every part of the water which by day is seen as foam, glowed with a pale light. The vessel drove before her bows two billows of liquid phosphorus, & in her wake was a milky train. As far as the eye reached the crest of every wave was bright; & from the reflected light, the sky just above the horizon was not so utterly dark as the rest of the Heavens.

And again, at the entrance of the river on April 24, 1833, when much lightning and an angry sky continued throughout the night, and the royal masthead of the 'Beagle' glowed with St. Elmo's fire, Darwin made note of the curious fact that the Río de la Plata seems to form a nucleus for thunderstorms, which are comparatively rare both to northward and to southward along this coast (1933, 144).

Storms from the northward, locally known as "zondas," are usually deprived of their rain before reaching this latitude. They are accompanied by a rise in temperature as sharp and remarkable as the lowering which characterizes the storms from the opposite direction, *i. e.* the pamperos. The latter blow from the southwest, gathering dust on the pampas, and reach the gulf as a hurricane accompanied by lightning, thunder, and rain. A pampero is generally foreshadowed by a suffocating day and by heavy clouds to southward and westward. The temperature often drops 10° C. within a few minutes after the storm strikes, and the blasts of dust are followed by downpours of rain. The tempest sometimes lasts as long as three days (White, 1881, 1, 15).

Hudson (1870, 798) has thus described the way in which duststorms or incursions of insects bring birds of the pampas to the edge of the gulf, the gulls referred to being *Larus maculipennis*, although in this citation the author used another specific name:

> Whenever there is a dust storm in the vicinity of Buenos Aires myriads of gulls . . . appear flying before it. This is always the case even when a gull had not previously been seen for months. A dust storm is always preceded by a long drouth, which means that the water-courses along which the gulls would ordinarily live have been dried up. In seasons when grasshoppers abound, flocks of the gulls also appear working as veritable armies and sometimes coming in such multitudes that they free entire districts from the devastating storms of the insecrs. The line of birds sometimes presents a front of several thousand feet, with a breadth of 60 or 80. Along this line of battle the cries of the birds produce a loud incessant noise and all the time the hindmost birds are flying over the flock and alighting in the front ranks so that the whole body is steadily advancing.

The entrance of the great bight of the Río de la Plata is 193 kilometers wide from Punta del Este in Uruguay to Cape San Antonio on the outer coast of the Province of Buenos Aires, Argentina. The gulf receives the water of six rivers, comprising the second largest river system in the world. In ancient times the extent of the inlet was very much greater than at present, as is proved by the deposits of marine shells far up the Río Paraná, but the size of the old arm of the sea has decreased proportionately with an uplift of the land. The estuary as a whole is remarkably shallow, and the silt carried by the river water normally discolors the ocean for 125 kilometers or more from the coast. Islands at the mouth of the Paraná are formed of this recent sediment and, according to Burmeister (1876, 283), one finds in these deposits remains of contemporary marine animals, from which he infers that the Atlantic penetrated this far even within recent geologic times. At the present day much of the outer body of water still pertains to the ocean, but the inner part, extending from Punta de Espinillo, west of Montevideo, and Punta de las Piedras on the Argentine side, contains mostly fresh water and has lost practically every marine attribute.

The outer gulf therefore represents an expanded bay in front of the triangular estuary of the combined rivers. Except in freshet season, the water is here often clear and has considerable salinity, which becomes rapidly reduced inside Montevideo. When *en route* from the north, the first land seen by the traveller is usually the Lobos Islands which, in turn, are likely to be presaged by thousands of seals playing in the open sea (Morong, 1892, 479). Here the pilot may be taken aboard and shortly afterwards the Banda Oriental, or "Purple Land," comes into view. The shores nearly everywhere are bluffs of granite and other metamorphic rocks, with the rolling grasslands beyond. Cunningham (1871, 44) describes his first glimpses of this part of the coast as follows:

> On the 23d of Nov. land was reported soon after sunrise. As we steamed up the estuary of the Plate, the low land on the northern shore, between Maldonado and Monte Video, brought to my remembrance my first sight of the Dutch coast, to which it bears a considerable resemblance in respect of its sand-dunes, with the low-lying, mostly treeless country beyond them, dotted here and there with windmills. A large wasp flew on board in an exhausted condition, and about the same time the rigging of the ship became covered with immense quantities of cobweb. Everywhere long delicate threads could be seen streaming out into the air, and a considerable number of their constructor, a minute reddish-brown spider, were to be observed associated with them. This curious phenomenon is of frequent occurrence in the Plate on a fine day after stormy weather.

In the same place a century ago, the rigging of the 'Beagle' likewise became coated and fringed with gossamer webs of the aëronaut spiders, some of which, Darwin calculated, must have come through the air a hundred kilometers. Many butterflies, also, are often seen here, and dead insects sometimes pepper the surface of the water, while it is not unusual for many kinds of land birds to rest on passing ships.

Along the rocky northern shore of the gulf, as far westward as Montevideo, there are large areas inaccessible to modern steamers. Even in the deeper expanses toward mid-channel numerous banks, covered by only a few meters of opaque water, have been the cause of countless wrecks. The beginning of the inner, triangular part of the gulf can at once be recognized by the muddy hue of the water and its lessened salinity, although the prospect is still that of a sea, with no shore yet visible to southward. A stiff breeze from the latter direction will quickly pile up sluggish waves, which Darwin likened to moving mountains of mud. He also made the following acute observation regarding the interrelationships of the continental waters and those of the ocean (1933, 82):

The fresher, discolored water from its less specific gravity floats on the surface of the salt; this was curiously shown by the wake of the vessel, where a line of blue might be seen mingling in little eddies with the adjoining fluid; in this case instead of stirring up the mud, it was the reverse and stirred up the clear water.

The ridge of sand marking the Banda Oriental terminates in cliffs opposite the island of Martin García. From this point, if the traveller has clung to the northern shore, the Argentine coast may appear magically, under a mirage, with the trees suspended in air.

The southern side of the gulf presents a marked contrast with that on the north. It is rockless and without hills, almost level, and so low that it does not become visible from a deck until it is very closely approached. Its general elevation is from 2 to 7 meters above the sea, and there is but one kind of native tree, known as the "ombú," which sometimes grows to a height of 12 meters and is commonly buttressed around the base with large knees. From the vicinity of Magdalena, all the way out to Cape San Antonio, there are few landmarks on the low shores other than scattered groups of these trees. Along the semicircular beach of the Ensenada de Samborombón, between Punta de las Piedras and Cape San Antonio, are very extensive flats and shallows, with water less than 10 meters in depth at distances of 6 to 7 kilometers from shore. The Río Salado, largest stream of the pampas, reaches the sea in the middle of this stretch, but is entirely inaccessible from the gulf; as a rule the depth of water is not more than a meter at its mouth. The whole water front here, as also the grasslands stretching toward Lake Chascomús and numberless other bodies of fresh water, is a famous resort of ducks, swans, flamingoes, the Coscoroba, and many species of shore birds, including native forms as well as migrants from North America and the Arctic. Gibson (1918, 363) states that the coastal land is here so young that remains of six or more whale skeletons may still be seen on one hacienda. Floods sometimes cover much of it, as they did during October, 1913. The country just inside, or to westward, of Cape San Antonio is thus described by Gibson who, at intervals of forty years, has written two delightful papers about the birds of the region:

. . . . here are the "rincónes," a maze of islands, peninsulas, and tidal creeks, with countless ramifications. The surface of the mainland is here recent and quaky, with a softer subsoil. The innumerable creeks are called "cangrejales" from the myriads of small burrowing crabs inhabiting their banks. Inland the cangrejales merge with freshwater fens. There are small areas of natural woods on rises of ground in this district, although the average altitude is probably not more than six feet above sea level. At night the uncanny shrieks of the *viuda loca* (limpkin) may be heard from the swamps.

Outside Cape San Antonio the beaches are bathed by blue, saline water, that is, "blue" compared with the muddy water of the rivers. As a matter of fact, the ocean surface over the entire coastal shelf between Uruguay and Cape Horn, and offshore to a point well east of the Falkland Islands, is prevailingly greenish, and quite unlike the ultramarine sea along the central coast of Brazil. Southward from Cape San Antonio the sand hillocks gradually give way to a dead-level line of cliffs about 10 meters high, an indication of the impressive and considerable recent elevation of the coast, which increases southward into Patagonia. Behind the bluffs stretches the level and unbroken pampa except where, at long distances apart, a line of bare hills becomes visible from sea. Such hills, an occasional bend or corner, an islet or promontory, or the narrow gorge of a river cut through the table-land, henceforth make the landmarks of an otherwise almost featureless coast.

In the summarized narrative of the Brewster-Sanford Expedition, near the beginning of this book, I have referred to Mr. Beck's profitable visit at Mar del Plata in the austral spring of 1914. Making headquarters at this popular watering-place on the outer coast of the Province of Buenos Aires, just north of Cape Corrientes where the shore line turns westward toward El Rincón, he divided his time between land and sea, according to each day's weather, and had full opportunity to observe the wealth of local birds. Between September 18 and October 27 he collected about 375 specimens, comprising 25 to 30 dry-land forms and a larger number of ocean fowl, marsh birds, and shore birds. Much of the country was flooded during Beck's stay; his notes for late September tell of cornfields ankle-deep or knee-deep in water, with thousands of ducks feeding close to plowmen working under difficulties, and almost oblivious even of gunners. The bulk of the ducks were Brown Pintails, but there were also plenty of Widgeon, Shovellers, Teal, and others.

A good proportion of the water birds and waders were beginning to nest, as were also two kinds of tinamou, Short-eared and Burrowing Owls, and many lesser plains and thicket birds. Mingling with and feeding with these residents, however, were numerous species at the opposite physiological pole of their annual cycle, namely the migrant Charadriiformes from North America. This peculiar combination, to be best observed, perhaps, in this very part of South America, is a phenomenon unknown anywhere in the holarctic continents. Mr. Beck collected a goodly representation of migrant snipe, sandpipers, plovers, etc., only one example of which needs special mention. On September 29 a shore bird which he took to be an Eskimo Curlew (*Numenius borealis*) flew past him. Beck whistled an imitation of the Hudsonian Curlew's call, which had no effect. He then gave the call of the Black-bellied Plover, whereupon the Curlew at once turned and flew into range. It proved to be an Eskimo Curlew, with its stomach characteristically full of insects. From several even more recent records, we know that this "virtually extinct" arctic species probably still visits the pampas.

The general composition of the bird life back from the seashore on the lake-dotted plains of the Province of Buenos Aires is, in many respects, suggestive of the avifauna of somewhat similar prairies in the interior of North America. The analogy is interesting in view of the fact, stressed elsewhere, that the Argentine pampas correspond geographically with the central part of the northern United States, rather than with the eastern seaboard. In the following partial list of pond and swamp birds of Buenos Aires, mostly collected by Beck or mentioned in his journal but added to from the excellent monograph by Wetmore (1926), such resemblances will be evident.

Native Species

Chilean Grebe. *Colymbus chilensis.*
Pied-billed Grebe. *Podilymbus podiceps antarcticus.*
Night Heron. *Nycticorax nycticorax hoactli.*
Azara's Least Bittern. *Ixobrychus involucris.*
Maguari Stork. *Euxenura galeata.*
Chilean Flamingo. *Phoenicopterus chilensis.*
Screamer. *Chauna torquata.*
Black-necked Swan. *Cygnus melancoriphus.*
Fulvous Tree Duck. *Dendrocygna bicolor bicolor.*
White-faced Tree Duck. *Dendrocygna viduata.*
Coscoroba. *Coscoroba coscoroba.*
Cinnamon Teal. *Anas cyanoptera.*
Gray Teal. *Anas versicolor.*
Yellow-billed Teal. *Anas flavirostris.*
South American Pintail. *Anas spinicauda.*
Southern Bahama-duck. *Anas bahamensis rubrirostris.*
Chiloé Widgeon. *Mareca sibilatrix.*
Red Shoveller. *Spatula platalea.*
Black-headed Duck. *Heteronettd atricapilla.*
Rosy-billed Duck. *Metopiana peposaca.*
Southern Ruddy Duck. *Oxyura vittata.*
Limpkin. *Aramus scolopaceus carau.*
Magellanic Rail. *Rallus limicola antarcticus.*
Argentine Sora. *Porzana spiloptera.*
Great-footed Coot. *Fulica armillata.*
White-winged Coot. *Fulica leucoptera.*
Red-fronted Coot. *Fulica rufifrons.*
Painted Sandpiper. *Nycticryphes semi-collaris.*
Teru-teru. *Belonopterus chilensis lampronotus.*
Collared Plover. *Charadrius collaris.*
Paraguayan Jack-snipe. *Capella paraguaiae paraguaiae.*
Black-tailed Stilt. *Himantopus himantopus melanurus.*
Kelp Gull. *Larus dominicanus.*
Gray-hooded Gull. *Larus cirrocephalus.*
Brown-hooded Gull. *Larus maculipennis.*
Trudeau's Tern. *Sterna trudeaui.*

Northern-Hemisphere Migrants

Golden Plover. *Pluvialis dominica dominica.*
Eskimo Curlew. *Numenius borealis.*
Hudsonian Godwit. *Limosa haemastica.*
Lesser Yellowlegs. *Tringa flavipes.*
Greater Yellowlegs. *Tringa melanoleuca.*

Spotted Sandpiper. *Actitis macularia.*
Robin Snipe. *Calidris canutus rufus.*
Sanderling. *Crocethia alba.*
White-rumped Sandpiper. *Erolia fuscicollis.*
Baird's Sandpiper. *Erolia bairdii.*
Pectoral Sandpiper. *Erolia melanotos.*
Buff-breasted Sandpiper. *Tryngites subruficollis.*
Wilson's Phalarope. *Steganopus tricolor.*

During the southern-winter season there is also a migration into the Province of Buenos Aires from more southerly latitudes and from the highlands to westward. In this movement such shore birds as the Falkland Plover (*Charadrius falklandicus*) and the Seed Snipe (*Thinocorus rumicivorus*) take part.

In certain sections of the Province of Buenos Aires, and still more toward the borders of Patagonia and beyond, some of the standing bodies of water are salt lagoons. These, too, are well peopled with birds. Doering (1881, 19) lists as characteristic species the Bahaman, Yellow-billed, and Cinnamon Teals, the Shoveller, Chilean Flamingo, Falkland Plover, Stilt, and Kelp Gull. The last is typically a coastal bird, but Wetmore (1926, 133) found it on the pampas nearly 200 kilometers from the ocean, which is the less surprising since it is said to nest about some of the larger Andean lakes in Argentina. Flamingoes noted by Wetmore in the salt lagoons seemed to be feeding upon a species of brine shrimp (*Artemia*).

The foregoing lists, which might readily be extended, refer altogether to birds found in various types of terrain behind the shore. But Mr. Beck also carried on much field work from boats during October, 1914, making several trips to fishing-banks about 30 kilometers off the coast, where the craft of the Mar del Plata fleet were crowded together so that they almost touched one another. It was on these banks, usually when fish were being hauled in fast, that the greatest number of pelagic birds was seen. Here, as on the land, there proved to be an extraordinary intermingling of species from opposite ends of the Atlantic Ocean, but in this case even the southern-hemisphere forms were mostly at a considerable distance from their nesting grounds. The species collected, or in one or two instances merely observed, by Beck between the roadstead of Mar del Plata and his farthest point from shore were the following:

South Atlantic Species

Magellanic Penguin. *Spheniscus magellanicus.*
Royal Albatross. *Diomedea epomophora.*
Black-browed Albatross. *Diomedea melanophris.*
Giant Fulmar. *Macronectes giganteus.*
Cape Pigeon. *Daption capensis.*
White-chinned Petrel. *Procellaria aequinoctialis.*
Greater Shearwater. *Puffinus gravis.*
Sooty Shearwater. *Puffinus griseus.*

Wilson's Petrel. *Oceanites oceanicus.*
Chilean Skua. *Catharacta skua chilensis.*
Brown Skua. *Catharacta skua*, subspecies?
Kelp Gull. *Larus dominicanus.*
Brown-hooded Gull. *Larus maculipennis.*
South American Tern. *Sterna hirundinacea.*

Migrants from the North Atlantic

Manx Shearwater. *Puffinus puffinus.*
Parasitic Jaeger. *Stercorarius parasiticus.*
Long-tailed Jaeger. *Stercorarius longicaudus.*
Royal Tern. *Thalasseus maximus.*
Common Tern. *Sterna hirundo.*

On several days, according to Beck's journal, the two species of jaegers from breeding grounds in the arctic tundra were the commonest birds along the coast of eastern Buenos Aires. Sooty Shearwaters from the Cape Horn region, Greater Shearwaters from Tristan da Cunha, and Manx Shearwaters from Europe or Bermuda, perhaps, sometimes formed indiscriminate bands. In general, Beck thought, the flocks of migrant shearwaters that seemed to be bound southward kept much farther from the Argentine shores than similar streaming flocks do from the shores of California and Chile.

From Mar del Plata and Cape Corrientes the low coast, which is generally swept by a long-shore surf driven before winds off the pampas, turns westward toward El Rincón, the angular concavity in which Bahía Blanca lies. The Sierra de la Ventana, on the northern side, rises to an altitude of 1250 meters, the greatest elevation on the Atlantic coast between Brazil and Tierra del Fuego. The entrance to Bahía Blanca and the whole western shore of El Rincón are lined by low, flat, marshy islands, intersected by creeks. In rhe southern part of the bight, sandbars extend up to 25 kilometers to seaward, and even the great rivers from the Andes, like the Colorado and the Negro, are partially blocked at their mouths with banks which are pounded by tremendous surf when the wind swings to an easterly quarter.

Darwin (1839, 93) thus describes the sheltered inner harbor of Bahía Blanca:

> The wide expanse of water is choked up by numerous great mud-banks, which the inhabitants call Cangrejales, or crabberies, from the number of small crabs. The mud is so soft, that it is impossible to walk over them, even for the shortest distance. Many of the banks have their surfaces covered with long rushes, the tops of which alone are visible at high water. On one occasion, when in a boat, we were so entangled by these shallows, that we could hardly find our way. Nothing was visible, but the flat beds of mud: the day was not very clear, and there was much refraction, or as the sailors expressed it, "things loomed high." The only object within our view, which was not level, was the horizon; rushes looked like bushes unsupported in the air, and water like mud-banks, and mud-banks like water.

The islands along the western shore of El Rincón, such as Bermejo, Trinidad, and Verde, as well as others south of the double mouths of the Río Colorado, are all low, occasionally more or less overflowed, and suitable only for marsh birds. Little is specifically known of their fauna, but the southernmost islet in San Blas Bay, just north of Punta Rubia, bears the name of Isla de la Gama or "Deer Island."

The Río Negro marks the northern boundary of Patagonia, a word which now has only traditional political meaning, for it finds no place among the modern geographic divisions of Argentina. Nevertheless, it will always maintain a regional and zoögeographic significance, for Patagonia is the home of many organisms not found outside its borders. For example, while the Common Rhea (*Rhea americana albescens*) ranges southward only to the Río Negro, it is replaced between the south bank of that river and the Strait of Magellan by a bird of a different genus, Darwin's Rhea (*Pterocnemia pennata pennata*). From another distributional point of view, we may cite the Condor (*Vultur gryphus*), a mountain bird which regularly descends to sea level in desert districts. This species crosses the continent from the Andes of northern Argentina, and reaches the Atlantic coast only southward of the Río Negro from where, like Darwin's Rhea, it ranges to the Strait of Magellan. Related instances might be multiplied.

The Río Negro is shallow and treacherous at its mouth, like all other rivers of this coast. It enters the sea just north of the second of the three deep bights between the Río de la Plata and the Strait of Magellan, namely the Golfo de San Matías. This inlet marks the beginning of the Patagonian table-land at the coast, for the whole western border of the gulf is high and bold. To northward and eastward are plains which slope almost imperceptibly toward the Atlantic, but at San Matías it is as though the ocean had cut into the North American continent as far as the meridian of Chicago, to which, in such a fanciful geographic comparison, the excellent port of San Antonio might be likened.

In the Gulf of San Matías we also reach the northern limit of the ancestral breeding range of the Magellanic Penguin on the east coast of South America, although the vast majority of the birds are now confined to more southerly nesting localities. The present or former existence of seals and sea-lions in abundance is indicated by such names as Banco Lobos and Punta Lobos, which appear, not once but several times, on charts of the adjacent shores. We have now reached, by the way, one of the world's "guano coasts," though of far less importance than that on the opposite side of the continent. Guano, derived from the excreta of penguins and other birds, and doubtless also the inferior product of sea-lions, was formerly "mined" at many Patagonian localities between Bahía Blanca and Río Gallegos.

The southern side of the Gulf of San Matías is formed by the Peninsula de Váldez, which is nearly constricted off from the coast of Chubút by the smaller gulfs of San José and Nuevo. The expanded termination of the peninsula, which is 85 kilometers in length from north to south, differs little from the mainland, being flat country with shallow depressions, covered with the usual stunted vegetation and inhabited by the usual birds and mammals of the pampas. The Golfo Nuevo, on the southward side, was formerly supposed to be stagnant in its depths, and hence of peculiar physico-chemical character throughout. The 'Meteor' party recently discovered, however, a deep and hitherto unknown channel through the barrier, indicating that new supplies of Atlantic water constantly reach the gulf at all levels (Spiess, 1928, 169).

Along the Patagonian coast the flood-tide comes in a wave from the south, and on the outer front of Váldez Peninsula it advances with great violence, causing overfalls which are dangerous to small craft. The onrushing water pours with a speed attaining 11 kilometers per hour into the narrow inlet known as Váldez Creek, on the eastern side of the peninsula, and into the Gulf of San Matías and connecting bodies of water. The average rise and fall is 6 meters in this region. Southward it becomes less, being about 3.6 meters at Puerto Deseado, after which it increases again toward the Horn, attaining a range of 7.3 meters at Santa Cruz and still more near the Strait of Magellan.

The entire Atlantic coast between the Province of Buenos Aires and the Strait lies within the zone of prevailing westerly winds. From September to June these are interrupted at frequent intervals by southeasterly gales which are the winds that bring the rains and raise the heaviest seas. Between latitudes 40° and 50° S., that is from El Rincón to Puerto Santa Cruz, the seaboard is characterized by notable uniformity of climatic conditions. In many parts of this stretch of coast it is injurious for wooden ships to lie at anchor for even brief periods during the summer season, so desiccating is the power of the rarely clouded sun in the practically complete absence of either rain or dew. Darwin (1933, 220) was extraordinarily impressed by the strong westerly breezes, with dry air and a brilliant sky, encountered at the mouth of the Río Santa Cruz. He never ceased to regard it as marvelous, moreover, that at the distance of less than 200 kilometers to southward, such astonishing weather conditions were replaced by almost constant cloudiness, rain, hail, sleet, and snow.

The essential geographic trait of Argentina is, indeed, the great transformation in the climatic régime from north to south. In the northern and central parts of the republic, the rainfall diminishes regularly from east to west. Toward the south, on the contrary, as soon as one has entered the zone of perpetual west winds, the rains are borne from the west and give out toward the ocean. In these latitudes, as one leaves the slopes of the Andes and goes toward the Atlantic, aridity steadily increases, forests disappear, the steppe itself gives out; the rivers, carrying only the water of their remote montane sources, receive no affluents from the pampas, which have either an interior-basin drainage or are without surface-flow of any sort. Toward the eastern ocean the country bears more and more the stamp of the desert. San Antonio, on the Gulf of San Matías, receives but 180 millimeters of rainfall annually, and a similar supply holds for a long distance southward. Beyond the Río Santa Cruz, however, precipitation begins to increase again, this being the latitude in which the cordillera drops somewhat, making a gap through which moisture-bearing winds are free to blow across the continent from the Pacific. Puerto Gallegos receives 400 millimeters of rainfall; Ushuaia 500. A system of winter rains is general on the plateau, but less regular at the coast. The winter maximum is here interrupted by a short dry period (August at San Antonio, July and August at Bahía Camarones, June at Puertos Deseado and Santa Cruz), which is marked by a truce of the west winds. The coast is washed by cold ocean waters and the land breezes cause upwelling from the depths, resulting in mists and fogs, which do not penetrate far inland and which recall the Peruvian garúas. The blankets of fog, while often very extensive over the offshore waters, are likely to be exceedingly shallow, so that the masts and upper spars of ships project through them, a phenomenon mentioned in many accounts of voyages. The fogs are only one instance of the erratic possibilities of Patagonian coastal climate, despite its prevailing uniformity. Broiling sunshine and light breezes may be suddenly succeeded at almost any season by cold blasts that bring masses of low clouds and bursts of rain. Periods of drought, such as are characteristic of the whole shore between Bahía Blanca and the Strait of Magellan, are likely to be abruptly broken by squalls and fogs.

As the humidity increases to southward of Santa Cruz, the rainy season also changes. At Río Gallegos the wettest month is December; at Ushuaia the steady rains last from September to March. The volume of river water is entirely determined by distant snowfall. From the Colorado and the Negro southward to the Santa Cruz and the Gallegos, all the streams have their freshets at the end of springtime; in autumn those which do not come from the Andes dry up long before they reach the ocean.

As has perhaps been sufficiently inferred, the Patagonian climate in the region between the Río Negro and the wet zone of the southern tip of the continent is not only arid but is also rude. Violent westerlies rage clear to the Atlantic, and on across it. Simpson (1934, 184) humorously remarks that it is important "to keep papers from blowing away, out of consideration for the people in Africa!" Along the coast the mean temperature lowers southward a little less than one degree Centigrade for each degree of latitude. Thus it is 14.5° at San Antonio near 41° S.; 8.5° at Santa Cruz, in 50° S.; 4.4° at Ushuaia, close to 55° S. The average temperature of the summer months is more sharply reduced, being 21.4° at San Antonio; 14° at Santa Cruz; and 9.2° at Ushuaia. Grain does not ripen south of Chubút.

Along the Patagonian coast from the neighborhood of Váldez Peninsula southward, we begin to encounter masses and marine hedges of the giant kelp (*Macrocystis pyrifera*). This is a seaweed of great importance in the ecology of most forms of sub-antarctic neritic life. It is also a living index of the general range of ocean temperatures and of the distribution of many organisms, such as penguins and the southern pinnepeds, which select cool and richly nutrient waters. The first extensive fields of kelp are found, perhaps, in Desvelos Bay, a short distance south of Puerto Deseado. From here southward it grows abundantly along all sub-antarctic shores, and about the northerly antarctic islands, such as South Georgia. Uprooted strands of kelp may, of course, be cast by the sea on beaches far removed from the point of origin. Admiral Spiess mentions finding pieces 17 meters in length along the African coast, supposedly carried from Tierra del Fuego by the west-wind drift. The west coast of South

America, because of conditions produced by the Humboldt Current, is favorable for the extension of kelp far into the tropics; so that along the continental border as a whole it is, in effect, one of the symbols of the pan-antarctic littoral, as discussed heretofore. Cunningham (1871, 60) gives the following picture of the giant kelp and of its place in nature:

This wonderful plant, the most gigantic Alga known, exists in vast beds around the coasts of Patagonia, Tierra del Fuego, and the Falkland Islands, in general growing in depths of from six to twenty fathoms, and is of the greatest service to the navigator as an indication of the presence of rocks to be avoided by him. From a branching root, in the intricacies of which small Molluscs, Crustacea, Echinoderms, and Annelids nestle, arise small fructiferous bladderless submerged fronds, and long slender stems, which reach the surface of the water, and there give off hundreds of elongated elegantly-shaped jagged-edged fronds, varying in length from four to six inches to one or two feet, each provided with a pyriform air-vesicle at the base. These fronds, derived from one another by a process of vertical splitting, spread out on the surface of the water like so many banners, the manner in which they are directed being an infallible index of the ebb and flow of the tide, and I know few more beautiful sights to be witnessed, than by leaning over the gunwale of a boat on a calm day, and gazing through the clear depths of these submarine forests, in which fish swim about as birds fly through the trees of a wood.

Vallentin (1924, 378) writes that at the Falklands

. . . where, in great patches, this weed luxuriates, it forms such a dense mass that I have often experienced great difficulty in forcing my boat through it during low water. Frequently, when out collecting in my dinghy, I have comfortably ridden out a heavy squall by making fast the bows to a substantial growth of seaweed.

Most of the roots of *Macrocystis* are attached to rocks or stones of varying sizes, but in many of the protected fiords they seem to grow freely on the muddy bottom. In the interstices of these tangled roots hosts of forms lie hidden, and one or more specimens of the fish *Lycodes* can nearly always be found therein. A list of the inhabitants of one of these roots would include the names of almost all the invertebrates found round these islands; while on the fronds abound hydroids and bryozoa of various kinds.

Crawshay (1907, xxii) states that during the expedition of the 'Erebus' and 'Terror' kelp strands more than 200 meters in length were found. He also quotes Sir Joseph Hooker, the botanist of the expedition, as follows:

In the Falkland Islands, Cape Horn, and Kerguelen's Land, where all the harbours are belted with its masses . . . , it generally rises from eight to twelve fathom water, and the fronds extend upwards of one hundred feet upon the surface. We seldom, however, had opportunities of measuring the largest specimens, though washed up entire on the shore; for on the outer coasts of the Falkland Islands, where the beach is lined for miles with entangled cables of *Macrocystis*, much thicker than the human body, and twined of innumerable strands of stems coiled together by the rolling action of the surf, no one succeeded in unravelling from the mass any one piece upwards of seventy or eighty feet long; as well might we attempt to ascertain the length of hemp fibre by unlaying a cable.

Southward from the Váldez Peninsula the coast continues high in front of country which has long been farmed by Welsh settlers, and which is at least more populous than most of Patagonia. The coast, and the valley of the Chubút, are notable in ornithological annals because of the collecting and writings of Durnford. By way of picturing the abundance of resident sea birds, I may quote this author's description of a colony of terns (*Sterna hirundinacea*) made at Tombo Point, the southern headland of Janssen Bay, just beyond latitude 44° S.

> I was prepared when I visited this place in December to see a considerable quantity of birds; but the number that met my eyes fairly staggered me. These nests cover an area about 150 yards square. Allowing three nests and five eggs for every square yard (a very moderate computation, it being difficult to walk without treading on the eggs), we arrive at the extraordinary number of 67,500 nests, 135,000 birds, and 112,500 eggs; and, wonderful as these figures may appear, I feel sure that I have rather understated than overstated the numbers (Durnford, 1878, 404).

The Río Chubút, which enters the sea in the middle of this stretch of coast, is narrow and shallow at its mouth, and approach to the hinterland is made mostly by way of Puerto Madryn, in the Golfo Nuevo. In fact, the Río Santa Cruz, far to southward, is the only Patagonian stream accessible to large vessels, and this more because of the great tidal rise in its estuary than of mean depth in the channel. All of this coastland has been progressively uplifted between middle Tertiary time and the present day. Several distinct systems of coastal terraces along the Atlantic have resulted from the emergence, which at the edge of the sea has apparently been greatest in the neighborhood of Puerto Deseado. The more recent terraces contain fossils of species now living in the adjacent ocean, indicating a relatively late lowering of the marine level (Rudolph, 1934, 258). Feruglio (1933, 1) recognizes six successive terraces, as follows:

VI.	5–6 meters	. Mollusks all of local recent species.
V.	8–12 m.	. . Mollusks all of local recent species.
IV.	15–30 m.	. . Mollusks all of recent species, but with some austral and Chilean elements suggesting colder waters.
III.	35–60 m.	. . Mollusks mostly recent species, but with some northern elements suggesting warmer waters.
II.	115–140 m.	. . Some extinct mollusks.
I.	165–185 m.	. . Many extinct mollusks.

The shore everywhere between the well-separated ports presents a wild and lonely appearance, enlivened chiefly by birds that inhabit the strands and cliffs and the noisy herds of sea-lions on such islets as those of Leones and Toba, south of Bahía Camarones, as well as at favored places on rocks or shingle beaches of the mainland itself. The roads parallel to the sea usually run some distance inland, and practicable paths down the bluffs are far apart, sometimes 15 kilometers or more. The few rivers enter the ocean through deep and steep-cut valleys, and in some places altitudes of 200 to 300 meters rise abruptly from the shore.

Simpson (1934, 273) describes a recent trip by motor, southward on roads varying from indifferent to execrable along the coastal terraces of the Golfo de San Jorge, from Comodoro Rivadavia to Puerto Deseado. He refers to a very large "lobería" or seal rookery on a beach of the gulf which, for some incomprehensible reason, has been persistently singled out by the sea-lions throughout a long period, in preference to identical sections of beach on either side. Here an old local sea-lion fishery has now developed into an elaborate modern whaling station, in which the machinery is operated by electricity, and from where both local sealing and offshore whaling are conducted at respectively appropriate seasons.

Between the Río Chubút and the Río Deseado, and most notably along the northern half of the Golfo de San Jorge, the coast follows great mesetas, or high pampas, which are elongate, relatively narrow, and parallel with the shore line. The only marked gap is the Gran Bajo Oriental, between Comodoro Rivadavia and Caleta Olivia. The region back of the mesetas (aside from enclosed basins) is drained by the Senguerr-Chico system and the Deseado. Near longitude 69° 30′ W. these are less than 80 kilometers apart, but they then turn northeast and southeast, respectively, and their waters reach the sea (via the Chubút in the northern system) some 500 kilometers apart in a straight line. The lower courses of each system are parallel with the coast, west of the mesetas, for some distance. Thus the Río Deseado is little more than 30 kilometers from the sea at a point from which it flows more than 150 kilometers before reaching it. In like manner, the Río Chico is only 45 kilometers inland in a straight line at a point 275 kilometers from its mouth. This meseta barrier has had a very marked influence in the history of the region, and the country behind it was almost the last to be explored and settled.

The usual shore in this section, roughly that of the Golfo de San Jorge, is marked by three features: restinga, beach, and cliff. The restinga is a broad wave-cut platform in the country rock (Eogene tuffs, Patagoniano, etc., here always Miocene or earlier), and its level is between tides but nearer low tide. Its surface is broadly plane, but very rough in detail, with many pools in which fishes and other marine animals survive between tides. The rocky projections are usually covered with mussels. Birds, especially gulls, congregate here in enormous numbers at low tide. Beach débris is not commonly found on the restinga.

The beach usually begins abruptly on the shoreward side of the restinga, and extends to the base of the cliff. It may be broad and nearly level, but more commonly is narrow and steep, close to the angle of repose for its material. Modifications, such as ridges and beach cusps, are common. The usual material is shingle, derived from the famous Tehuelche Gravel that covers the pampas of Patagonia, but reduced in size and often brightly polished by wave-action. This grades into fine sand, as at the Balneario, south of Comodoro.

At the points and along some of the indentations the sea cliff is high and abrupt, and is cut in the native rock, like the restinga, the structure being that of a cut-notch or step, with débris, the beach, piled against its riser. Along the larger and older indentations, however, such as that of Bahía Solano, the true cut-cliff is low or absent, and the beach abuts against a series of older marine terraces (Simpson, MS).

The Golfo de San Jorge terminates at Capes Tres Puntas and Blanco, beyond which there are great shoals along the coast running nearly due south toward Deseado, the Port Desire of the early British explorers and one of the oldest settlements in Patagonia. The river to which the town owes its existence is little more than a trickle, but it opens into an estuary to which vessels can scud for shelter, rare enough on this coast. Just south of Puerto Deseado are the famous Penguin Islands, described hereafter in the biography of the Magellanic Penguin. The mainland cliffs are also occupied by many nesting waterfowl, and the Isla del Cañadón del Puerto, in the very mouth of the river, is probably the northernmost breeding station of the Gray Cormorant (*Phalacrocorax gaimardi*) on the east coast of America (Renard, 1931, 412). Other islets, such as Shag Rock, off Hilly Point, where the coast turns southwestward, and Bird and Flat Islets, which lie in front of the great table-land just north of Port San Julián, are likewise the headquarters of an important aggregation of marine birds which are associated with definite oceanographic conditions in South America, and several representatives of which we are now about to encounter for the first time during the course of our circumnavigation.

All along this water front the table-land rises just above the breaking waves, being interrupted in places by broad arroyos which are dry and salt-encrusted during much of the year. At certain points, indeed, whole blocks of the plateau have weathered away, so that only isolated natural turrets and castles of stratified material remain. South of Puerto San Julián, between latitudes 49° and 50° S., steep white cliffs, with an average height of about 100 meters, loom like a wall from the sea, which at high tide washes their bases but at low water leaves a broad front of shingle and mud.

Such Patagonian cutbanks are famous in the history of palaeontology, from the days of the 'Beagle' to the present, fossils being exposed at nearly all levels. Below the sea cliffs, moreover, the tidal flats make a great natural sorting-pan for the detritus of a world that is no more, as indicated by the mineralized bones and trees, and other manifestations of Tertiary life.

The estuary of the Santa Cruz is a relatively sheltered and commodious arm of the ocean, navigable well inland, and with sea-lion and penguin islets out of sight and sound of the open Atlantic. Spring tides here sometimes attain a maximum rise of nearly 18 meters (Riggs, 1926, 537). The gorge or fiord drops abruptly from an extremely level and sterile plain. The river itself is geographically one of the most important, and historically perhaps the most interesting, of all the Patagonian streams. Here, in April, 1834, Fitz Roy and Darwin, with their boat parties, made a traverse across the pampas, and rather tragically turned back just as they were on the verge of discovering Lago Argentino. After one day's journey up the river the 'Beagle' found itself practically beyond tidal influence. Between here and the farthest point reached during the boat-trip of several weeks, the stream holds a breadth of from 300 to 400 meters and a depth in the center of the channel of about 5 meters. Most remarkable is the constant rapidity of the current, which runs at a rate of from 7 to 11 kilometers per hour, the water being always of a fine blue color, very slightly milky. The entire valley formed by the age-long erosion of the stream maintains a width of from 8 to 15 kilometers and leads very directly westward, bounded by horizontal plains of from 100 to 150 meters in elevation. In the bottom of this great canyon the river itself follows a meandering course (Darwin, 1933, 221).

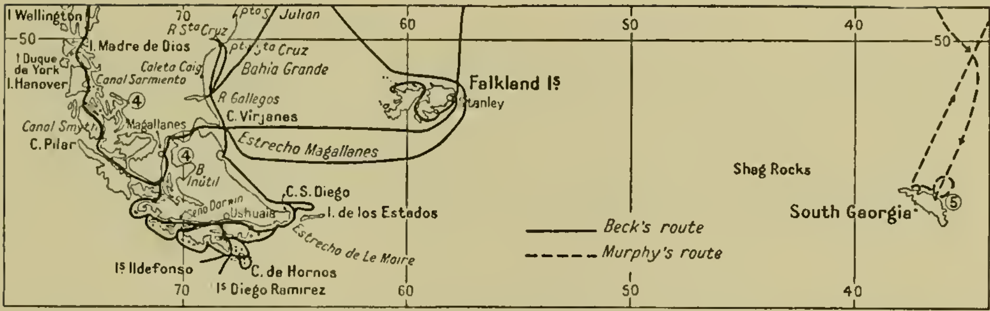


FIG. 27. Southernmost South America and the associated islands. For detailed maps of the latter see figures 37 (Tierra del Fuego), 28 (Falkland Islands), 31 (South Georgia). In addition to the tracks of Beck's and Murphy's travels, local American Museum field work is indicated by figures in circles: 4, Chapman, reconnaissance in Tierra del Fuego and western Patagonia; 5, Correia, at South Georgia.

The coast between Santa Cruz and the eastern entrance of the Strait of Magellan, and beyond toward the tip of Tierra del Fuego, requires no detailed topographic description, because of its substantial resemblance to those we have been skirting. It is made up of the usual cut edge of the pampa, with a succession of light-colored cliffs, and with shingle beaches, flats, and foul ground along the shore. The highest land is in the neighborhood of Puerto Gallegos which, with the remainder of this bight of the Patagonian coast, was so much frequented by Mr. Beck during the course of the Brewster-Sanford Expedition.

As intimated above, we are now in the zone of what we may broadly term the Magellanic marine avifauna, an assemblage of birds belonging to the southern tip of South America, to associated continental islands such as Staten Island and the Falklands, and in certain instances to islands of the Scotia Arc and the Antarctic Archipelago. Some of these species are strictly neritic in habit and are sedentary rather than migratory. Others, having their breeding grounds wholly or partly within the same region, are pelagic during a portion of the year, making an annual exodus that carries them, variously, a few degrees into lower latitudes, as far as the tropics, or even into remote oceans of the northern hemisphere. The breeding ranges of all species in the aggregation by no means coincide; they differ greatly, indeed, for reasons which may be either readily comprehensible or entirely obscure. In most instances such breeding ranges extend along a considerably greater length of coast on the Pacific side of the continent than they do in Atlantic Patagonia. Thus a composite of a number of characteristic examples would show a coastal distribution from near the southern end of the Golfo de San Jorge, in Patagonia, to close to the northern end of Chiloé Island in Chile or, roughly from latitude 47° S. on the Atlantic seacoast to 41° S. on the Pacific. The overbalance in favor of the Pacific within these latitudinal limits is probably due less to climate and to physical attributes of the ocean water than to better shelter among the maze of Magellanic islands, and to the mere territorial or areal advantage which is inseparable from the enormously greater length and complexity of coast line throughout southern

Chile. Another controlling factor has to do with the enormous tidal rise along the Atlantic coast, which peters out very rapidly both inside the Strait of Magellan and along the coast toward the Strait of Le Maire. The significance of this in relation to waterfowl distribution is discussed below.

Most of the Magellanic birds may be regarded as typically sub-antarctic. Some of them, however, will have to be called pan-antarctic because of their considerable extension toward polar land areas. Others, on the contrary, push their breeding ranges so greatly to northward on one or both coasts of South America—passing the tropic of Capricorn and even approaching the equator—that their precise distributional classification presents difficulties. These can be in part resolved through consideration of data presented in the preceding section on hydrology; the anomalies are most understandable along the Pacific coast, where the Humboldt Current carries a temperate environment far into the tropics.

Doubtless the best method of expressing the different geographic relationships will be to divide a list of characteristic species into several categories, beginning with exclusively Magellanic and relatively sedentary salt-water forms and ending, as I have already done under a discussion of tropical birds, with brief references to species which are neither oceanic, nor even necessarily riparian, but which, nevertheless, reflect the zoögeographic circumstances it is desired to point out. Regarding rhe last group, it may be said that, whereas within the humid tropics numbers of continental lowland marsh birds reach the borders of the ocean, in the cooler belt of southern South America it is chiefly the species of the bare highlands that do so.

It is hardly necessary to point out that the indicated distribution, from a more or less definite point on the Atlantic coast to a similar one on the Pacific, is rarely continuous. As suitable coastal habitats for any species are more often "spotty" than uniform, so are the ranges of the birds. Annotation of pertinent facts under the individual species will best serve our purpose.

(1) SEDENTARY AND EXCLUSIVELY MAGELLANIC SALT-WATER BIRDS

Diving Petrels

Pelecanoides magellani. Coasts and inland waterways from Puerto Deseado on the Atlantic, southward to Cape Horn, and northward on the Pacific coast to Chiloé Island; approximately 48° S., Atlantic, to 42° S., Pacific.

Cormorants

Phalacrocorax magellanicus. The Falkland Islands, and South American mainland and insular coasts from the Río Santa Cruz, Argentina, to Chiloé Island; approximately 50° S., Atlantic, to 42° S., Pacific.

Phalacrocorax albiventer. The Falkland Islands; South American coasts from Puerto San Julián, Argentina, to southern and western Tierra del Fuego; approximately 49° S., Atlantic, southward to near Cape Horn.

Geese

Chloëphaga hybrida. Southern Patagonia, on the Strait of Magellan, to Chiloé Island; approximately 52° S., Atlantic, to 42° S., Pacific. A distinct race (*C. h. malvinarum*) inhabits the Falkland Islands.

Like the South American Flightless Steamer Duck, discussed below, the Kelp Goose tends to avoid coasts characterized by large daily tidal amplitudes. This fact alone would limit its distribution on Atlantic shores.

Steamer Ducks

Tachyeres pteneres (Flightless), *T. patachonicus* (Flying), and *T. brachypterus* (Falkland Flightless). The three forms of steamer ducks are thus classified in Part II of this book. *T. brachypterus* is confined to the Falkland Islands.

The distribution of the mainland Flightless and Flying species largely coincides throughout a range extending from Puerto Deseado on the Atlantic, southward to Cape Horn, and northward on the Pacific coast to Corral. This is approximately 48° S., Atlantic, to 40° S., Pacific. The Flightless species (*pteneres*) avoids, however, coasts having a marked tidal rise and fall, with the result that it is normally absent from the whole eastern part of Tierra del Fuego and the Atlantic coast of Patagonia. Most of the steamer ducks in these districts represent the Flying species. To southward and westward, and throughout the Pacific extent of the range, the two are to be found together.

Oyster-Catchers

Haematopus leucopodus. The Falkland Islands; South American mainland and insular coasts from the Río Chubút, Argentina, to Chiloé Island; approximately 43° S., Atlantic, to 42° S., Pacific.

Gulls

Leucophaeus scoresbii. The Falklands; Tierra del Fuego; probably breeds also northward well toward Chiloé Island on the Pacific side. While this gull is mainly sedentary, there is a more or less sporadic migratory movement that carries certain individuals northward as far as the Río Gallegos, Argentina, and Mocha Island on the Pacific side. The species is not antarctic, and its inclusion within the South Shetland Island avifauna is probably based upon error.

(2) MAGELLANIC MIGRATORY SALT-WATER BIRDS

Penguins

Spheniscus magellanicus. Breeds at the Falkland Islands and along South American mainland and insular coasts from the Gulf of San Matías, Argentina, southward to Cape Horn and northward to the Bay of Arauco, Chile, or approximately from 42° S., Atlantic, to 37° S., Pacific. During the southern-hemisphere winter this penguin migrates northward to southern Brazil, sometimes as far as latitude 23° S., as previously noted. On the Pacific coast it wanders as far northward as central Chile (30° S.), overlapping the range of a closely related and representative species, *Spheniscus humboldti*.

Skuas

Catharacta skua chilensis. Breeds from southern Patagonia and eastern Tierra del Fuego to the Bay of Arauco, Chile, or approximately from 52° S., Atlantic, to 37° S., Pacific. Migrates northward at least to the coast of Brazil in the Atlantic, and into the northern hemisphere along the Pacific coast of America.

Catharacta skua antarctica. Breeds at the Falkland Islands. (This is alleged also to be the resident race of Tristan da Cunha and Gough Island, but probably in error.) Migrates northward in the Atlantic to the edge of the tropics or beyond.

The two Magellanic forms of the skua are arbitrarily placed in this category, rather than the next, despite the fact that they are both races of a bipolar species which has six or more subspecies. The Falkland and Chilean skuas are so distinct from the race inhabiting South Georgia, for example, as well as from one another, that each form may here be treated as though it were a full species.

(3) SEDENTARY SALT-WATER BIRDS OF COMBINED MAGELLANIC AND HUMBOLDT CURRENT RANGE

Cormorants

Phalacrocorax gaimardi. From Puerto Deseado, Argentina, through the Fuegian waterways, and northward along the Chilean and Peruvian coasts at least to the Guañape Islands; approximately 48° S., Atlantic, to 8° S., Pacific.

Oyster-Catchers

Haematopus ater. The Falkland Islands; South American coasts from islands off the southern shore of Uruguay southward to Cape Horn, and northward along the Pacific to northern Peru; approximately 35° S., Atlantic, to 6° 30′ S., Pacific.

Terns

Sterna hirundinacea. The Falkland Islands; both coasts of South America from Cape Horn northward. On the Atlantic side it nests northward to the Gulf of La Plata (35° S.), and possibly to the vicinity of Cape Frio (23° S.). Along the Pacific coast it nests northward to San Gallán Island, Peru (14° S.), and probably farther. In winter it wanders as far as Bahia, Brazil, and northern Peru.

All antarctic records for this tern, such as the generally accepted legend that it breeds at the South Orkney and South Shetland Islands, etc., appear to be due to confusion of the species with *Sterna vittata.*

(4) WIDELY DISTRIBUTED SUB-ANTARCTIC SALT-WATER BIRDS, WITH SOUTH AMERICAN BREEDING RANGES RESTRICTED TO THE MAGELLANIC DISTRICT

Penguins

Eudyptes crestatus. The Falkland Islands; easterly and southerly islands of the Fuegian region. The westward progress of this penguin ends at the phytogeographic limit of bare or grassy islands; it avoids forested or shrubby shores, such as characterize western Tierra del Fuego. The Jackass Penguin (*Spheniscus magellanicus*), on the other hand, occupies either bare, grassy, or wooded islands indifferently.

Albatrosses

Diomedea epomophora. Alleged to nest about Lake Cami or Fagnano, in Tierra del Fuego.

Shearwaters

Puffinus griseus. Nests at the Falkland Islands; islands of the Fuegian complex near Cape Horn; northward along the Pacific coast to Mocha Island, Chile (38° S.); and perhaps in the Andes of northern Chile.

Diving Petrels

Pelecanoides urinatrix. A race of this circumpolar species (*P. u. berard*) is resident at the Falklands and migrates as far as the coast of the Province of Buenos Aires. A less-well-known (or possibly the same) form occurs among the archipelagoes of southern Chile.

(5) MAGELLANIC SALT-WATER BIRDS OF PAN-ANTARCTIC OR MORE EXTENSIVE BREEDING RANGE

Penguins

Aptenodytes patagonica. South Georgia; Staten Island; formerly the Falkland Islands and various easterly outliers of Tierra del Fuego.

Albatrosses

Diomedea melanophris. South Georgia; the Falkland Islands; Ildefonso and other southerly Fuegian islets.

Diomedea chrysostoma. South Georgia; the Falkland Islands; Diego Ramírez Islets, off Cape Horn.

Petrels

Oceanites oceanicus. The South Shetland and South Orkney Islands; South Georgia; various Fuegian islets near Cape Horn. It appears, however, that the native Magellanic examples of this storm petrel represent a distinct and endemic race.

Cormorants

Phalacrocorax atriceps. South Shetland and South Orkney Islands; South American coasts from the Río Santa Cruz, Argentina, to Corral, Chile; approximately 50° S., Atlantic, to 40° S., Pacific.

The exact specific and subspecific relationships of the pan-antarctic White-breasted Shag have not yet been satisfactorily worked out. Future study may make it necessary to change the status of the Magellanic representative, as here recorded.

Gulls

Larus dominicanus. The South Shetlands, South Orkneys, and South Georgia; the Falkland Islands; South American insular and mainland coasts from Rio de Janeiro, Brazil, southward to Cape Horn, and northward to Lobos de Tierra Island, Peru; approximately 23° S., Atlantic, to 6° S., Pacific.

In addition to all of the above, reference should be made to the Sheath-bill (*Chionis alba*), a bird of uncertain status, the eggs of which have not been found within the Magellanic region. The Sheath-bill nests at South Georgia and in many parts of West Antarctica. It is found, at times in relative abundance, at the Falklands, in Tierra del Fuego, and along the southerly Patagonian coast, and it may yet prove to be a permanent resident of some part of South America. The Bigüá Cormorant (*Phalacrocorax olivaceus*), which reaches the southern tip of South America from the north, is a sort of distributional antithesis of the Sheath-bill. Its "zoneless" type of range has been previously discussed, and it remains to say only that this curious cormorant is as much at home on the bold shores of Cape Horn as it is on Caribbean sandbars or in Brazilian lagoons.

Finally, there are numerous birds which, farther north in South America, belong to the highlands or, at any rate, to the interior of the continent rather than the coast, but which in the Magellanic part of their ranges reach the edge of salt water. Among these are the following, the subspecific names, by which four or five of them have been distinguished from more northerly representatives, being omitted from the list.

Little Grebe. *Colymbus chilensis.*
Red-necked Grebe. *Aechmophorus major.*
Night Heron. *Nycticorax nycticorax.*
Black-necked Swan. *Cygnus melancoriphus.*
Andean Goose. *Chloëphaga melanoptera.*
Upland Goose. *Chloëphaga picta.*
Ashy-headed Goose. *Chloëphaga poliocephala.*
Coscoroba. *Coscoroba coscoroba.*
Crested Duck. *Anas specularioides.*
Spectacled Duck. *Anas specularis.*
Gray Teal. *Anas versicolor.*
Yellow-billed Teal. *Anas flavirostris.*
South American Pintail. *Anas spinicauda.*
Chiloé Widgeon. *Mareca sibilatrix.*
Red Shoveller. *Spatula platalea.*
Spurwing Plover. *Belonopterus chilensis.*
Rufous-throated Plover. *Oreophilus ruficollis.*
Pigmy Seed Snipe. *Thinocorus rumicivorus.*

7. The Atlantic Sub-Antarctic Islands

Again we may leave the continent in order to consider the geography and avifauna of more or less remote islands. Staten Island is definitely part of the Fuegian district, and will be treated in connection with the mainland. South Georgia, although oceanic, is antarctic rather than sub-antarctic and is, moreover, a unit of the Scotia Arc, to which a separate section will be devoted.

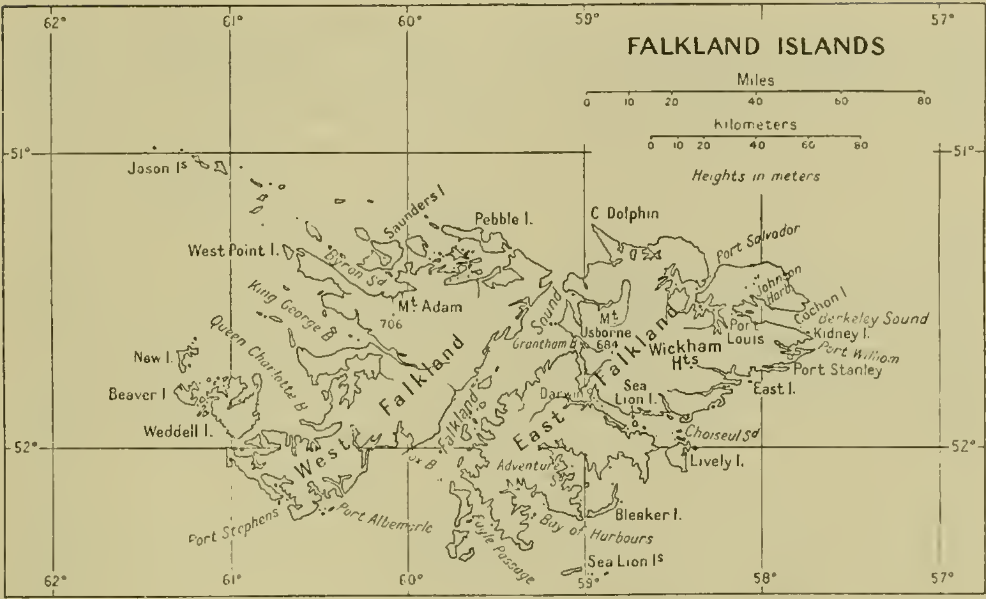


Fig. 28.

This leaves, therefore, only the Falklands, the islands of the Tristan da Cunha group, and Gough or Diego Alvarez Island. The two latter are among the most isolated bodies of land in any ocean, while the Falklands lie entirely within the 200-meter contour of the Patagonian coastal platform. Nevertheless, the distinctly oceanic elements in the bird population of the Falklands and of the Tristan area have many resemblances.

a. Falkland Islands.

The Falkland Islands lie on the continental shelf, about 418 kilometers east of southern Patagonia. With the exception of Beauchêne Island, in latitude 52° 55′ S., they are included between the parallels of 51° and 52° 30′ S., and the meridians of 57° 30′ and 61° 30′ W., their southern boundary being on a line with the eastern entrance of the Strait of Magellan. The group consists of more than one hundred islands and islets, but the bulk of the surface area of about 16,835 square kilometers is comprised within the two principal islands of East and West Falkland. These are separated by a strait or sound varying in width between 4 and 29 kilometers. East Falkland is in turn very nearly bisected into northeast and southwest halves by long fiords extending inland from the Atlantic and from Falkland Sound, respectively, a narrow central neck of land alone connecting the two main bodies.

Ridges of rocky hills traverse broad tracts of turf without a tree, sloping down nearly everywhere to low rocky coasts. In the northern half of East Falkland, the chief range, known as Wickham Heights, runs east and west, culminating in Mt. Usborne, 684 meters high, near its western extremity. Practically all of the southern portion of the island, south of Choiseul and

Grantham Sounds, is so low that it has very little visibility from the deck of a ship at a distance of 8 to 10 kilometers. West Falkland is of slightly greater average height, its peak, Mt. Adam, rising to 706 meters. Its hills run mostly north and south. Along the western coast of the group there are precipitous cliffs exposed to the fury of the almost incessant westerly winds.

The Falkland Archipelago appears to differ in geological structure from the Patagonian mainland. The terrain resembles, however, the western part of Tierra del Fuego in showing evidence of very extensive glaciation. The innumerable inlets and sounds indenting the shores of the islands are all of the deeply incised, fiord type. The hilly surface is free from striking irregularities, although most of the uplands terminate in points and crests rather than in rounded or tabular formations. Low stony ridges, more or less devoid of vegetation, cross the land at irregular intervals and run in all directions, as if without plan. Even the lower-lying tracts are intersected by quartzite reefs which stand out in sharp contrast with the dark background of the peat-bogs. A peculiar feature in the geology of the islands is presented by the much-described "stone rivers," which are made up of blocks and fragments of quartzite that have the appearance of flowing in narrow ribbons down the slopes of the hills. The lower land is made up of undulating plains, more or less resembling tundra, with winding brooks in the hollows and valleys, and with here and there boggy patches which show the dangerously warning color of bright green. Little seems to be known about relatively recent changes in the level of the land, but some of the older chronicles, such as that of Fanning (1838, 199), allege that entire skeletons of large whales have been found in elevated situations along the coast.

> The early navigators who saw the Falklands without landing, described them as being well wooded. These reports were owing to the islands being nearly covered with the most beautiful—as well as the most nutritious—grass in the world: 'the golden glory of these islands' . . . . Patches of tussock-grass (*Poa flabellata*) look from a distance like small low groves of palm trees. From 200 to 300 shoots spring from one plant, which rises to a height of between 5 and 7 feet; the leaves are sometimes 6 feet long. They possess valuable feeding properties, being rich in protein, and are eaten eagerly by horses, cattle, and sheep. A few inches of the bases of leaves, stem, and root are sweet and, according to Clayton, 'when roasted eat like almonds.' Ross says that two Americans who had wandered or deserted from their ship lived on West Falkland for fourteen months on tussock culm. The first French explorers thought it a kind of flag and called it *glayeuls*, though Bougainville recognized it as belonging to the *graminae*. Clayton, Penrose, and other English called it Penguin Grass, because in it the penguins made their nests, 'burrowing under ground like rabbits in their holes.' Whether by accident or design it was frequently set on fire by the early settlers, with disastrous results to the birds and seals. . . .
>
> To be really happy it requires a peat bog soil with the sea-spray on it. As Governor Moody says: 'Where the sea beats with the greatest violence and the spray is carried farthest, there the tussac grass thrives best on the soil it loves.'
>
> Owing to the abundance of sheep, this grass has almost vanished from the East and Western Islands, though an attempt was made in 1922 to plant an area with it near Port Stanley. In some of the smaller islands—such as West Point—it still grows luxuriantly, rising to a height of six feet, or more, the long leaves hanging gracefully down (Boyson, 1924, 276, 278).

Such is a description of the most famous of Falkland plants, a grass which is, or was, of great importance in the ecology of the native birds, as it is also at certain antarctic islands, such as South Georgia. Another plant of interest is the peat-forming *Empetrum rubrum*, related to the crowberry of the northern continents. This is the often-mentioned "diddle-dee," a word which, incidentally, was long ago transplanted to Nantucket, Massachusetts, if indeed the whalemen and sealers from that island did not originally introduce the name into the Falklands.

Boyson (1924, 267) writes further:

> In a wind-swept country such as the Falklands one place seems to resemble another in outline and appearance, all being undulating grass-land and 'diddle-dee.' Looking down from a height the general aspect is grey. The rocks which, seen close, are streaked with red and gold lichens, become merged in grey distance; and grey seems the far-off, unquiet sea. The absence of trees—though, as will be seen, attempts are being made to introduce them—adds to the monotony. 'Pas un arbre, pas un véritable arbrisseau ne vient rompre l'uniformité de ces vastes solitudes,' wrote Dumont d'Urville in 1822. The blossoming shrubs bear no brilliant flowers to bring colour to the landscape, but delicately tinted blossoms, frail-seeming, many most sweetly scented, and almost hiding from view.

It is the constant gales that prevent the growth of trees and large shrubs, except in the most sheltered places, and even there the tops are sheared off wherever they project beyond the windbreak. Consequently, the scenery in general resembles the northern moorlands of the British Isles. In the terse words of the 'South American Pilot,'

> Wind is the principal evil at the Falklands; a region more exposed to storms, both in summer and in winter, it would be difficult to mention. The winds are variable, seldom at rest while the sun is above the horizon, and at times very violent. During the summer a calm day is an extraordinary event. Generally speaking, the nights are less windy than the days, but neither by night nor by day nor at any season of the year are these islands exempt from sudden and severe squalls or from gales which blow heavily, though not usually lasting many hours.

Bryce, after remarking that the "winds are so strong and incessant that everybody goes about stooping forward," continues (1913, 314):

> I have seen many wild islands in many stormy seas, but never any inhabited spot that seemed so entirely desolate and solitary and featureless. There was nothing for the eye to dwell upon, no lake, no river, no mountain,—only scattered and shapeless hills,—a land without form or expression, yet with a certain simple and primitive beauty in the colours of the yellow grass and grey-blue rocks, shining through clear air, with the sea-wind singing over them.

The Falkland climate is of the sub-antarctic oceanic type, with marked equability throughout the year and frequent, though by no means heavy, precipitation. There are showers, on the average, on 250 days in the year, and yet the mean rainfall amounts only to about 660 millimeters. October is the finest month and March the worst. The mean temperature of the two midsummer months (December and January) is 8.3° C., that of the two midwinter months 2.8° C. Frosts and snow are not uncommon even during the summer, but thick ice rarely forms on the ponds at any season and snow lies long on the ground only in the highlands. The surrounding ocean is always ice-free. The extent of overclouding is high, even though the air is often extraordinarily clear. Falkland nights tend to be relatively brighter than the days, and the stars frequently shine with the brilliance of the tropics.

All the island coasts are, of course, rich in intertidal life. Kelp and other seaweeds pile up in enormous windrows along the beaches and, with flood and favorable gales, are likely to be rafted off to distant parts of the Atlantic. Calcareous algae, sea-anemones, many crustaceans, mollusks and other invertebrates abound everywhere in the shallow water, and the ocean surface is rich in nutrient material, as described in an earlier section of this book.

Movements of the surface water are complicated around the archipelago because, in addition to the northward-setting flow of the Falkland current, there are strong tidal waves among some of the tortuous channels between the islets. In the neighborhood of the Jason Islands, which form the northwesterly extension of the whole group, the movement augments to a race with a speed of 10 to 11 kilometers per hour. The southerly shores of the archipelago, and the wide funnel at the southern end of Falkland Sound, are usually strewn with flotsam from the Fuegian region, which includes branches and trunks of trees as well as great masses of kelp and fragments of the wreckage of ships.

Taste and industrial trends have not led the Falklanders to take to the sea to an extent transcending the necessary inter-island commerce, such as has been described in connection with the journeys of Mr. Beck. The inhabitants are, in fact, heirs of the gauchos, except that sheep rather than horned cattle are their present charges. As a constituent of island diet, mutton is known as "three sixty-fives." Bryce was struck by the anomalous absence of fishing-boats in the various ports. Despite a small total population, all but the very smallest islets of the archipelago are now inhabited at least by shepherds.

So far as known, primitive man never reached the Falklands, and since there was supposedly but one native mammal—the endemic wild dog commonly known as the Falkland fox—the islands were a paradise of sub-antarctic bird life. The "fox" has been rare for a century and extinct since about 1875. Darwin (1839, 477) noted that the Falkland geese, which were originally fearless of man, were quite aware of the danger from the predacious dogs. Since the disappearance of the latter, in fact, there seems to have been a change in habit of certain waterfowl which were once confined to outlying islets, but which have now added the moorlands of the main islands to their breeding area. On the other hand, the settlement of the Falklands, and the successive introduction of horses, cattle, and sheep; the rivalry between sheep and such native birds as the Upland Goose (*Chloëphaga picta*) in the consumption of pasturage, which has led to the placing of a bounty upon the head of this bird; raids upon the penguin colonies for blubber-oil and eggs; the classification of hawks, caracaras, and skuas as pests; and other more or less inevitable human meddling, have conspired to bring about an unfortunate reduction of the pristine bird life.

The Falklands, being cold-temperate, have an avifauna which is somewhat analogous in its components with that of high northern latitudes. While a number of the sub-antarctic species have no homologues in the northern hemisphere, the general aspect of Falkland bird life is not dissimilar from that of the fiorded coasts of Labrador and southern Greenland. Thus there is a profusion of gulls and terns (four species), a skua, several ducks and geese, numerous petrels and other Procellariiformes, and two native cormorants. The latter are both of sub-antarctic affinities, for the Bigüá Cormorant (*Phalacrocorax olivaceus*), which we have noted as occurring practically everywhere in America southward to the very island on which Cape Horn stands, has never reached the Falklands. This is curious, especially since the islands lie directly to leeward of waters inhabited by this cormorant and in a zone of powerful westerly winds. It goes to show that the Bigüá Cormorant, like the Brown Pelican, must be regarded as a species which closely hugs the continental seacoast, and which therefore could only fortuitously obtain a footing at relatively remote islands, as the pelican has done at the Galápagos.

Visitors in different decades, even in different centuries, have obtained a notably uniform impression of Falkland bird life. Fanning (1838, 196) writes: "The various sea-fowl, resting upon the slight eminences, and brought in strong relief against the sky, ofttimes deceive the experienced eye of the mariner, by having their puny dimensions magnified in size to those of human form." Several recent voyagers have independently made the same observation, adding the turkey vulture to the list of sentinels that loom large on the mounds and headlands. The earliest voyagers also very quickly arrived at a gastronomic classification of Falkland birds, which time and taste have not modified. Clayton (1776, 104) and others give detailed notes on the relative edibility of the different species of geese and of the different kinds of penguin eggs, and name the season in which each may be taken to best advantage. Other mariners report the distance to which the various penguins and the King Shag may be seen offshore from the Falkland colonies. The penguins travel so far that their presence may be discounted by shipmasters. Flocks of shags, however, will probably mean rocky coasts "within ten miles."

Bennett (1927, 259) makes the interesting statement that several species of Falkland birds lay smaller sets of eggs than their relatives in other parts of the world; both the resident oyster-catchers, for example, lay at most two eggs and not infrequently only one.

The avifauna of the Falkland Islands comprises about 102 species (Bennett, 1926, 306), this figure including numerous ocean wanderers which never voluntarily come ashore. The latter are chiefly petrels from the Antarctic or the north. These, together with visiting northern-hemisphere shore birds, regular migrants from Patagonia, casual or accidental species, and introduced birds, make up a third of the total. Bennett (1922, 256) reports extensive migrations of South American birds to the archipelago during years of continental drought, such as 1920. More than half of the 69 resident species are fresh-water or marsh birds and land birds, such as coots, plovers and their relatives, herons, Anatidae, vultures, hawks, owls, *Cinclodes*, flycatchers, wrens, thrushes, pipits, finches, and troupials. Chapman (1934, 6) lists six or seven endemic forms among the land birds, of which either two or three are to be regarded as full species.

There remain the 29 waterfowl listed below. Not all of these are strictly salt-water forms, two of the geese, for instance, being grassland birds, and several others feeding more or less in ponds or elsewhere back from the coast.

The list includes one endemic species, the Golden Grebe, *Colymbus rolland,* and at least two endemic subspecies; the status of some of the others is still to be determined. The King Penguin, and possibly one or more of the other birds, have recently become nearly or quite extinct at the Falklands.

PENGUINS
Aptenodytes patagonica
Pygoscelis papua
Eudyptes crestatus
Spheniscus magellanicus

GREBES
Colymbus rolland
Colymbus occipitalis

ALBATROSSES, PETRELS, AND DIVING PETRELS
Diomedea melanophris
Diomedea chrysostoma
Macronectes giganteus
Halobaena caerulea
Pachyptila belcheri
Procellaria aequinoctialis
Puffinus griseus
Garrodia nereis
Pelecanoides urinatrix berard

CORMORANTS
Phalacrocorax magellanicus
Phalacrocorax albiventer

GEESE AND DUCKS
Chloëphaga picta
Chloëphaga rubidiceps
Chloëphaga hybrida malvinarum
Tachyeres brachypterus
Tachyeres patachonicus

OYSTER-CATCHERS
Haematopus leucopodus
Haematopus ater

SKUAS
Catharacta skua antarctica

GULLS AND TERNS
Leucophaeus scoresbii
Larus dominicanus
Larus maculipennis
Sterna hirundinacea

The list should not be closed, moreover, without a reference to the Wattled Sheath-bill (*Chionis alba*), which has the appearance of a resident, even though it is less common in summer than in winter, and though its eggs have not with certainty been found in the Falklands (Bennett, 1926, 321).

b. Gough Island.

The islands of the Tristan da Cunha area constitute one of the most remote aggregations in any ocean. The southernmost and only completely isolated island in the region is Gough, or Diego Alvarez, the Portuguese name having priority by two centuries or more. It lies roughly 2500 kilometers west by south of the Cape of Good Hope, more than 3000 kilometers north by east of Cape Horn, and about 350 kilometers southeast by south of the nearest land, which is Nightingale Island of the Tristan trio.

Gough Island extends northeast and southwest for a distance of 13 kilometers, its greatest breadth being about half its length. Of volcanic origin, it rises abruptly from the sea on every side, with wave-cut cliffs suggestive of Madeira or still more of St. Helena. These increase in height toward the northern end where they reach about 300 meters. The altitude of the highest peak

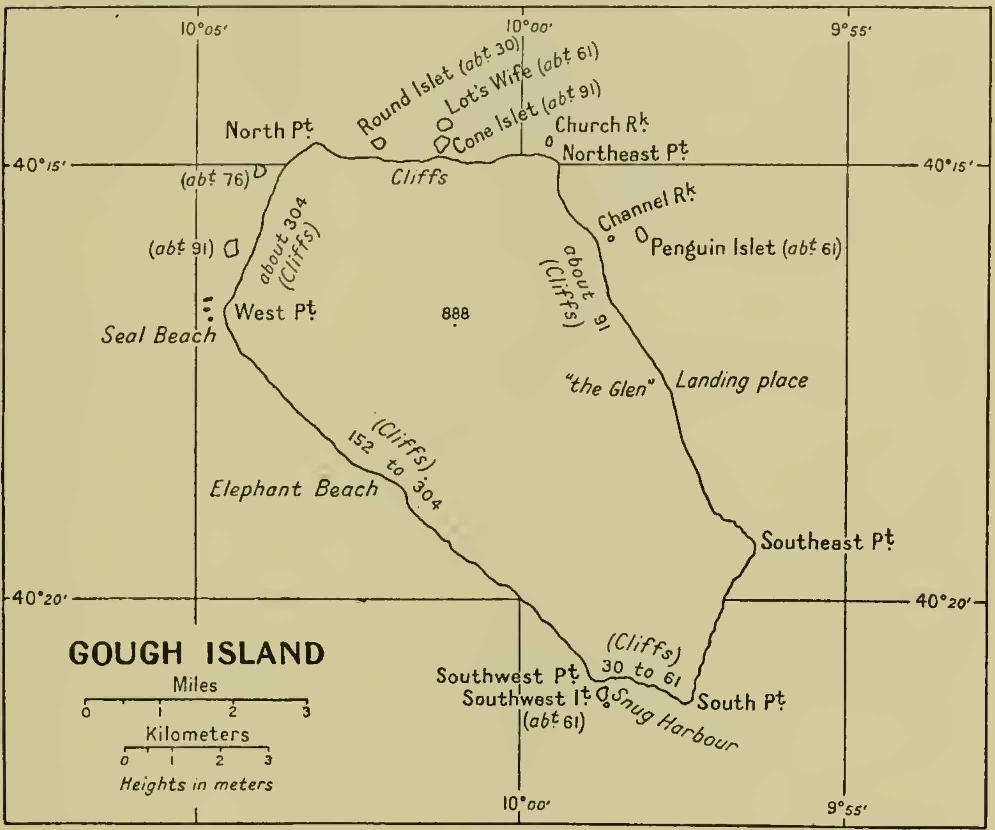


Fig. 29.

has been determined by Captain G. V. Douglas of the 'Quest' as 888 meters, instead of the 1300 meters previously reported. The island may be regarded as one of the pinnacles of the long mid-Atlantic ridge which makes its southernmost appearance above the ocean at Bouvet Island. Gough has been greatly eaten away by the sea, and the submarine contours, at least as far as the one marking a depth of 200 meters, have an outline very similar to that of the island itself. Off all coasts except the southwestern there are numerous exposed rocks and islets a short distance from shore. Several of these seem to be important as nesting grounds for certain terns and other sea birds to which the main island is unsuited. The largest are Lot's Wife, the Cone, and Round Islet, off the northern end, and Penguin Islet off the eastern coast.

Although Gough Island has never had permanent human inhabitants, it has been visited more or less infrequently for well over a hundred years, and numerous records of landings since 1820 have been carved on slabs of stones in the so-called "Glen" by whalemen, sealers, and ostensible diamond miners. The first scientific information about Gough came from collections and meteorological observations made by Captain George Comer, who has had a long association with the American Museum of Natural History, to which he presented the type of the Gough Island Rail (*Porphyriornis comeri*) and other specimens. His journal, and notes on his collections, have been published by Verrill (1895, 430). More recent scientific reconnaissances are those of the 'Scotia' party in April, 1904, and of the antarctic explorers in Shackleton's 'Quest,' made at the end of May and the beginning of June, 1922. The present notes are based in large part upon observations set down during these visits, as recorded respectively by Brown (1905, 430) and Wilkins (1923, 501).

The naturalists of the 'Scotia' were surprised to find Gough Island beautifully clothed in green from the tideline almost to the summit, and to see streams tumbling everywhere from hanging valleys or pouring over sheer precipices into the sea. Above the brinks the ground slopes more gradually towards the summit, though a considerable proportion of the land appears nearly inaccessible. Throughout the island, steep radiating ridges are separated by narrow glens, many of which harbor good growths of trees. Landing is practically impossible on the western side, the water's edge of which, however, can be reached overland, according to Captain Comer's diary. Excessive wave-erosion is testified to by the fact that most of the stream valleys have their courses truncated sharply by cliffs, so that the running water necessarily ends in a cascade. Some of the sea caves have evidently been left stranded at heights of from three to five meters above the present level of the ocean, indicating a relatively recent change in relation. Many mariners have stressed the difficulty or impossibility of effecting a landing at Gough Island except in quiet weather (Spiess, 1928, 98). Wilkins, however, went ashore from the 'Quest' on each of the four days between May 28 and June 1, which is close to the winter season. He states that the feat proved sometimes difficult but never dangerous to experienced men, and that by taking advantage of the shelving rocks at the foot of a cliff near the Glen, landing would be practicable in any weather.

The southerly slopes of Gough Island, according to Brown, appear more fertile and luxuriant than those toward the northern end. The vegetation is, however, very dense nearly everywhere, presenting a serious obstacle to walking about. This is partly due to the thick tufts of tussock grass (*Spartina arundinacea*), which is also the species of Tristan but is quite different from the tussock of the Falklands and South Georgia. Gnarled and stunted buckthorn trees (*Phylica nitida*) thrive from sea level to an altitude of almost 600 meters and grow even on exposed ridges. This is the species described nearly a century ago from Tristan da Cunha as *Phylica arborea* by du Petit Thouars, who said that it was the only tree growing on that island and that it reached a height of about 5 meters, with a trunk diameter of 15 centimeters or thereabouts. Later travellers have recorded boles up to 40 centimeters in diameter. The relationships of the genus are definitely with South Africa, where many other species are known. In a ravine south of the Glen, which lies near the middle of the east coast of Gough Island, members of the 'Quest' party discovered a grove of trees of a different sort, "growing as if planted in an orchard," and reaching a height of 4 to 5 meters. These have been identified as *Sophora tetraptera goughensis*, a variety of leguminous tree peculiar to this island but very closely related to one native in the New Zealand region. A third arboreal plant, if it may be so called, is the low tree fern (*Lomaria Boryana*), which reaches a height of only a little more than a meter and is characteristic of the damper hollows and sheltered glades throughout the island. The total Gough Island flora of about seventeen species of flowering plants, ten ferns and many other cryptogams is, as might be expected, very similar to that of the Tristan group, although it shows perhaps a stronger American element, as well as greater luxuriance. The coast is fringed with the usual border of kelp common to all sub-antarctic islands.

Native insects include a number of species of beetles and flies. At the date of Comer's visit, and apparently ever since, the island has been overrun with mice. These are generally assumed to be introduced house-mice. The only other mammals are the fur seals and sea-elephants which formerly hauled out in great numbers on all accessible shores.

Data on the climate of Gough Island are chiefly in the form of general descriptions and impressions. Weather conditions are not very dissimilar from those at the Tristan group, concerning which a few figures are recorded below, but they are more severe, since Gough lies well within the Sub-Antarctic Zone of surface water, while Tristan is close to the convergence with the Sub-Tropical Zone. Spiess describes the torn gray clouds that seemed to whirl around the peak on July 1, and Wilkins not only repeatedly mentions the rain, but also states that snow covered the higher slopes on May 31 and June 1. Rainbows were a notable feature of the weather during the brief visit of the 'Scotia.' Comer's residence at the island continued from August 23, 1888, until January 23, 1889. His journal of the weather and related phenomena is published in full by Verrill (1895, 472). It stresses the fog, gales, and excessive precipitation of this five-month period, and reports that a man of the party was frozen to death in the hills on October 19. Specifically, rain fell during six of the last nine days of August; on 19 days in September, with snow on three or four; rain or snow, or both, on 22 days in October; the same on 17 days in November, with many gales of wind, chiefly from a westerly quarter, but also with an increasing number of days characterized as "pleasant" in the entries; rain on 18 days in December, and on 15 days during the first 23 of January.

Comer notes also the gradual warming of the ocean water at Gough Island with the advance of spring and summer. Between August 25 and 29 it ranged between 8.9° and 10.6° C., while a reading of the air-temperature on August 28 showed 11.1° C. Throughout September the ocean surface water remained between 10° and 10.6°; during October the range was from 10° to 11.1°; all the November entries record 11.1°; on December 24 it reached 12.2°, and on January 6, 12.8° C.

The following record of landing, investigation, and personal experience at Gough Island is from the always illuminating and spirited pen of Sir Hubert Wilkins (1923, 504), who was naturalist of the 'Quest':

Keeping close to the beach we followed the east coast, which presented a much more rugged and broken appearance than the steeper, higher, and less eroded western side. On the east side deep valleys ran steeply to the central ridge. One conspicuous peak, named the Monument, stood out boldly, and falsely assumed the appearance of the highest point. Twisted and straggling trees were silhouetted against the sky-line, and were noticed in rough perpendicular rows on the slopes facing the sea. This may be evidence of heavy snowslides, or perhaps of the distribution of seeds from the trees at the higher levels. This theory is supported by the fact that the bigger and older trees are found at the top of the hills; on the other hand, it may be accounted for by the fact that the several parties who have lived on the island may have cut down for firewood all the bigger trees on the lower slopes. Jagged rocks footed the cliffs, which varied in height from 20 to 800 feet, and numerous caverns and caves were observed. The waves dashed on to the beach and into the caves with restless energy, and it was only on the rocks and sheltered coves that easy landings could be made. Here and there along the coast was a stretch of shingle beach, where the easier slopes approached the sea. It was on one of these and a few yards inland that two small huts were observed. One was the ordinary white man's type built of weatherboard and roofed with iron; the other was a shanty, half underground, stone-walled, and thatched with the tussock grass of the island. The 'Quest' anchored about two hundred yards from the beach, and a landing was made in the early morning. Both huts were found to be in a very good state of repair, and the iron-roofed one proved a haven of refuge one night, when during a violent storm of hail and sleet our tent was literally blown from the ropes, leaving us exposed beneath the skeleton of ridge pole and guys. The wind, although not blowing a continuous hurricane, sweeps down the gullies and over the cliffs in terrific gusts at the rate of sometimes more than a hundred miles an hour. There was a quantity of stores, supplies, and household utensils found in the huts, and round about were strewn implements and apparatus commonly used by gold and diamond miners throughout the world. A "dolly" still on its rockers stood in position near a trickling stream of water that has been guided to the spot. Beneath this miniature waterfall has been placed a butt, now filled with water, and in this was the first evidence of the tragedy that happens to natural life when civilised man makes an entrance. The dark blue back of a Penguin floated level with the water; its head and legs hung limply in death, for its curiosity had led it into the tub, and, being unable to get out, it had slowly starved to death. Many other skeletons were noticed about the camp, terrible evidence of man's destructiveness. . . .

The weather during most of the visit to Gough Island was not favourable for observation generally, pouring rain, high winds, and low temperature not only making for physical discomfort, but also rendering hill-climbing difficult. The hills are mostly very steep, and it is only with the aid of the tussock grass, trees, and tree-ferns that one is able to scramble up their slippery slopes. The vegetation is almost tropical in its luxuriance, but at the time of our visit the ground was so wet the plants were easily pulled from the shallow earth and failed to give a firm foothold. The trees grow so close together on the easier slopes that it is impossible to walk around or underneath them, and the branches are so intertwined that it is necessary in places to crawl through and over them for distances of a hundred yards or more. Clothes were torn to ribbons, and the pouring rain spoiled the appearance of most of the specimens collected. Wherever a sufficient depth of earth was discovered not overgrown with trees, it was honeycombed with holes made by the various species of Petrel that breed on the island. Very few of these birds remained during the daylight hours, but an occasional croaking betrayed a bird as the tramp of feet disturbed it in its resting-place. By this means several birds were located and added to the collection. Two *Adamastor cinereus* were discovered high up on the central ridge, and on the steep hillside above the hut four Broad-billed Prions (*Pachyptila vittata keyteli*) were secured. Many more were heard, but, as these birds have rather long and deep burrows dug beneath the tangled and tough tussock grass, it took some considerable time to dig them out. They were found in pairs in these holes, but no sign of a nest or the development of sexual organs showed a near approach to the breeding season.

In the dusk of the evening the air was filled with cries of birds returning from their daily visits to the sea, and, although it was too dark to shoot in the ordinary way, a huge fire was lit and Major C. W. R. Carr, the aviator to the Expedition and an excellent shot, helped me to secure some birds as they flew through the firelit area. In this manner we secured several birds, but they were difficult to find in the high tussock grass when they fell out of range of the light. If they were left out all night they were found to have been almost entirely eaten by numerous mice that swarmed everywhere, even among our party as they lay in the tent at night.

At the back of the huts and at several other points were Penguin rookeries, but they were deserted at the time of our visit, 1 June. They were invariably situated in the boulder-strewn narrow lowland between the high hills and the sea, and were partly hidden by the rank vegetation growing in the rich guano soil. A few old eggs and some skeletons were noticed here and there at the nesting-sites, but these were remarkably few, as was also the case at rookeries I have visited at South Georgia, South Shetlands, Graham's Land, and the Tristan da Cunha group. It is difficult to say what becomes of the old birds and the young ones that die from disease, for the numbers of skelerons in all rookeries visited would not amount to as many as one would expect to find in any one area as the result of death from natural causes.

The two land birds of Gough Island are endemic. One is the rail mentioned above, belonging to a genus found elsewhere only in the Tristan da Cunha group. The other is a finch formerly associated with the Tristan genus *Nesospiza*, but regarded by Lowe (1923, 512) as a peculiar genus and species, *Rowettia goughensis*. He holds that its affiliations are with *Melanodera*, the Yellow-browed Finch of southern South America and the Falkland Islands. Clarke (1913, 277) records 23 or 24 kinds of birds from Gough Island, but several of these represent merely pelagic transients collected over the adjacent waters. Below is a list of the oceanic species known, or assumed on reasonable evidence, to breed at the island. Future research may extend it considerably.

PENGUINS
Eudyptes crestatus

ALBATROSSES AND PETRELS
Diomedea exulans dabbenena
Diomedea chlororhynchos
Phoebetria fusca
Macronectes giganteus
Pachyptila forsteri
Adamastor cinereus
Puffinus assimilis elegans
Pterodroma mollis
Fregetta grallaria (?)
Garrodia nereis
Pelecanoides urinatrix dacunhae

SKUAS, GULLS AND TERNS
Catharacta skua, subspecies?
Larus dominicanus
Sterna vittata
Anoüs stolidus (?)

While the 'Scotia' was lying off Gough Island from April 21–23, 1904, all of the birds in this list except the Kelp Gull and the Noddy Tern were captured or observed. In addition, as recorded by Wilton, Pirie, and Brown (1908, 75), the Scottish naturalists collected the following four species which are not known to nest at the island and which belong, in fact, to a more southerly breeding zone.

Diomedea melanophris
Phoebetria palpebrata
Procellaria aequinoctialis
Oceanites oceanicus

The three albatrosses breeding at Gough Island are all "low" sub-antarctic forms, even the resident Wandering Albatross being of a race quite distinct from that inhabiting South Georgia and other islands lying in the Antarctic Zone of surface water. The lesser albatross (*Diomedea chlororhynchos*) is also different from species nesting at the Falklands or elsewhere in the higher sub-antarctic latitudes. In the presence of such species as *Pterodroma mollis* and *Anoüs stolidus* we can discern even the suggestion of an approach toward the Sub-Tropical Zone. It is not established that the Noddy nests at Gough Island, although it has been reported in winter as well as in summer, and it breeds no farther away than the Tristan group. Comparing the whole marine avifauna of Gough with that of the Falklands, we find perhaps six species common to each, but an even larger number of related forms are distinct either as to species or subspecies. Furthermore, Gough lacks entirely the cormorants, grebes, ducks, geese, swans, and shore birds represented at the Falklands, and boasts only a rail and a finch as reminders of remote zoögeographic bonds with the continents.

Wilkins observed at Gough Island the definite predilection that insular sea birds appear to have for windward coasts throughout the belt of strong westerlies. During the entire stay of his vessel the notable concentration of albatrosses, petrels, and terns was always to be found over waters to westward of the island, scarcely any birds being observable in the lee. The phenomenon reminded him that the great albatrosses at South Georgia and other islands of the southern oceans seem to show a cognate preference in making their nests chiefly in westerly situations, where they are most exposed to wind and weather but as a consequence enjoy optimum advantages in the relatively difficult matter of taking flight. Just why such birds should still find windward coasts attractive after they are once in the air is less clear; possibly there are advantages connected with a supply of food at the surface.

c. Tristan da Cunha.

The islands of the Tristan group are referred to so frequently in the biographies of the Rockhopper Penguin and of several albatrosses and other birds that a brief description will here suffice. The three members form a triangle within easy sight of one another, the peak of Tristan, which is in latitude 37° 5′ 50″ S., longitude 12° 16′ 40″ W., being, indeed, visible in clear weather for well over 100 kilometers. As with Gough, their pedestals are on the mid-Atlantic ridge but there are soundings of 2000 meters or more between them. The closest continental point is the Cape of Good Hope, distant about 2500 kilometers; St. Helena and South Trinidad, the nearest islands except Gough, lie more than 2000 kilometers beyond the northerly horizon.

Tristan da Cunha itself is 11 kilometers in diameter, nearly circular, and with the profile of a truncated cone projecting at an angle of forty-five degrees. The height of the peak is 2329 meters, and in the extinct terminal crater is a lake around which albatrosses were accustomed to nest at least until after the date of the 'Challenger's' visit in 1873. The coast is mainly precipitous, with cliffs from 300 to 600 meters, broken here and there by steep gulches ending in shingle beaches. Along the northwesterly side, however, an extensive sloping grassy shelf, upon which the settlement is established, stretches for about 4 kilometers in front of the abruptly rising terrain, and terminates in Herald Point.

The coasts of Tristan da Cunha have a scanty covering of green, derived mainly from grasses, sedges, mosses, ferns, the crowberry (the same as the

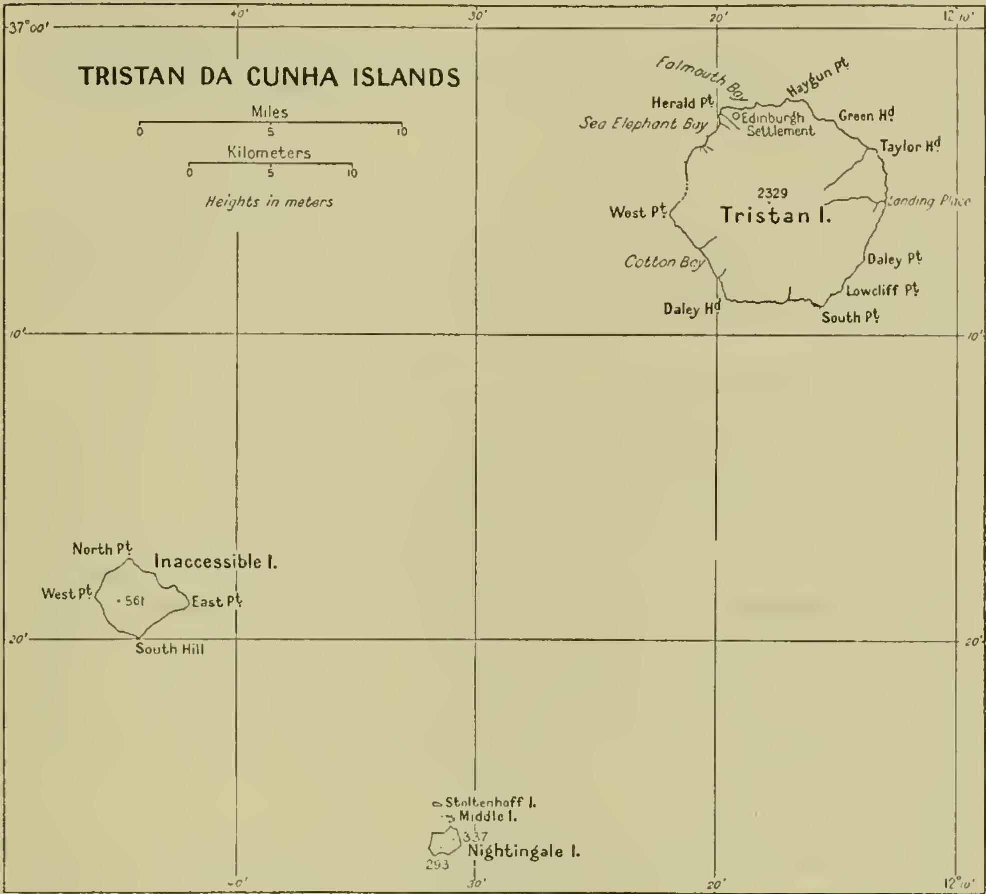


Fig. 30.

"diddle-dee" of the Falklands), and the darker patches of buckthorn trees. Many plants are of northern-hemisphere affinities, such as a bright green dock (*Rumex*), which grows under the bluffs and along the numerous watercourses. Dotted among the other herbage are the bluish green tufts of the tall reed-like grass (*Spartina arundinacea*) which is the so-called tussock peculiar to the Tristan group, Gough, and Amsterdam Island in the Indian Ocean. In many respects, this is the most important plant of Tristan and its neighbors. Moseley (1879, 117) writes of it as follows:

> In Penguin rookeries the grass covers wide tracts with a dense growth like that of a field of standing corn, but denser and higher, the grass reaching high over one's head. . . . Here there is a sort of mutual-benefit-alliance between the penguins and the tussock. The millions of penguins sheltering and nesting amongst the grass, saturate the soil on which it grows, with the strongest manure, and the grass thus stimulated grows high and thick, and shelters the birds from wind and rain, and animals, such as the predatory gulls.

The lower slopes of the mountain are covered with brush and ferns, including a small tree fern. Formerly this might appropriately have been called the forest belt of the island, but destruction of the woody vegetation progressed very rapidly after the beginning of colonization in 1817. By the time of the 'Challenger's' visit, good-sized examples of the one large tree, the native buckthorn (*Phylica nitida*), were to be found only in remote gorges of the mountains (Thomson, 1878, 34).

The constant heavy gales do not permit the tree to grow erect; the trunk is usually procumbent at its origin for several feet, and then rises again often at a right-angle. It is always more or less twisted or gnarled. In sheltered places, as under the cliffs on the north-east of Inaccessible Island, the tree is as high as 25 feet, but it is not nearly so high on the summit of the island, though the trunks are said to reach a length of 30 feet or more. The largest trunk I saw was about one foot in diameter, but they are said to grow 18 inches (Moseley, 1879, 112).

Giant kelp grows sparingly in shallow water around all of the islands.

Inaccessible and Nightingale Islands lie southwestward from Tristan at a distance of 32 kilometers, and about 18 from each other. The first of these is diamond-shaped, approximately 5 kilometers in length between its east and west points. The highest peak, situated near the western end, is 561 meters in altitude, and is said to enclose an old crater containing water, like that of Tristan. From this hill the land slopes irregularly, terminating in lofty cliffs except on the northerly coasts where there is a foreshore with negotiable landing places, dense growths of tussock, and even small copses of the buckthorn trees covered with a drapery of lichens. In addition to the main peak, there are two lesser rocky cones on Inaccessible. Wilkins landed at this island on May 22, 1922, and, by making full use of the tough tussock, he and other members of the 'Quest' party hauled themselves to the plateau after a stiff climb from the beach on the eastern side.

Nightingale is really a group of three islands lying along a north-south line. Nightingale itself is the southernmost, and is somewhat less than 2 kilometers in length from east to west, with two peaks, the higher of which is upwards of 300 meters in altitude, appearing of conical form in certain aspects. Most of the coasts are precipitous and have been carved by the sea into deep recesses and caves. The explorers from the 'Quest' crossed the island on May 21, 1922, and found that the way to the summit could be forced only with great difficulty through the high tussock grass. Many petrels were found in their burrows, and three examples of the Greater Shearwater (*Puffinus gravis*) were collected at a season when most examples of the species had previously been supposed to be on their migration toward the northern hemisphere. From the anchorage, at night, innumerable calls were heard of petrels returning from sea. A large number of Kelp Gulls was also observed at the island.

To northward of Nightingale, beyond a narrow strait which is blocked by rock fragments, lies the relatively low Middle Islet; and 1500 meters to northward of the latter is Stoltenhoff Islet, named for the marooned Germans who were taken from Inaccessible by the 'Challenger.' This island is precipitous but flat-topped, and is broken into three parts by narrow chasms.

The Tristan da Cunha group has a wet and stormy climate, with frequent precipitation during at least nine months of the year. There are, unfortunately, no comprehensive meteorological figures, but Wilkins (1923, 502) gives the following records relating to the year 1908: rainfall, 1646 millimeters; sun all day, 126 days; sun part of day, 232 days; sun unrecorded, 7 days; extremes of temperature 3.3°–25.4° C. Hail, snow, and ice are very rare near sea level, though between June and September the summit of the mountain is usually snow-covered. The finest season is from mid-December to March, January and February especially being usually bright and sunny months, with light breezes. Shortly before the end of the most unpleasant season, namely in mid-September, the majority of the oceanic birds which breed at the islands "begin to muster in couples on the sides of the mountains, and fill the air with the sound of their noisy courtship" (Earle, 1832, 366).

Moseley found that the temperature of the fresh-water runnels on Tristan was 10° C., and he inferred that the lower levels of the island were constantly cooled by the descent of such water from the snow fields far above.

Rollers, or great oceanic waves such as have been described for Ascension and St. Helena, sometimes reach Tristan da Cunha and pile high against the rocks. Early in the nineteenth century one such cast the British warship 'Julia' ashore on the island with heavy loss of life.

Of the domestic animals introduced into the Tristan islands, pigs, goats, rabbits, cats, and rats have successively become feral. The first three were subsequently exterminated at Tristan itself, two of them by the human inhabitants, and the rabbits and cats (!) by rats, which in turn have unquestionably been responsible for the disappearance of many native birds. An account of the accidental introduction of rats into Tristan, and of the subsequent effects, is given on page 481. The dogs of the islanders are also known to have been very destructive to ground-nesting petrels. At Inaccessible Island, wild hogs, which feed largely upon sea birds and their eggs, have existed for a great many years (Thomson, 1878, 153). One entire penguin colony had been wiped out by these animals even before the time of the 'Challenger' expedition. According to Gordon (in Mathews, 1932, 21), "seemingly there are no rats yet on either Inaccessible or Nightingale Islands, and long may it continue so."

To ornithologists familiar with phenomena of insular evolution, it will not seem surprising that each of the three islands of Tristan da Cunha harbors endemic races of land birds, and that Inaccessible is the home of a unique rail (*Atlantisia rogersi*), which is one of the most extraordinary flightless birds in the world. Its origin, and the manner in which its ancestors may have reached this speck in the wide Atlantic, pose many obscure problems. The remaining land birds are the Tristan Coot (*Porphyriornis nesiotis*), with a cousin at Gough Island; a species of thrush (*Nesocichla*), with distinct subspecies on Tristan and Inaccessible; and two species of buntings (*Nesospiza*), one of which is represented by separate races on Tristan and Nightingale Island; the second, *Nesospiza wilkinsi*, is a giant form peculiar to Nightingale. The land birds of Tristan da Cunha itself have all become extinct, and many of the sea fowl have been driven to residual sanctuary at the two lesser islands, where man has long been a devastating visitor but is not yet a permanent curse.

The Tristan da Cunha group shares all the native sea birds of Gough Island save the Giant Fulmar (*Macronectes*). The latter has been included among the resident species by Peters (1931, 46) and several preceding writers, but apparently in error. In no part of the world, I infer, does its zonal nesting range extend northward quite to the Sub-Tropical Convergence; Gough Island seems, indeed, to represent the closest approach.

Tristan, on the other hand, has seven or eight residents not yet recorded from Gough, but it would be rash to make a hard-and-fast comparison before the avifauna of Gough is much better known than at present. The ultimate residue in favor of Tristan will doubtless include some of the following species, especially such as have at least a slight sub-tropical stamp.

Puffinus gravis
Pterodroma macroptera
Pterodroma incerta
Pterodroma externa
Pelagodroma marina
Fregetta grallaria
Anoüs minutus

One would expect *Pterodroma macroptera*, in particular, to nest also at Gough. The status and ranges of the various Mother Carey's chickens of the genus *Fregetta* are still very uncertain, despite recent discussion by Mathews (1928, 7; 1932, 24).

8. The Scotia Arc

The narrowest gap between south polar lands and the rest of the world is that separating the Antarctic Archipelago from the southern tip of South America. Even here the barrier is a great one from a biotic point of view, because Drake Strait is nowhere less than 700 kilometers in breadth, while the abyss of its waters descends to 4000 meters.

To eastward and northward of the Antarctic Archipelago a garland of islands curves like a sickle toward Cape Horn, presumably connecting the lines of the Patagonian Andes with those of the Antarctandes. From the South American end, Tierra del Fuego, Staten Island, the Burdwood Bank, Shag Rocks, South Georgia, Clerke Rocks, the South Sandwich group, the South Orkneys, Clarence and Elephant Islands, the South Shetlands, and the islands once collectively called "Graham Land," complete the loop, which is known as the Scotia Arc. Echo-soundings show that most of the submerged portions can still be traced in the relief of the sea bottom. At the bend of the bridge lies the South Sandwich chain, closely paralleled to eastward by a narrow trench with contours going 8000 meters beneath the surface. All the evidence seems to indicate a protrusion of circum-Pacific tectonic structures into the heart of the South Atlantic, repeating the condition of similar arcs in the Caribbean region.

The contrast between the islands of the Scotia Arc and any of the insular or continental sub-antarctic districts we have thus far discussed is a profound one. Most of these American antarctic islands, as pointed out by Holtedahl (1931, 401), are now in the climatic state of Norway during the Ice Age. The more southerly members are covered in large measure by an antarctic ice-mantle type of glacier, *i. e.* the sort produced when ice covers the greater part of the land mass down to sea level, and yet is of no great thickness, the undulations of the terrain being still registered on the surface. Within historic time considerable direct evidence has been noted that this ice-domination is on the wane, and that the action of the foreland glaciers is gradually subsiding. Nevertheless, the environmental difference between such a region as Tierra del Fuego or the Falklands and the islands of the Scotia Arc, all of which lie within the Antarctic Zone of surface water, is very great. The more southerly of these islands are, indeed, hardly removed from extreme polar conditions. Even those farthest from the antarctic circle, like South Georgia and the northern members of the South Sandwich group, which because of milder winters, a higher temperature range, a greater amount of ice-free surface, and more abundant precipitation, have a perceptible plant cover, are still characterized by a greater paucity of life than anything known in continental South America, or even in truly polar lands of the northern hemisphere. The source and effect of the antarctic oceanic climate have perhaps never been stated more clearly than by Darwin (1839, 274) when pointing out the significant differences between the productions of the antarctic islands and of corresponding latitudes in the northern hemisphere:

> On the northern continents, the winter is rendered excessively cold by the radiation from a large area of land into a clear sky, nor is it moderated by the warmth-bringing currents of the sea; the short summer, on the other hand, is hot. In the Southern Ocean the winter is not so excessively cold, but the summer is far less hot, for the clouded sky seldom allows the sun to warm the ocean, itself a bad absorbent of heat; and hence the mean temperature of the year, which regulates the zone of perpetually congealed undersoil, is low.

Notwithstanding these considerations, the long extension of the Antarctic Archipelago toward relatively mild winds in the belt of westerlies has endowed this section of Antarctica with at least relatively favorable life conditions, making it on the whole the richest part of the south polar regions. If we assume that all its life originally entered from the north, we may say that the peninsuloid protrusion of a chain of high islands from the antarctic continent toward the South Shetlands and Joinville Island has enabled no fewer than ten species of birds to gain a local foothold in Antarctica. Furthermore, stray continental birds appear to enter this region with extraordinary frequency. A North American migrant sandpiper (*Bartramia longicauda*), and the South American Pintail Duck (*Anas spinicauda*), have been taken at Deception Island, latitude 63° S. (Bennett, 1927, 259), while in 1916 and 1917, after a prolonged drought in Argentina, so many examples of a central South American duck (*Oxyura vittata*) migrated to the South Shetland Islands that remains of these birds were commonly found for several years thereafter (Bennett, 1920, 30). Such casual happenings are suggestive in connection with the permanent immigration into the Antarctic of terns, skuas, sheath-bills, etc.

a. South Georgia.

If we start eastward from Staten Island, the first considerable land mass encountered in the Scotia Arc is South Georgia, lying between latitudes 54° and 55° S., and longitudes 35° 50′ and 38° 15′ W., and approximately 4000

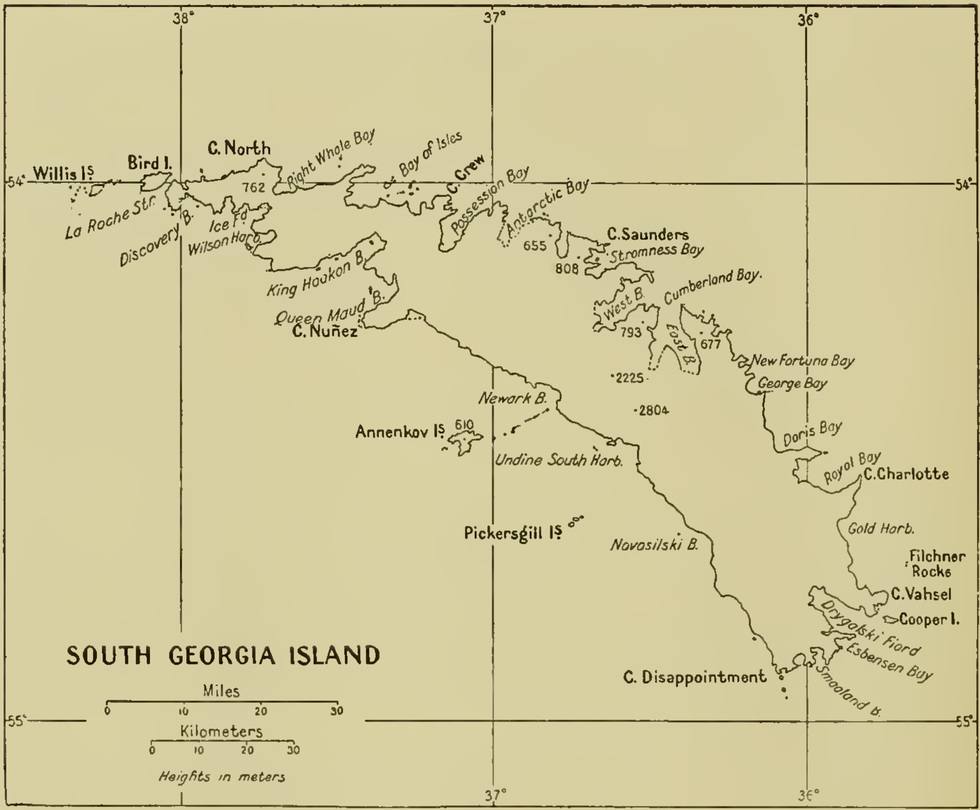


FIG. 31.

square kilometers in area. Its length is 160 and its greatest breadth about 30 kilometers. The trend of the island is southeast-northwest and it is crossed in the same direction by a mountain range with folds overthrust toward the north. The coast is deeply fiorded, the drowned valleys filled by glaciers as mighty as those of Spitsbergen, and snow-capped peaks rise to elevations of well toward 3000 meters. From shipboard in clear weather the island presents one of the world's most glorious spectacles—like the Alps in mid-ocean. The present snowline lies at an altitude of about 500 to 600 meters which, it should be noted, is lower than the treeline in the same latitude on Tierra del Fuego.

Along the northeastern side of South Georgia a wind likened to the Alpine foehn frequently sweeps down the mountains and tends to prevent the accumulation of snow on the lower slopes, even in winter. Such "williwaws" are sometimes strong enough to roll stones along level ground; they are usually accompanied by a rise in temperature, owing to pressure-heating of the descending air. The proximity of Weddell Sea, with its tendency to project cold weather northwards, produces generally low temperatures, the annual mean being 1.4° C., or fully 5° lower than that of Tierra del Fuego. Moreover, the low-pressure nucleus of Weddell Sea exerts the same influence as at the South Orkneys, so that the temperature curves of these islands and South Georgia parallel each other. The temperature amplitude is low because of the oceanic influences, the mean for June, the coolest month, being −2.0° C., that for February, the warmest, 4.9° C. The recorded absolute minimum and maximum temperatures are −12.3° C. (July) and 20.7° C. (February). The mean temperature of the seawater in Royal Bay during 1882–1883 was 1.63° C. Precipitation is relatively abundant, an annual average of about 1300 millimeters falling even on the less-exposed northeastern side of the island. The monthly total is least in October and highest in April. Fullness of the glacial streams depends rather upon the melting than the falling of snow; the torrent season begins in November and doubtless has an important local effect upon the enrichment of the sea. Although South Georgia is often spoken of as sub-antarctic, as by Mecking (1928, 319), it is in an oceanographic sense an outer antarctic island, more or less surrounded by ice during several months of each year.

South Georgian vegetation reflects the climatic conditions. There are but 19 species of vascular plants, of which the most pretentious is a grass. Of cryptogams about 200 species have been recorded. The affinities of the flora are in the main with South America, to a lesser extent with easterly islands toward New Zealand. The flora represents a transition between the Falkland type and that of the Antarctic Archipelago. The most abundant and conspicuous plant is the virile tussock grass (*Poa flabellata*), which covers much of the low ground and on favorable northern exposures straggles up to altitudes of three or four hundred meters. As at the Falklands, this grass loves the vicinity of the sea and thrives particularly well on the low-lying islets off the coast, localities that never suffer from the detriment of an ice cap, and on which the fallen snow is always exposed to the denuding violence of the gales. The other grasses of South Georgia are inconspicuous. The plant next in prominence to the tussock is a rosaceous herb (*Acaena adscendens*), common also to the southern islands of the Indian Ocean. The round red-flowering heads of *Acaena* blossom out attractively on the moraines and lower hillsides all through the South Georgian summer, often pushing through beds of lingering snow.

All but three or four of the other phanerogams must be diligently sought to be seen at all. Then there are four species of modest ferns of which two are rare, and a variety of liverworts, mosses, lichens, and algae. An orange-colored lichen (*Placodium*) forms brilliant patches on the ledges along the coast, and a shaggy gray *Usnea* beards many of the rocks. About the first of February, small red toadstools (*Marasmius*) spring up between the tussock hummocks on the higher beaches, and for the remainder of the brief southern summer add one homelike feature to the cold ground. Girdling the shore, and dampening the action of surf along many stretches, are dense growths of the giant kelp (*Macrocystis*), the longest of sea plants which harbors among its branches an aggregation of living creatures more abundant than any inhabiting forests of the upper world. When the ocean is calm, and the sun peeps through the clouds, sending a shaft of light down into the brown obscurity of the kelp beds, the water may be seen to be literally filled with minute beings which constitute part of the plankton.

South Georgia has the richest insect fauna of any American island lying wholly within the zone of antarctic surface water. There are five species of beetles, four of Diptera, and five of Collembola, not counting a considerable number of parasitic forms.

Mecking is over-optimistic when he states that South Georgia seems to be not without prospects of success as a sheep country. As a matter of fact, introduced sheep and European rabbits, both of which thrive at Kerguelen Island, have failed to survive at South Georgia. The severity of the climate seems to be just beyond the threshold of conditions compatible with their existence. On the other hand, feral horses and reindeer have found the climate and the rich pasturage quite to their liking, while rats have been acclimated since the early days of fur seal hunting, probably since about 1800. Still another introduced animal is the much-persecuted Upland Goose (*Chloëphaga picta*) of the Falkland Islands. A few pairs were introduced from the Falklands in 1910, and have since thriven and multiplied in the grasslands about the several fiords of Cumberland Bay, where they should be forever untroubled by the rivalry of sheep (Murphy, 1916, 276).

The native birds of South Georgia have been studied during two American Museum expeditions, as described in an earlier section (pp. 25, 26). They include two endemic species, namely, a pipit (*Anthus antarcticus*) and a teal (*Anas georgica*). Both of these are representatives of species inhabiting southern South America, directly to windward. The teal is, in fact, a close relative of the Brown Pintail (*Anas spinicauda*). No other species at the island is more than racially distinct from its nearest of kin. With the exception of the teal and the pipit, the avifauna is thoroughly characteristic of the Antarctic Zone. It lacks, indeed, only four birds found in the highest group of latitudes to which the sea extends, namely, the Emperor and Adélie Penguins, the south polar form of the skua, and the Antarctic Petrel (*Thalassoica*). The complete list of breeding sea birds of South Georgia is as follows:

PENGUINS

Aptenodytes patagonica
Pygoscelis papua
Pygoscelis antarctica
Eudyptes chrysolophus

ALBATROSSES AND PETRELS

Diomedea exulans exulans
Diomedea melanophris
Diomedea chrysostoma
Phoebetria palpebrata
Macronectes giganteus
Daption capensis (probably)
Procellaria aequinoctialis
Pagodroma nivea
Oceanites oceanicus
Fregetta tropica
Garrodia nereis
Pelecanoides georgicus

CORMORANTS

Phalacrocorax atriceps georgianus

DUCKS

Anas georgica

SHEATH-BILLS

Chionis alba

SKUAS, GULLS AND TERNS

Catharacta skua lönnbergi
Larus dominicanus
Sterna vittata georgiae

The breeding record of the Snow Petrel (*Pagodroma*) perhaps needs confirmation. Moreover, if this species nests at South Georgia, it is hardly likely that *Priocella antarctica* does not. It should be remembered that the mighty steeps and headlands of the southwesterly, windward, and colder coast of the island are still little known. Probably a search of suitable localities near the southern extremity would disclose *Daption*, *Pagodroma*, and *Priocella* as common resident petrels.

b. South Sandwich Group.

The South Sandwich Islands, which form an arcuate chain at the eastern apex of the Scotia Arc, may still be called one of the least-known archipelagoes in the world. Discovered by Cook, in January, 1775, they were mistaken for promontories of an antarctic mainland, but von Bellingshausen, in December, 1819, distinguished several of the islands, observed their volcanic, steaming character, and even pointed out that the penguins made use of land kept clear of snow and ice by the warm vapors. He also mentioned particularly the large numbers of sea birds of other sorts seen about the group and over the neighboring fields of floating ice (von Bellingshausen, 1902, 56). Morrell (1832, 65) later visited several of the islands in the 'Wasp,' and recorded the presence of albatrosses, Giant Fulmars, skuas, and Sheathbills, in addition to at least one bird conjured out of his imagination.

Coming to modern times, the 'Scotia' passed the southerly islands in 1903, and Larsen made important landings upon a number in 1908. Dur-

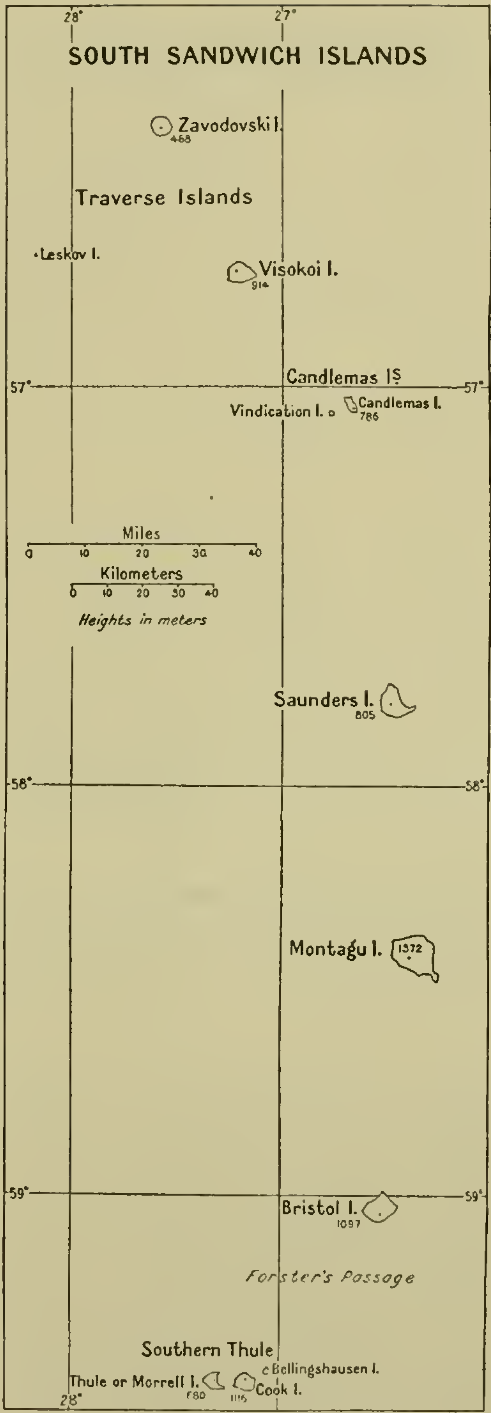


FIG. 32.

ing the spring of 1911, the 'Deutschland' cruised along the chain, and Filchner (1922, 111) has written of the abundance of penguins, Cape Pigeons, and Snow Petrels. The 'Quest' made a brief reconnaissance of the northerly members during January, 1922, Wilkins (1923, 490) subsequently publishing some excellent observations on the bird life, most of which are quoted in my biographies. The 'Meteor' later passed to northward and eastward of the group in the middle of the summer period, and plumbed, by means of echo-soundings, the adjacent deep, which shows an extreme of 8060 meters (Spiess, 1928, 199).

The explorations listed above all culminate in the thorough reconnaissance made by R. R. S. 'Discovery II' at the end of February, 1930 (Kemp and Nelson, 1931, 133). In the course of this notable cruise the British research vessel steamed at slow speed around each of the islands. The position of each was fixed by astronomical observation, and continual soundings were carried out. Good use was made of the camera, and provisional maps were prepared of the eleven islands and their outliers. Twenty days were spent in the survey. Temperatures proved low, even in this midsummer period, and for one week the thermometer never rose above the freezing-point.

The group lies between latitudes 56° 18′ and 59° 28′ S., and between longitudes 26° 14′ and 28° 11′ W. The northernmost island is about 535 kilometers east ½ south from South Georgia. The chain is over 350 kilometers long, and concave toward the west. The largest member is Montagu, circumference about 44 kilometers, and the smallest Leskov, with a circumference of about 3 kilometers. All of the islands are volcanic, several of them still being in the stage of simple cones. Five have definite present activity, emitting vapors of internal warmth, while three others, namely, Bristol, Cook, and Thule, are very heavily glaciated, without sign of warmth and with an ice cap at sea level attaining an average thickness of 60 meters. Candlemas Island has an active crater on the southern side of the summit, and several lesser cones that emit steam and sulphurous fumes. Penguins avoid this part of the island, but elsewhere they occupy the ground in large numbers wherever the absence of glaciers and cliffs permits them to gain the shore and establish themselves. The 'Discovery II' party specifically noted penguin rookeries upon four of the other islands as well.

The tussock grass of South Georgia apparently grows nowhere in the South Sandwich group. Giant kelp is also completely lacking in the waters round about. (Kelp occurs at the South Orkneys, though much less abundantly than at South Georgia, while it is missing at the South Shetlands.)

Many icebergs were found stranded near the shores of the South Sandwich Islands. Between the group and South Georgia a tabular berg with an estimated length of over 100 kilometers was encountered; the 'Discovery II' rode out a full gale of wind under the lee it afforded. During the winter, of course, the South Sandwich Islands are completely beset by pack-ice from Weddell Sea.

The ornithological status of the archipelago may best be summarized in the words of the 'Discovery II' naturalists:

Birds are numerous on the islands. Penguins are especially abundant and have built their rookeries in almost every suitable place. They will not nest on the glacier itself, nor, doubtless because of the danger of falling ice, on the beaches beneath it. In consequence they find much difficulty in establishing themselves on the more heavily glaciated and precipitous islands; on some, such as Thule and Bristol, there are only one or two small headlands which they can occupy, and they appear to be altogether absent from Cook and Leskov. On islands where the warmth of the rock has melted much of the snow they are particularly abundant, and on Bellingshausen it was noticed that small groups had climbed the steep slopes of the cone, ascending almost to the edge of the crater and to a height of at least 450 ft. above sea-level.

The Antarctic or Ringed Penguin (*Pygoscelis antarctica*) is much the commonest species, and Dr. Marshall, who landed near a small rookery on Thule Island on March 7, tells us that he found the young birds shedding their down coats. Gentoo and King penguins (*Pygoscelis papua* and *Aptenodytes patagonica*) were seen on Zavodovski and Saunders Islands. They probably occur on other islands also, but even with powerful glasses it was difficult to identify the species of penguin from on board ship. Those frequently seen on icebergs were invariably *P. antarctica*. Capt. J. Brown, who landed a party on Zavodovski in 1830, reported that his men found five different species of penguin, but he does not give their names. On this island Larsen found the Macaroni penguin (*Eudyptes chrysolophus*) in addition to those mentioned above. The Adélie penguin (*Pygoscelis adeliae*) probably occurs, but was not recognized with certainty. Mecking's statement that the Emperor penguin (*Aptenodytes forsteri*) occurs at the islands in large numbers is certainly incorrect.

The Cape pigeon (*Daption capensis*), known to some of the early voyagers as "the Spotted Eaglet," is extremely abundant at most of the islands, but seemed to be less common at the Southern Thule Group. Very frequently it was seen flying or swimming with the Silver-grey fulmar (*Priocella glacialoides*) [= *P. antarctica*], which is equally numerous. Both species were seen in thousands perched on ledges on the steep cliff sides, and we think it certain that they nest on the islands.

Another species common at many if not all the islands is a tern, doubtless a form of *Sterna vittata;* small flocks were frequently seen sitting head to wind on an iceberg in company with Antarctic penguins. The Giant petrel (*Macronectes giganteus*) was sometimes numerous, but the Shoemaker (*Majaqueus aequinoctialis*), a skua which appeared to be identical with that at South Georgia (*Catharacta lönnbergi clarkei*) and the Dominican gull (*Larus dominicanus*) were less common. Wilson's petrel (*Oceanites oceanicus*), a most abundant bird at South Georgia, was here very scarce, and whale birds (*Prion* sp.) [= probably *Pachyptila desolata*] were seen only on a few occasions. A Shag (*Phalacrocorax atriceps*) [subspecies doubtful] was observed at the Candlemas Group, and a large flock of them was constantly around us while at anchor at Bristol Island A single Mollymauk (*Diomedea melanophrys*) was seen at Saunders. Other Albatross (*Diomedea exulans* and *Phoebetria*), the Snow petrel (*Pagodroma nivea*), the Diving petrel (*Pelecanoides*) and the Sheathbill (*Chionis alba*) were not seen at all. In the nesting season other birds are doubtless to be found at the islands: Larsen reports that in November he saw thousands of *Pagodroma nivea* nesting with *Daption* on Leskov (Kemp and Nelson, 1931, 156).

c. *South Orkneys.*

The South Orkneys lie about 500 kilometers from the tip of the Antarctic Archipelago, nearly 1000 kilometers southeast by east of the Falklands, and about half that southwest of South Georgia. Although landed upon frequently between 1821 and 1893, there were no more than meagre descriptions until the visit and subsequent wintering of the 'Scotia' in 1903 and 1904. Only two of the several islands are of considerable size, namely, Coronation, which is the most westerly, and Laurie, the most easterly. These and the lesser islets represent parts of mountain ranges which have been submerged to such an extent that only their topmost peaks project from the sea.

Lying on the northerly side of the antarctic low-pressure trough, the South Orkneys are constantly swept by west and northwest winds. During four-

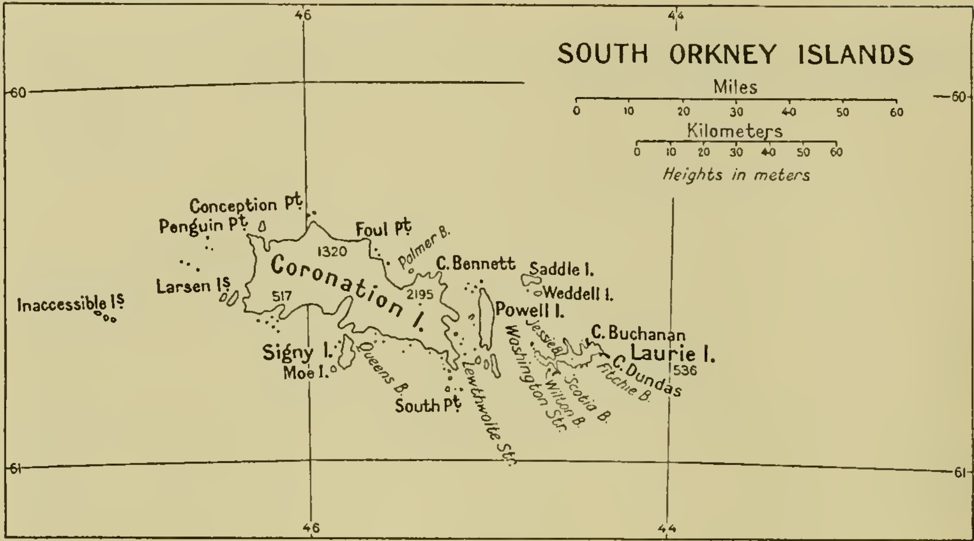


Fig. 33.

fifths of the year the sky is completely overcast; in this respect the group constitutes a sort of antarctic equivalent of Jan Mayen. Precipitation averages little more than one-third that of South Georgia. The mean annual temperature is about −5.0° C., but it varies greatly both diurnally and annually with the breaking through of polar influences. The mean temperature for the three warmest months barely passes the freezing point (0.1° C. for January). Therefore the cold desert and tundra of the true antarctic reign here, limiting plant life to the development of mosses and lichens (Mecking, 1928, 318).

Clarke (1913, 220) summarizes the relation of South Orkney weather to surrounding meteorological influences as follows:

> . . . in winter, owing to the freezing up of the sea to the south, the islands are virtually on the edge of a continent, and the temperature at that season is thus characterised by great variability, the range of the thermometer frequently exceeding 60° F. in twenty-four hours. If the wind is in the south, very low temperatures, as low as 40° below zero F., are recorded; but with a change of wind to the north the thermometer may rise, even in the depth of winter, above the freezing-point. Summer is characterised by almost continuously overcast skies, and the finest and clearest weather occurs in winter. Owing to the large amount of cloud which hangs over the islands in summer, the temperature is much the same as at places ten degrees further south. The snowfall is excessive, the sunshine is very deficient, and strong gales are frequent.

Laurie Island, where the 'Scotia' wintered, was the main scene of the labors of the Scottish expedition, and it is upon observations and collections made during eleven months' residence there that the following notes are based. The length of this island is about 19 kilometers, its maximum breadth 10 kilometers, and its area fully 75 square kilometers. The interior is lofty, and several of the summits reach to an altitude of from 600 to 900 meters. A number of deep bays run inland from north to south, separated by narrow rocky peninsulas or steep ridges, and cause the island to have a very polypode outline. All the valleys are choked by glaciers, and what little exposed rock remains visible is precipitous in the extreme. Here and there on the lower slopes and at sea level are a few areas of more or less level ground. In winter the whole island, including even the faces of cliffs, becomes covered with snow, which does not commence to disappear until October and November (the late spring and early summer months); then, however, patches of moss-covered ground are laid bare, some of them supporting a thin soil of vegetable mould. The rocks are mostly covered with lichens, especially *Usnea* (Clarke, 1913, 219).

The flora of the islands is poor in species, poorer than might be expected from their latitude. The predominant forms are lichens and mosses, but there are fewer species of both than in Graham Land farther west and sourh: fourteen mosses and eleven lichens are known from the South Orkneys, whereas twenty-seven mosses and fifty-five lichens have been found on the west coast of Graham Land, as well as two flowering plants and three hepatics unknown from the South Orkneys. There are, nevertheless, pleasing patches of vegetation in the lower snow-free places.

Seals and sea birds are summer visitors that leave when the islands are ice-bound in winter. Fur-seals once occurred in small numbers, but none remains; there are Sea Elephants, Weddell Seals, Sea Leopards, and occasional Crab-eaters. Eighteen species of birds nest in the group, some in enormous numbers; there are Petrels, Gulls, Terns, a Shag, the Sheathbill, and Penguins. Adélie and Antarctic Penguins are very numerous. There are few invertebrates: two earthworms, some free-living Nematodes, three Collembolans, and a few mites are known (John, 1934, 30).

Knowledge of the bird life of the South Orkneys is due mainly to the investigations of the Scottish naturalists, as reported by Clarke. However, Valette (1906, 3), who resided for a considerable period at the meteorological station maintained by the Republic of Argentina, has also given us an extraordinarily illuminating record of the life histories of South Orkney birds, a document upon which I have drawn heavily in preparing the accounts of several species.

The birds known to breed at the islands are the following:

PENGUINS

Pygoscelis papua
Pygoscelis adeliae
Pygoscelis antarctica
Eudyptes chrysolophus

PETRELS

Macronectes giganteus
Daption capensis
Pachyptila desolata
Priocella antarctica
Thalassoica antarctica (?)
Pagodroma nivea
Oceanites oceanicus
Fregetta tropica

CORMORANTS

Phalacrocorax atriceps

SHEATH-BILLS

Chionis alba

SKUAS, GULLS AND TERNS

Catharacta skua lönnbergi
Larus dominicanus
Sterna vittata

The bird last named is listed in most of the literature as the South American Tern (*Sterna hirundinacea*). Elsewhere, however, I present evidence to show that the latter species does not enter the antarctic regions.

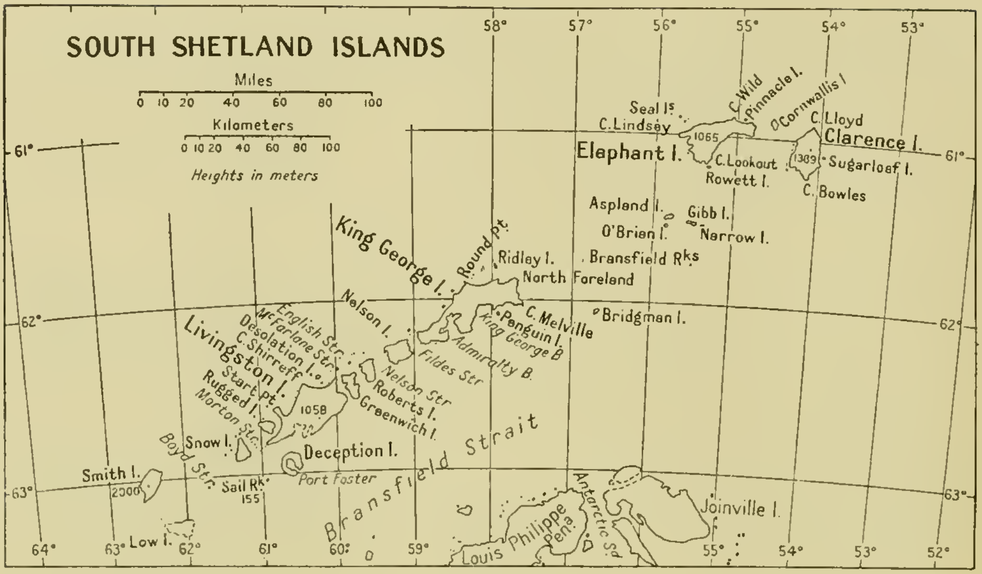


Fig. 34.

d. South Shetlands.

Just off the northern tip of the Antarctic Archipelago, which was until recently regarded as a mainland peninsula, are the South Shetlands which, together with Elephant and Clarence Islands to eastward, constitute a chain more than 500 kilometers in length. The group as a whole lies between the parallels of 61° and 63° S. The islands are wild and mountainous, with sharp peaks surrounded or covered by ice, and the rock is at least in part andesitic lavas which have counterparts in the backbone of South America. There is less floating ice, and far fewer bergs, than in the neighborhood of the South Orkney and South Sandwich groups because of the great stretch of open Pacific to windward of the South Shetlands, and the geographic and meteorological barriers between them and the waters of Weddell Sea.

Deception Island, which is one of the few volcanoes that have been breached and inundated by the ocean, is the best known of the South Shetlands. The sheltered basin of its circular crater-harbor, with a single narrow entrance and a depth of 175 meters, was used by Yankee sealers of the early nineteenth century and is now the seat of an extensive whaling exploitation.

The ice-covering of Deception Island is more or less undermined and eliminated by volcanic gases, steam, and hot springs. Mosses and lichens form in some places a carpet over the soil, where insects of a few forms thrive. Grass is lacking. There are penguin rookeries with a total population of more than one hundred thousand birds. These, and other species, seem to be affected to a certain extent by the volcanic warmth of the island. Snow-free sites appear relatively early in the antarctic spring, and the Kelp Gull nests at Deception Island, according to Bennett (1927, 259), fully a month earlier than it does at the Falklands.

The composition of South Shetland bird life is not very different from that at the South Orkneys, but excessive numbers have been attracted to the former group by modern whaling operations. The still harbor of Deception Island is sometimes almost hidden under a raft of petrels of several sorts. Sir Hubert Wilkins, who made the island the base of his notable exploratory flights toward the antarctic continent, has informed me that the enormous bird population constitutes the greatest single hazard for an airplane. When taking off from the water, or alighting, at Deception Island, he has found it necessary first to attempt to clear a lane of water by driving a power-boat back and forth through the hordes of swimming birds.

The fault basin of Bransfield Strait, which separates the South Shetlands from the neighboring antarctic region of many names, which is now known to consist of lofty islands, forms the pathway of numerous and variable ocean currents. One movement of surface waters, swinging around the tip of the Antarctic Archipelago, tends to thrust the ice-fields far back toward the southwest. A warm eddy from the north frequently passes southward through the strait, while close along the southerly coasts of the South Shetlands there is commonly a cold current running strongly northeastward. Here in late January the 'Meteor' found air temperatures of 1° C. at the surface of the water, overlaid by temperatures up to 11° C. at altitudes of 300 meters, a condition which sufficiently accounts for the dense, low-lying fogs that often prevail under clear skies (Spiess, 1928, 189).

e. The Antarctic Archipelago.

"Palmer Land," "Graham Land," and other units of this long projection of West Antarctica, succeed one another southward in the form of islands large and small to a point beyond the 70th parallel, where Stefansson Strait divides the chain from Hearst Land in the still problematical part of the antarctic continent. Through this gap it is probable that quantities of ice are short-circuited out of the head of Weddell Sea. The insular wall of the Antarctic Archipelago is steep along the western side, with a tabular region to eastward. Like Chilean Patagonia it has a fiord-and-channel coast. Old beaches, at both lower and higher levels than those of the present day, are perhaps as familiar here as in southern South America (Daly, 1920, 246).

A mountainous country, with peaks at least 3000 meters in height, with snowfall greater than snow-waste, even during the summer months, and with the rock exposed only where the slopes are steeper than the angle of repose for snow, it is in some respects a region of extreme polar conditions. Terrestrial vegetation is reduced to a minimum, and away from the penguin rookeries there is almost no terrestrial fauna. Taking advantage of a milieu produced by the birds, there are mites, a few such lowly organized insects as Collembola, a wingless Chironomid fly, a number of rotifers, one or more tardigrades, and protozoans, in the moss. Members of several of these groups are, like the vegetation, characterized by enormously specialized viability. They awaken for at most a few days in the summer season in order to carry on their active life

FIG. 35.

processes, and they are capable of existing for months or even for years in a frozen state.

Despite this picture, the temperatures along the whole western coast of the Antarctic Archipelago are relatively high for the respective latitudes because of the tempering influence of the open sea to westward. The minimum temperatures, in particular, are less severe than in Weddell Sea or even at the South Orkneys. In more or less direct relation with these facts, it is noteworthy that the penguins and other antarctic birds all breed considerably farther southward along the west coast of the Antarctic Archipelago than they do on the eastern or Weddell Sea side. This is clearly shown by the distributional charts of the Second French Antarctic Expedition (Gain, 1914).

The present paucity of vegetation and animal life in this region is doubtless post-glacial, and is due not alone to the direct effect of cold but also to the physiological dryness of land covered with unusable water, *i. e.* snow and ice. At any rate, a rich flora which resembled in many respects that of modern New Zealand, Australia, and southern South America, once flourished. Fossil floras of both Jurassic and late Cretaceous or early Tertiary age, and including such trees as *Sequoia*, *Araucaria*, and beeches, are known from West Antarctica. It has been suggested that from this region as a center many plants and animals once extended their ranges into more northerly zones. At Seymour and Snow Hill Islands, just east of the tip of the Antarctic Archipelago, the Swedish expedition discovered the extraordinarily varied fossils of middle Tertiary penguins which are briefly described below in my introduction to the section on that family.

For much of our still scanty knowledge of contemporary bird life in West Antarctica we are indebted to the researches of the Second French Antarctic Expedition, commanded by Dr. Jean Charcot. By the members of his corps the neck of "Graham Land" and the adjacent parts of this most northerly extension of the south polar regions were not, of course, recognized as wholly insular. Nevertheless, between the years 1908 and 1910 the 'Pourquoi Pas?' cruised southward from Beagle Channel to Deception Island, turned northeastward to the end of Bransfield Strait, and subsequently skirted the entire western coast of the Antarctic Archipelago southward beyond the 70th parallel. The French ship next proceeded westward past lonely Peter Island, which is long and narrow, with a bare cliff suitable for the nesting of sea birds on its western face, and then on beyond longitude 120° W., before turning again toward the Magellanic district.

According to the masterly report of Gain, ornithologist of the French expedition, only about 25 kinds of birds were observed beyond latitude 60° S., and most of these were wanderers from more northerly belts rather than polar species. As pointed out in several parts of my text, the antarctic Procellariiformes have been quick to take advantage of the new butchery produced by the whale fisheries. They assemble in vast numbers wherever shore whaling is in progress, and even appear to wait about for the steamers to arrive at their customary berths. Bennett (1927, 259), who has especially studied this phenomenon, states that the incredible swarms of Cape Pigeons and other petrels have increased enormously since the year 1915, and that the area of their nesting sites has been proportionately enlarged. He believes, moreover, that the albatrosses nesting at South Georgia and elsewhere in American Antarctica have become more local in their ranges since the advent of whaling, and that only two birds, the Snow Petrel (*Pagodroma*) and the Antarctic Petrel (*Thalassoica*), have been affected in no way by the novel conditions suddenly produced by man.

With a handful of exceptions, all of the antarctic birds subsist, of course, only upon food which they themselves take from the water. The only species which find any portion of their food upon the land or which, indeed, are even capable of recognizing food that is not afloat, are the skuas, the Tern, the Gull, the Sheath-bill, and the Giant Fulmar. Penguins and petrels alike would literally starve to death in the midst of plenty if their normal food of fish, or shrimps, or cephalopods, were heaped up about their nests and the birds restrained in some way from entering the water. A strictly new terrestrial feeding technique of Wilson's Petrel (*Oceanites*) is, however, reported by Bennett, who states that these Mother Carey's chickens have acquired the custom of feeding upon coagulated whale-oil that washes ashore. The birds have therefore learned the new art of "walking" on the land while feeding. They accomplish this by keeping their wings vibrating in exactly the same manner as though they were skipping and dancing across the surface of the water.

In considering the following list of birds that cross the 60th parallel of south latitude, a list modified from the records of the 'Pourquoi Pas?' naturalists, the place of whaling operations as a somewhat artificial lure must be kept in mind. Forms known to breed in the Antarctic Archipelago are preceded by an asterisk. The exact identity of a number of subspecies, and even of species, is still open to doubt. Such petrels as *Procellaria*, which has been observed southward to De Gerlache Strait and over the open Pacific to latitude 63° S., and *Adamastor*, recorded as far as latitude 60° S., are mere wanderers.

Penguins

Aptenodytes forsteri (migrates northward along both coasts of the Antarctic Archipelago, and doubtless breeds in high latitudes both to eastward and westward)

Aptenodytes patagonica (probably bred in former times as far southward as the South Shetlands; see page 344)

**Pygoscelis papua* (breeds southward to about latitude 65° 30′ S.)

**Pygoscelis adeliae*

**Pygoscelis antarctica* (breeds southward to about latitude 65° S.)

Albatrosses and Petrels

Diomedea exulans
Diomedea melanophris
Diomedea chrysostoma
Phoebetria palpebrata
**Macronectes giganteus* (breeds southward to De Gerlache Strait, about latitude 64° 30′ S.)
**Daption capensis*
Halobaena caerulea
Pachyptila desolata
**Priocella antarctica*
**Thalassoica antarctica*
Adamastor cinereus
Procellaria aequinoctialis
**Pagodroma nivea*
**Oceanites oceanicus*

Cormorants

**Phalacrocorax atriceps* (breeds southward slightly beyond latitude 65° S.)

Sheath-bills

**Chionis alba*

Skuas

**Catharacta skua lönnbergi*
**Catharacta skua maccormicki* (the dividing line between the breeding ranges of the two forms of skua is still problematical)

Gulls

**Larus dominicanus*

Terns

**Sterna vittata*

The identity of the last species, the Antarctic Tern, has been confused in much of the ornithological literature pertaining to the region. In Gain's (1914, 184) report, however, the species is correctly named and is recorded as a breeding bird at the South Orkneys, South Shetlands, Louis Philippe Land, Seymour, Snow Hill, Joinville, and Paulet Islands, "Graham Land," Booth-Wandel Island, and other antarctic localities. Gain states that the Polar Skua (*Catharacta skua maccormicki*) also nests northward to the South Shetlands, where it meets and mingles with the lower antarctic form (*C. s. lönnbergi*). This problem is discussed in the biographies. It may yet prove necessary to regard the two skuas as distinct species, instead of as races of a common species.

(1) BOUVET ISLAND

Bouvet Island is far from the South American region but it is important from our point of view as a way station in the eastward distribution of two or more species of sea birds which probably originated in the American quadrant of Antarctica. The island was one of the first antarctic land masses known to Europeans, being discovered in 1739 by Pierre Bouvet, who mistook it for a headland of a southern continent. Its subsequent history was for a long time puzzling. Often searched for in vain, rediscovered and lost again, it appeared upon successive maps not only in various positions, but even as several distinct islands, until its latitude and longitude were correctly ascertained in 1898 during the cruise of the 'Valdivia.'

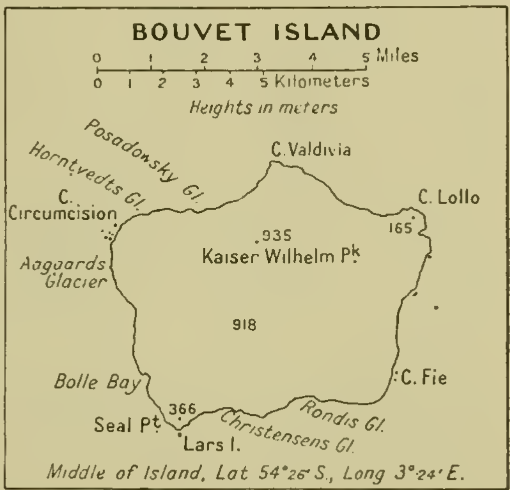


Fig. 36.

The island rises abruptly from great depths to an elevation of 935 meters above sea level, and it is almost completely covered by an ice cap with sheared and precipitous edges around most of the coast. On the western side are steep cliffs with an altitude of about 400 meters. Although the latitude of the island is the same as that of South Georgia, its glaciation is considerably more excessive because of the influence of Weddell Sea ice which here follows the general trend of wind and current circulation toward the north and east. The 'Meteor,' on her transoceanic cruise from the Falklands, encountered near the mid-Atlantic rise this drift of very cold water, which sharply lowered the temperature of the air (Spiess, 1928, 138). Bouvet is surrounded by pack-ice during much of the year and is prevailingly hidden by dense fog. Dredgings from the adjacent ocean bottom, and observations ashore as well as from an airplane, show that the island is volcanic. Sachse, of the 'Valdivia,' presumed it to be a cone, with traces of a crater near its high northern side, but Mosby, of the 'Norvegia' expedition, regarded it as a plateau, the whole mass, according to his view, being part of one flat stream of lava. The visible discharge of gases from Bouvet, reported by the observers of the 'Meteor' in 1926, was not observed by the 'Norvegia' party (Aagaard, 1929, 71). To southward and eastward are relatively gentle slopes toward the level of the sea. The east-west diameter of the island is about 9.5 kilometers.

On December 1, 1927, when the 'Norvegia' expedition took possession of Bouvet in the name of the King of Norway, countless penguins of "three species" were observed at the commencement of their breeding season (Aagaard, 1928, 5). Photographs have identified two of these as the Ringed Penguin (*Pygoscelis antarctica*) and the Macaroni Penguin (*Eudyptes chrysolophus*). The third has been called the Adélie Penguin but, in the absence of proof, the presence of this high antarctic species at Bouvet must be regarded as doubtful. If the Adélie does prove to be a resident, the record will mark a notable northward extension of the range, and will emphasize the peculiar hydrographic and climatic conditions described above. Noteworthy, in the meantime, is the fact that at Bouvet the Ringed Penguin, indubitably a bird of the American section of the Antarctic, here reaches the easternmost limit of its range, while the Macaroni Penguin has probably followed the same route in its partly circumpolar dispersal.

By the Norwegian visitors penguin colonies were found both on the main island and on Lars Islet off the southwestern tip. The latter has a length of about 500 meters, is fairly flat and low, and has several tunnels completely through it. It is the home of great numbers of fur seals as well as of the penguins.

Chun (1900, 171) records numbers of Cape Pigeons (*Daption*) and Snow Petrels (*Pagodroma*) in the vicinity of Bouvet, and the 'Meteor' party observed Wandering Albatrosses to southward of the island (Hentschel, 1933, 121). Data on the breeding birds are much needed. Reichenow (1904, 347), as a result of the 'Valdivia' collections, records *Phoebetria palpebrata*, *Priocella antarctica*, and a skua as resident birds. It would be of special interest to learn which of the following genera, and what forms of each, are represented at Bouvet: *Pachyptila*, *Fregetta*, *Pelecanoides*, *Phalacrocorax*, *Chionis*, *Sterna*.

9. Eastern Fuegia to Central Chile

a. Staten Island.

Divided from Tierra del Fuego by the Strait of Le Maire is Staten Island, with its high ridge extending from west to east along the path of the Scotia Arc. In the words of de Agostini (1924, 228), the isle is a chaos of rugged rocks and peaks, almost without level terrain and with scarcely a shelving strand upon which a boat might safely run ashore. Rich beech woods and shrubbery of Fuegian type spread a green blanket over the mountain slopes. The island is furrowed—even almost cut through—by many narrow fiords, of which the most important is Puerto Parry, near the middle of the northern shore, and easily recognized because Monte Buckland (914 meters) rises from its eastern side.

Staten Island is a focus of such raging, buffeting winds as are to be expected in latitude 54° S. of the Atlantic. Its mean annual temperature is 5° C., which is very markedly higher than that of South Georgia, on the same parallel, but the seasonal succession of temperatures and rainfall is similar. An annual precipitation of 610 millimeters is vastly less than that of the western or windward face of Tierra del Fuego. On the other hand, it is practically double that of Magallanes, showing how even a narrow reach of ocean, coupled with an abrupt wall of hills, can make possible the wringing of new moisture out of winds so recently depleted.

Not far off Puerto Parry are the five small Año Nuevo Islets, on the largest of which meteorological observations have been recorded for many years. Here Argentine mail ships call regularly. Large colonies of ocean birds occupy Año Nuevo as well as the northeastern end of the main island, where a peninsula known as Punta Pájaro (Bird Point) extends from a treeless stretch of peatland. This is occupied by thousands of penguins, cormorants, and other Magellanic species, while sea-lions and fur seals haul out on the rocks at sea level.

The avifauna of Staten Island cannot be called well known, but it doubtless includes most of the sub-antarctic sea fowl of Tierra del Fuego and the Falklands, as well as numerous land birds. Four kinds of penguins have been recorded as resident, together with albatrosses, petrels, shags, skuas, gulls, terns, shore birds, and ducks. In addition to the casual notes of de Agostini, data on the birds have been published by Salvadori (1900), Crawshay (1907), and Hartert and Venturi (1919). In September, 1915, Mr. Beck collected or observed in the waters about Staten Island albatrosses of four species, petrels of the genera *Macronectes*, *Daption*, *Priocella*, *Halobaena*, *Procellaria*, *Pachyptila*, and *Garrodia*, several of which were merely transients, as well as two species of shags and the Sooty Shearwater (*Puffinus griseus*). The last presumably nests at the island.

b. Tierra del Fuego and Patagonian Chile.

Quien come Califate,
Vuelve por más.

Of one of the earth's most complicated minglings of land and sea, in which the islets are numbered literally by thousands, I can perforce give only a cursory description. For a suggestive cross-section of the region, as made during the Brewster-Sanford Expedition, the reader is referred again to the summary of Mr. Beck's narrative, pages 8 to 25 of this book.

In the eastern part of the area is the great land mass of Tierra del Fuego itself, the leeward portions largely low-lying and relatively dry. To southward it is nearly cleft in twain by the long arm of Admiralty Sound and the higher plane of Lake Cami. Beyond these, in turn, stretches the lofty Cordillera Darwin, which terminates to westward and windward in the jig-saw puzzle of the Brecknock Peninsula, where mainland and islet can scarcely be distin-

TIERRA DEL FUEGO
Miles
Kilometers
Heights in meters
I. Pacheco
Grupo Cuarenta Dias
Is Las Evanjelistas
Estrecho de Magallanes
I. Desolación
I. Landfall
B. Otway
Pen. de M. Gamero
1750
Sena Skyring
Lo Blanca
I. Riesco
I. Isabel
Sena Otway
Magallanes (Punta Arenas)
Pen. de Brunswick
C. Froward
Isla Sta Ines
Is Grafton
Isla Clarence
I. Noir
Canal Cockburn
I. London
Pen. Brecknock
2300
I. Dawson
Canal Whiteside
Estrecho de Magallanes
C. Virjenes
Pta Dungenes
ISLA GRANDE DE TIERRA DEL FUEGO
B. de S. Sebastián
B. Inutil
R. Grande
Lo Cami
2150
Ushuaia
Pto Harberton
I. O'Brien
I. Stewart
I. Gilbert
I. Londonderry
Sena Christmas
I. Hoste
Canal Beagle
I. Navarino
I. Picton
I. Nueva
I. Lennox
Golfo de Nassau
Pen. Hardy
Is Morton
I. Henderson
Falso Cabo de Hornos
Is Ildefonso
Islas Wollaston
I. Herschel
Is de Barnevelt
I. Deceit
I. Hornos
Is Hermite
CABO DE HORNOS
Is Diego Ramirez
C. S. Diego
Estrecho de le Maire
Is Año Nuevo
C. S. Juan
I. de Estados

FIG. 37.

guished one from the other. The same is true, indeed, of the labyrinths still farther southward, across Beagle Channel, and of those that extend northwestward to intercalate with ameboid branches of the drowned end of a continent.

Let us picture the region briefly in the words of those who have traced its tangles and felt its spell.

Of all the regions of the earth's temperate zones it is doubtful whether there remains a single one of which man's knowledge is so incomplete as of that of the southern Patagonian Andes from the forty-fifth parallel of latitude to the outermost islands of the Tierra del Fuego archipelago. Yet we can hardly call this land of mystery remote: not one of its 180,000 odd square miles of mainland and islands is 200 miles distant from one of the New World's oldest trade routes. Nor has there been a dearth of interest in it. Between Magellan's discovery of the strait in 1520 and the visit of the *Beagle* in 1832 no fewer than 81 expeditions representing many nations have explored there. Between the voyage of the *Beagle* and the publication of "Charles Darwin's Diary of the Voyage of H. M. S. 'Beagle' " last year scores of books and articles in various languages have appeared. Yet one needs only to glance over the most recent literature to realize how little is actually known, and even the latest maps disclose vast areas marked "inexplorado" (Rudolph, 1934, 251).

The external features of Tierra del Fuego are exceedingly varied. There are lowland flats with vast marshes and lakes more or less brackish, scrub-covered downs, bleak black peaty moors, practically impenetrable forests, and regions of everlasting snow probably never trodden by man. In the coastline, there is also much diversity. This may be low shingly beach with the land dead flat behind it, or bare perpendicular cliff washed at foot by the sea, or solid jagged rock overgrown to high-tide mark with impermeable thorn scrub, or else precipitous mountain covered with forest or glacier to the very ocean.

Grey sky, grey sea, grey beach, the land white, and the black rocky crests of snow mountains standing out in threatening relief suspended between earth and heaven. What a study the seashore, here, where the two greatest oceans meet and sweep round the tail of the greatest continent! What tremendous force of wind and water! Piled up in such confusion as to make one stand aghast in contemplating it are masses of sea-weed with rocks attached, mussel and limpet shells, the bones or entire carcases of whales—large and small, the carcases of sea lions and of guanacos, trunks of trees, and such evidence of the existence of man as a boat, a spar, an oar, a companion ladder, a ship's draught-board painted in black and white chequers on a stout piece of plank, and other wreckage (Crawshay, 1907, xiii, vii).

Among the earth's most turbulent waters are the seas of this region. The complicated currents set up in these labyrinths of canals by the ebb and flow of tides having considerable range were compared by Darwin to movements in a tub of boiling water, and the remains of vessels found along these rocky channels tell their own story. Diurnal tidal ranges here are equaled at but few coasts that at Puerto Gallegos, 45.6 feet (nearly 15 meters), being the greatest of all the world's tides listed by Bauer . . . . The height of the waves in these regions is also noteworthy, reaching 15 meters and more at Cape Horn. Employees of the lighthouse at one of the Islet Evangelistas, at the western entrance to the strait, found it necessary to build rampart walls to protect their water supply, at 56 meters height, from salt-water spray.

The west of the cordillera . . . is . . . one of the wettest regions of the earth's surface. Rainfall is nowhere less than 1000 millimeters; it reaches over 5000 millimeters . . . on Isla Desolacion. . . .

In the western and southern regions rain is more or less continuous throughout the year. Admiral Spiess writes of the Cockburn Canal that it has but a single day in a hundred of calm, sunshine and only occasional precipitation, while of Staten Island it has been written that 24 continuous hours without rain, sleet, or snow are unknown . . . .

Patagonia is also known for its "trenchant wind." The tip of the continent is marked by a conflict of ocean currents, the cold westerly drift dividing at Cape Horn into northward and eastward-flowing branches, while a branch of the warm current from Brazil impinges seasonally upon the Atlantic littoral. Turbulent wind conditions result—not alone the normal high winds due to an abnormally low average barometer but storms that arise suddenly and rage for a week or an entire month (Rudolph, 1934, 260).

Only when the winds have a southerly slant does bright, clear weather reign. Sometimes on quiet days banks of white, sharp-edged, solid-looking cumulus clouds may be seen mounting in the south, indicating to mariners a rising of the southwest wind. The clearest months in the Strait of Magellan are from September to the end of December, and the worst, on account of snow and heavy gales, from the middle of June to the middle of August.

Because of sketchy charting, tortuous bends, and innumerable reefs, navigation at night is rarely attempted in the Fuegian channels. Fortunately, friendly coves and holding ground are plentiful. Snug in such shelter, many voyagers have heard the storms raging fiercely overhead, while only occasional and fitful gusts descended as low as their ships. Thus, lying at anchor, Cordova (1820, 21) could write, "All the night the weather was cloudy, with showers of rain or rather snow. The wind continued with most furious blasts, which, however, only affected our upper rigging, without reaching the hull of the vessel."

[There is a sharp line of division] between the plant zones in southern Patagonia. The border between pampa vegetation and the forest approximates the eastern limit of the cordilleran-formations. . . . The plains of eastern Patagonia and of northern Tierra del Fuego are covered with short bunch grass and xerophytic bush. To the west lie the forest zone of deciduous beeches (*Nothofagus antarctica* on the lower slopes and *Nothofagus pumilio* on the slopes above 300 meters) and, finally, the moist zone of evergreen beeches (*Nothofagus betuloides*). Between is a narrow transition belt of underbrush, where the pampa invades the forest at one point and vice versa at another (Rudolph, 1934, 261).

Darwin speaks of the attractive, park-like appearance of the country in southern Tierra del Fuego, where the grasslands begin to give way to forests. Below is his field notebook impression of heavily wooded country on Brunswick Peninsula, about midway through the Strait of Magellan:

I left the ship at four o'clock in the morning to ascend Mount Tarn; this is the highest land in this neighbourhood being 2,600 feet above the sea. For the two first hours I never expected to reach the summit. It is necessary always to have recourse to the compass: it is barely possible to see the sky & every other landmark which might serve as a guide is totally shut out. In the deep ravines the death-like scene of desolation exceeds all description. It was blowing a gale of wind, but not a breath stirred the leaves of the highest trees; everything was dripping with water; even the very Fungi could not flourish. In the bottom of the valleys it is impossible to travel, they are barricaded & crossed in every direction by great mouldering trunks: when using one of these as a bridge your course will often be arrested by sinking fairly up to the knee in the rotten wood; in the same manner it is startling to rest against a thick tree & find a mass of decayed matter is ready to fall with the slightest blow. I at last found myself amongst the stunted trees & soon reached the bare ridge which conducted me to the summit. Here was a true Tierra del Fuego view; irregular chains of hills, mottled with patches of snow; deep yellowish-green valleys, & arms of the sea running in all directions; the atmosphere was not however clear, & indeed the strong wind was so piercingly cold, that it would prevent much enjoyment under any circumstances. I had the good luck to find some shells in the rocks near the summit. Our return was much easier as the weight of the body will force a passage through the underwood; & all the slips & falls are in the right direction (Darwin, 1933, 208).

Lord Bryce (1912, 306) writes:

Magellan's Straits are unlike any other straits in this respect, that the physical aspect of the two ends is entirely different. The character of the shores on each side is the same in each part of the channel, but both shores of the eastern half, from the Atlantic to Cape Froward, are unlike those of the western half from Cape Froward to the Pacific. The former has low banks, with smooth outlines, slopes of earth or sand dipping into shallow water, and a climate extremely dry. The latter half is enclosed between high, steep mountains which are drenched by incessant rains. The eastern half is a channel, narrow at two points only, leading through the southernmost part of the vast Argentine plain, which has apparently been raised from the sea bottom in comparatively recent times. The western half is a deep narrow cut through the extremity of a great mountain system that stretches north for thousands of miles, forming the western edge of South America, and the rocks on each side of it are ancient (palaeozoic or earlier). The western half is grand and solemn, with its deep waters mirroring white crags and blue glaciers. The low eastern half has no beauty save that which belongs to vast open spaces of level land and smooth water over which broods the silence of a clear and lucent air. A more singular contrast, all within a few hours' steaming, it would be hard to find.

Cape Froward, at the bend of the Strait of Magellan, marks the point in this latitude at which the mountains give way to the plains. East of this point, continues Bryce, who had come from the west,

. . . one is at once in a different region with a different climate. The air is drier and clearer. The shores are lower, the wood, still mostly of the Antarctic beech, is thicker, with many dead white trunks which take fire easily. The hills recede from the sea, and grow smoother in outline, finally disposing themselves in low flat-topped ridges, six or eight miles behind the shore-line. A wide expanse of water, and of land almost as level as the water, stretches out to the eastern horizon, so that at first one fancies that this apparently shoreless sea is part of the Atlantic, which is in fact still nearly a hundred miles away.

[Magallanes is the same distance to the south of the equator as the Strait of Belle Isle in Labrador is to the north], but the climate here is far more equable. It is never warm, but the winters are not severe, there is little snow, and frosts are moderated by the adjoining sea. The air is dry and healthy with a rain-fall of only ten inches a year. Though the landscape is bare, for trees can with difficulty be induced to grow, and though there is much wind and no shelter, still we found something attractive in this remote and singular spot, for one has a constantly stimulative sense of the vast expanse of sky and sea and the distant plain of Tierra del Fuego, with a touch of mystery in the still more distant ranges of that island which just shew their snowy peaks on the horizon. The light over sea and shore has an exquisite pearly clearness which reminds one of the similar light that floats over the lagoons between Venice and Aquileia. Can this peculiar quality of the atmosphere be due, here as there, to the presence of a large body of comparatively smooth and shallow water, mirroring back to heaven the light that it receives?

Crawshay also dwells upon the subdued tone of everything to be seen in land and sea and sky in Tierra del Fuego, and writes that "the soft sunlight resembles bright moonlight rather than the light of day."

Climatic conditions in Beagle Channel more or less parallel those in the Strait of Magellan. Thus to eastward of Ushuaia the weather becomes milder and dryer than in the western reach. The soil is less marshy and bears a rich pasturage. Grandeur in the landscape is replaced by aspects which may rather be described as pleasant and cheerful, in part because man has here built roads through the forests and dwellings along the shores. Gable Island, near the eastern end of the channel, consists of fertile alluvial land that supports several thousands of sheep. Opposite is Puerto Harberton and the beginning of the pack trail to Lake Cami, where the breeding of Royal Albatrosses (*Diomedea epomophora*) remains to be confirmed. The world's southernmost farm lands are on Navarino Island, just to southward. Though mountainous and heavily wooded, this island supports thriving sheep estancias along its northern coast. Navarino is the only island beyond Tierra del Fuego on which guanacos live, and wherever this mammal occurs life has proved tolerable for human beings, as regards both climate and productivity of soil (de Agostini, 1924, 218).

Father de Agostini has described also the picturesque northeast arm of Beagle Channel, which lies between the Cordillera Darwin and Gordon Island. On both sides the mountain steeps are here smothered under a growth of beeches and laurels, all of a fresh and bright shade of green. Higher up are vast stretches of yellow and reddish cryptogams, lined by glittering brooks and white cascades that are swallowed from view when they reach the forest. Gleaming snow covers the peaks beyond.

Numerous glaciers here descend to be reflected in the water of Beagle Channel, and small bergs against a background of greenery make a spectacle to astound the seafarer. Most majestic among these streams of ice is the Italia Glacier, with a menacing front more than a thousand meters in length along the channel, and a source on the slopes of Mount Darwin (2135 meters).

Two other modern authorities have written as follows regarding Fuegian glaciation:

The most striking feature of Beagle Channel is undoubtedly the astonishing number and variety of the glaciers, which occupy all the valleys descending from every mountain high enough to be covered with a mantle of perpetual snow. The general direction of these valleys is favourable as regards shelter from the summer sun. This fact, no doubt, accounts in a measure for the great extension of the glaciers. The coolness of the summer rather than the severity of the winter is also an important factor in maintaining both the glaciers and the comparatively low snow-line, which cannot be much more than 2000 feet above sea-level. It is to these features we must look in endeavouring to explain the glaciers of Tierra del Fuego.

Most of the larger glaciers we saw showed signs of shrinkage. Trees grow on the lower and older terminal moraines, the vegetation becoming younger as the actual ice-wall is approached. Lateral moraines are found stranded on the flanks of the valleys, high above the present level of the ice, and the polished rock indicates the height to which the glacier had once reached. These features were particularly noticeable in the case of the glacier opposite Romanche bay, and the large recession of glaciers in these regions is an interesting one for future investigation, and Beagle channel forms an admirable field for study (Crosthwait, 1905, 288).

The permanent ice fields of southern Patagonia are the largest glacial areas found within the temperate zones. At their northern limit, near the Río Aysen, these fields begin at about the 2000-meter level; in Tierra del Fuego they extend upward from 750–900 meters. Only a few crests and rocky points rise above these rugged white masses, which attain 30 kilometers and more in width. In the distance of 1200 kilometers from its beginning south of the Río Aysen to its termination with the Cordillera Darwin in Tierra del Fuego this ice mantle loses its continuity at but two localities—at Baker Canal and around the Strait of Magellan. Thus it is subdivided into three principal ice areas, of which the central is the most extensive. Ribbons of ice extend to the sea on the west and to the Andean lakes on the east. It is at latitude 46° 40′ S. that the northernmost of these glaciers, San Rafael, reaches the sea—10 full degrees more distant from the pole than the southernmost glacier of Alaska, more than 20 full degrees farther than Jökelfiord (68° N.), the southernmost glacier of Norway reaching the sea (Rudolph, 1934, 251).

Except in the near vicinity of glacier-snouts, the temperature of the salt water in channels throughout the Magellanic region is said to be everywhere above 4.4° C., doubtless because of the effect of warm Pacific surface waters that work in with the westerly winds, which prevail throughout the year.

Reynolds (1935, 65) gives a charming account of a visit during December, 1932, to the islands of the Cape Horn neighborhood, which include Grévy, Baily, Wollaston, Freycinet, Hermite, Jerdan, Hall, Herschel, Deceit and Horn, together with numerous adjacent islets and the easterly outliers of Barnevelt and Evout. The main group makes a rather compact cluster to eastward of False Cape Horn on Hoste Island, and south of the Gulf of Nassau. Parts of these islands are comparatively flat, with peaty ground reminiscent of the Falklands. There is also, however, considerable high land, such as Mt. Hyde on Wollaston, which attains an altitude of 674 meters, as well as imposing sea cliffs with great pillars of basalt. The larger islands are, indeed, so high that patches of snow persist toward their summits throughout the summer. The Barnevelt Islets, 14 kilometers to eastward of Deceit, differ much from the others, consisting mainly of tussock-grown land completely occupied by burrowing Magellanic Penguins, and surrounded by rocks and crags which are covered with cormorants.

All of these islands are now uninhabited, but are visited by otter hunters. The exposures toward the prevailing southwest wind on the Wollaston group are particularly bare and weather-beaten. Areas of outcropping granite protrude from a blanket of dwarfed and battered antarctic beach, through or over which progression is almost impossible. White-looking vertical lines of weather-killed trees are a feature of these gnarled woods.

> The north-eastern declivities are generally less steep, with the thick low vegetation covering peaty tracts, broken by bog-pools and extremely wet ground of a more open character. In sheltered places, such as the proximity of a lake at the northern side of Freycinet, precipitous ravines are submerged by evergreen forest of tropical aspect. So thick is the canopy that a chaos of decay exists in the semi-darkness prevailing beneath, and a small maidenhair fern combines with a deep layer of spongy moss to cover everything.

In such an environment of wooded glens, Reynolds heard the strange, mimicking notes of the Magellanic Thrush (*Turdus magellanicus*). Thus in the heavy drip of a rainy morning at Deceit Island, after the departure of petrels for sea, the subdued song of the thrush first unmistakably resembled the calling of these sea fowl as if at a distance, after which it imitated in turn the night voices of snipe and, at daybreak, its discreet whispering gave place to loud and bold mimicry of the chorus of Black Oyster-catchers, or the sudden clamor of Kelp Geese.

Exclusive of more than 30 species of sea fowl, waders, ducks and geese, no less than 25 kinds of land birds inhabit these blustery islands. They include, in addition to the thrush, a house wren and a marsh wren, a swallow, a siskin and three other finches, an Icterid or American blackbird, three species of tyrant flycatchers, four of *Cinclodes*, a spinetail, a babbler (*Scytalopus*), a kingfisher, and six birds of prey, the latter including a buzzard, eagle, kite, two caracaras, and the Turkey Vulture. The shores of all of the islands are frequented by sea-lions, fur seals, and the Fuegian otter. The only land mammals are a bat and a rodent (*Ctenomys?*).

The following two descriptive items relate, respectively, to the visit of the

'Valhalla' to the western end of the Strait of Magellan, and to the departure of the 'Beagle' from this exit into the Pacific:

At daybreak . . . we left Port Gallant, and, proceeding westwards, anchored towards evening at Churruca Bay, which is the most western anchorage in the Straits of Magellan. This place is one of the most beautiful that it has ever been my good fortune to see. Towering peaks, covered from summit to base with impenetrable beech forests, almost encircled the deeply indented bay, the water of which was inky black, and the surface smooth as glass Here and there were little islets, some fringed with a tall white-flowered plant; others surrounded with hedges of fuchsias in full flower. Flock after flock of Magellan cormorants flew by us, their white breasts flashing bright against the dark water of the bay, while steamer-ducks scudded to right and left, as we glided to our anchorage in the glorious natural harbour (Nicoll, 1908, 173).

In the morning in company with the Adventure, we made the best of our way into the open ocean. The western coast generally consists of low, rounded, quite barren hills of Granite. Sir J. Narborough called one part of it South Desolation, "because it is so desolate a land to behold"; well indeed might he say so. Outside the main islands, there are numberless rocks & breakers, on which the long swell of the open Pacific incessantly rages. We passed out between the "East & West Furies"; a little further to the north, the Captain from the number of breakers called the sea the "Milky Way." The sight of such a coast is enough to make a landsman dream for a week about death, peril & shipwreck (Darwin, 1933, 230).

Straight out to sea beyond the Long Reach are the rocks which Narborough called the Islets of Direction, but which are now known as the Evanjelistas. The group is conspicuous because of a hole through one of the slate cliffs and a contorted stratum of white quartz along the face of another. Rainfall at the lighthouse amounts to 2843 millimeters per annum. So uninterrupted are the hurtling, seething waves that, according to tradition, a vessel was once obliged to wait for forty days in the shelter of neighboring islets just off the coast of Pacheco Island before it could approach the Evanjelistas Rocks. Thus was established the name of the group and port still called Cuarenta Días.

According to Crawshay (1907) the majority of the birds in the Fuegian region are migratory summer visitors rather than permanent residents. This applies even to such common breeding waterfowl as ducks and geese and, of course, to the kinds of petrels and their allies that nest among the islands. The orders represented in Crawshay's book, as native to Tierra del Fuego, include penguins, grebes, cormorants, petrels and albatrosses, gulls, terns, and shore birds, rails, ducks and geese, herons, woodpeckers, parrots, owls, hawks, and many passerine forms.

Chapman (1933, 371) thus describes a late January morning's observations, made in part from a motor car, in Tierra del Fuego, close to the Strait of Magellan:

Our road, the product of use, crossed widespreading, rolling plains dotted with the yellow bloom of *califat* bushes and grazing sheep. Scattered here and there were families and flocks of Wild Geese. Eight Geese, it was said, eat as much grass as one sheep and these birds have no friends among raisers of wool and mutton . . . .

Strong-winged, heavy-bodied, powerful Skuas swept by us seeking what they might devour and Milvagos looked for lesser prey. There were Ducks and Gulls on the many ponds and lagoons, and shore-birds along their margins. . . .

The sun rose on a brilliantly clear morning. I could plainly see details on the shores of the mainland. The air rang with the cries of Gulls, the whistling and cackling of Geese, the high piping of Oyster catchers, the tinkling choruses of Ibises (*Theristicus*), the mellow, purring whistle of Widgeons, leading their broods on the lagoons, and from overhead, a Pipit showered me with song. There were notes in his voice that reminded me of both Skylark and Bobolink. I lay on my back to watch him flutter upward and float downward.

The channels of the southerly and windward coasts of Tierra del Fuego are frequently invaded during the winter by vast flights of oceanic birds, such as the Cape Pigeon, the Silver-gray Fulmar, and other wanderers from the Antarctic Zone. During the breeding season, however, one sees in these waterways few birds from offshore, but rather the native Kelp Goose and steamer ducks, cormorants, penguins, oyster-catchers, and skuas. After nightfall, new voices and the whish of wings may indicate the coming and going of the petrels that nest in this region, and about which next to nothing is yet known. Among the biographies forming Part II of this book I have quoted various obscure references to nesting petrels of Tierra del Fuego, such as Darwin's account of the whale-birds (*Pachyptila*) of Landfall Island, south of the western entrance to the Strait of Magellan. Beck's extraordinarily interesting discovery of the South American breeding grounds of the Sooty Shearwater and Wilson's Petrel is also recounted both in the life histories and in the narrative of the Brewster-Sanford Expedition. No doubt a rich field for ornithological finds, and data for solving many fascinating problems of avian taxonomy, distribution, biology, and behavior, awaits a field-worker prepared to investigate systematically the weather-beaten outer islands, such as Morton, Waterman, Gilbert, Stewart, Noir, Santa Inés, Naños, Graves, Desolación, and others, which stand as shock-troops against the assault of the gales from the Horn to Cape Pilar and beyond.

The outer Patagonian coast, from the Strait of Magellan northward to the far end of the chain of islands formed by the submerged southern portion of the maritime cordillera, is made up of a succession of high, forbidding, steep-cliffed islets separated by innumerable channels and penetrated by countless fiords and inlets, with two great gulfs that break the chain altogether and bring the open sea to the mainland of the continent. By no means all of this complicated coast is yet fully surveyed, and information about certain ship-passages is based upon observations by Captain Stokes of the 'Beagle' and other explorers of the same remote period. A boat-journey through such routes as the Smyth, Sarmiento, Messier, and Darwin channels is, as Chapman says, "a voyage through the Andes." The islands are so intricately cut up by reticulated waterways that they are like the tiles of a mosaic. It is difficult to group them into archipelagoes and their very nomenclature has been subject to endless confusion. In general, the seaward faces of the outer islands have a very different appearance from their eastern sides, along the channels, the former tending to be bare and gray, the latter green and dark. Still farther eastward the wooded slopes appear almost black beneath the rocky crests and the ice caps of regions still partly "inesplorado."

To the traveller, steaming up the inner channel of this coast with its labyrinth of fjords and islands, the land appears hopeless for the uses of man. Glaciers crowd down the sides of precipitous mountains that are gloomy with almost perpetual mist and rain, and covered at every possible point with an evergreen forest. . . . The persistent west wind gives a heavy rainfall . . . . The explorer is sometimes delayed by two or even three weeks of steady rain, and progress in the forest must be made over a mucky mass of rotting vegetation into which a man often sinks to his knees and where beasts of burden cannot go. Permanent settlements are not likely to be made here (Smith, 1904, 16).

During the middle of the eighteenth century, Commodore Byron, grandfather of the poet, was wrecked in the 'Wager' on the coast of the Guayaneco Islands, which form the southerly boundary of the Gulf of Peñas. His description of the region is as apropos today as it was at the date of Lord Anson's expedition round the world, in which the 'Wager' was participating when lost.

The Country hereabouts wears the most uncouth, desolate, and rugged aspect imaginable; it is so circumstanced as to discourage the most sanguine adventurers from attempts to settle it; were it for no other reason than the constant heavy rains, or rather torrents, which pour down here, and the vast sea and surf which the prevailing westerly winds impel upon this coast, it must be rendered inhospitable. All entrance into the woods is not only extremely difficult, but hazardous; not from any assaults you are likely to meet with from wild beasts; for even these could hardly find convenient harbour here; but from the deep swamp, which is the reigning soil of this country, and in which the woods may be said rather to float than grow; so that, except upon a range of deformed broken rocks which form the sea-coast, the traveller cannot find sound footing anywhere (Byron, 1768, 112).

Byron and his fellow survivors of the wreck kept life in their bodies mainly by capturing geese, especially the Canquén (*Chloëphaga poliocephala*), according to Crawshay (1907, 101). Relatively little is known about the pelagic bird life of this coast because, so far as I can learn, no one has undertaken collecting in the ocean just to westward, nor has any naturalist explored the difficult land areas in search of breeding grounds of petrels which are certain to be found here sooner or later.

It is at about the latitude of the Guayaneco Islands that the character of the Magellanic coastal forest is transformed. Southward of this point the floor of the dense woods of evergreen beech is made up mostly of mosses, peat, etc. To northwards there is an impenetrable undergrowth of bamboos; the southern beeches are replaced by other species of the same genus, likewise evergreen; the diversity of trees increases, and the boles and limbs supply a hold for epiphytes and lianas unknown nearer Cape Horn. In the words of Hellmayr (1932, 20),

Skottsberg . . . divides the south-Chilean rain forest into two subsections: the "Valdivian," richer in species and luxuriance, and the "Magellanic," characterized by the predominance of Patagonian trees, notably *Nothofagus betuloides*. The dividing line is drawn along 48° S. lat., which also coincides with the southern limit of the range of certain species of birds.

However, as the westerlies hinder the development of forest at sea level on the southwestern coasts of Tierra del Fuego, so do they above an altitude of 400 meters on the Peninsula of Taitao, and above 800 meters on Chiloé Island.

Between the Guayaneco Islands and the nearly decapitated peninsula of Tres Montes is the Gulf of Peñas, the first great gap in the seaward chain of islands.

Bryce (1912, 289) thus records his impressions from a steamship along this stretch of Patagonia:

> Among the headlands which we saw along this stern and lofty coast, two were especially striking from their height and form. One is called Tres Montes. Heavy clouds hid its top, but two thousand feet were visible of the steep face that rose above the sea. Further south the huge tabular mass of Cape St. George, grand and grey in its drapery of mists, looked out over billows, the spray of whose crests as they broke upon the rocks could be seen fifteen miles away. There is not in the world a coast more terrible than this. No hope for a ship driven in against it by the strong currents and the resistless western swell.

In a cove near Cape Tres Montes Darwin (1933, 262) noted vast numbers of seals and gulls on the rocks in January, 1835. He writes, too, of Turkey Vultures standing among the other creatures, as though patiently waiting for a seal to die. The vulture seems incongruous on this cool, soaked, and tumultuous coast, and yet it is a characteristic bird of the shore throughout the range of the southern sea-lion, upon the mortality of which it in part depends.

While crossing the gulf from Cape Tres Montes, during a storm on July 4, 1914, Beck saw very large numbers of small petrels which he could not identify—an indication of the profitable work still to be accomplished through collecting in this region.

In the northeastern extremity of the Gulf of Peñas, the little Río San Tadeo reaches the sea, the southernmost stream on the west coast with its mouth close to the open ocean; all its neighbors enter deep, landlocked fiords and esteros. The San Tadeo is not navigable for seagoing vessels. It flows through lowlands, and its mouth is blocked by a great bar, with long sandy beaches on either side. Within, the river widens and deepens, and in freshet season it carries tree trunks down to the swamps near its mouth. Somewhere near its headwaters is the traditional portage across which the Indians formerly dragged their canoes from one shore to another of the Isthmus of Ofqui, and so made their way from the Gulf of Peñas to the Estero Elefantes and other waters to northward of the Peninsula of Taitao. To schooners and small trading steamers this peninsula is a barrier between waters; to southward is the domain of the port of Magallanes, to northward that of Chiloé.

Here again a maze of numberless channels makes the "back country" accessible to vessels engaged in the lumber and fishing industries. The region has a romantic history, which is still largely to be written. With abundance of virgin territory among these wild islands, the number of settlements and their wide distribution are, nevertheless, surprising. Furthermore, the secluded harbors are so many and so secret, the turnings of the inlets so endless, that a pirate might lie at snug ease while all the navies afloat threaded the labyrinths in vain.

I have no idea whether or not the Estero Elefantes is named for the long extinct sea-elephants that once ranged far northward along the west coast of South America, as the Patagonian sea-lion still does. Its smooth, beachless shores are steep on both sides, and above them forest-clad heights rise more than a thousand meters. Looking southward, the white ribbon of the San

Rafael Glacier looms above the blind end of the gulch. To northward, at the opening of the estero, there are constant and dangerous tide-rips, and a heavy surf rolls across the mouth of the Río Huemules despite the barrier of islands that lies between it and the open Pacific. Huge palisades of uprooted trees, thrown on the bar during floods, block the entrance, while inside the mouth the flat marshland is covered as far as the eye can reach with the dead wreckage of a forest. When the exits of smaller neighboring streams become choked by such submerged timber, their flood-waters burst the banks and carve new courses through the floor of coniferous woodlands (Steffen, 1929, 173).

Only a little to northward, more or less navigable rivers begin, the first being the Aisen, which flows from one of the great watersheds of the Andes and has many settlements in its valley lands. Still more available as a transportation route for small craft is the Río Palena, one of the most important rivers in the southern part of a country which, in a sense, has no rivers deserving that adjective. Within this statement, incidentally, is encompassed one of the most profound geographic differences between the eastern and western seaboards of the continent.

North of the almost insular block of Taitao, the island fringe continues as the jumble of the Chonos Archipelago and the Guaitecas, the latter abutting on the Gulf of Corcovado, the second wide gap in the chain. Throughout this multitude of islands, those nearest the Pacific, which receive the full force of the west wind, tend to be bare, while those toward the mainland are covered with luxuriant tree and thicket growth from the water's edge. However, the relatively isolated, offshore islands of Guamblin and Guafo, about which regrettably little is known, are said to be covered with dense vegetation, including excellent "building timber." The pilot books hint obscurely of wild dogs, and even of wild men, on Guafo!

When Dr. Chapman approached the northern shores of the Guaitecas Islands, from Chiloé, on December 31, 1923, one member of his party bet another a Chilean dollar that there would be a Steamer Duck upon the first rock sighted. The bird was there as though by appointment. Entering among the islands, Chapman (1933, 360) writes,

> We were in a world of mountain tops flooded by the sea; there were little islands and large ones, low islands and high ones. Symmetrically rounded, in profile they were fluted, crenate, notched or dented but never peaked or pointed. Nearly every one, except the smallest rocky islet, was wooded from high-water mark to summit by a forest so thickly grown with trees and undergrowth, so clogged with fallen limbs and logs, that one could enter it only on hands and knees and then only for a yard or two. I was reminded of Darwin's story of the sailors from the *Beagle* (perhaps our Captain's father was among them) who, unable to penetrate the vegetation of a mountain side, clambered over it, stopping now and then to "take soundings."

After writing of the Steamer Ducks, Kelp Geese, and penguins of the Guaitecas, the same authority comments upon the land birds strangely grouped with these sub-antarctic sea fowl.

> The parrots, for which the forest seemed so well adapted, were actually represented by a flock of Chilean Paroquets that flew screaming through the tree tops. There was a Magellan Woodpecker, a superb black bird, fifteen inches long with a flaming scarlet crest, and many Ruby-

crowned Hummingbirds in the coihue blossoms. Penguins, Parrots, Woodpeckers, Hummingbirds, there is an avian association rivaling the fauna of the *Swiss Family Robinson!*

Nor can I do better than to continue to accompany the same master of South American ornithology and zoögeography from the Guaitecas to the opposite continental shore.

January 6th, we steamed across the Gulf of Corcovado and, after a six-hour voyage, reached the mouth of the Río Rodriguez. Here we replenished our supply of fresh water from a stream cascading down the mountain, picked strawberries on the shore, and entered the most beautiful forest growth we saw in southern Chile. Thence we continued up the eastern or mainland side of the gulf, exploring rivers, bays and fiords at will, always finding something new and interesting, always in the presence of supremely beautiful scenery. Corcovado was the dominant mountain, and a bay in which the German warship *Dresden* had sought seclusion had acquired historic distinction. . . .

Assured by Captain Yates that we would find Black-necked Swans in the Bay of Pumalin [in the shelter of Llahuen Island], we entered this land-locked body of water and found not only Swans but a place so filled with birds of land and water that of all the spots I have visited in Chile this is the one to which I long most to return.

There were pastures at the head of the bay, evidently on an alluvial fan through which a river wound its way across the mud flats at its mouth. Cattle had been raised here and a ranch house was occupied. . . .

Hudsonian Curlews called through the night, and in the morning we found them with Oyster-catchers on the mud flats. A flock of twenty Ashy-headed Geese were asleep on a sandbar, and on an adjoining pasture seven Ibises and four or five hundred Dominican Gulls were feeding.

On the river there were Teals (*Nettion flavirostre*) and broods of downy Widgeons attended by both parents. Penguins and Quettros rested on the pebbly bay shore, and on the bay itself there was a fleet of nearly one hundred and fifty of the Swans we had come to see. Singly or in pairs, they passed my hiding-place, their white bodies punctuated by their black necks and red bills. A superb picture they made breasting the crisp waves, with snowy Corcovado rising from the dark forest wall behind them . . . .

Land, as well as water, birds were abundant at Pumalin. One of our two days there I followed the course of the little river through the pasture to the woods. Thrushes, House Wrens, Swallows, Goldfinches, Andean White-throated Sparrows and Kingfishers, all resembling our North American species in voice, appearance, or both, bespoke the relations of the South and North Temperate Zones. But Cinclodes (*Cinclodes fuscus*), the Spinetail (*Aphrastura*), the Babbler (*Scytalopus*), the Turco (*Hylactes*) and the Cheucau (*Pteroptochus*) told with equal force of a distinct South Temperate fauna.

If we knew of Chiloé only what Darwin wrote in his field journal a hundred years ago, we should still be relatively up to date so far as concerns information within the field of natural history. An island 180 kilometers in length, it is largely covered with impenetrable forest as a result of the heavy precipitation. The soil is so wet that roads avail little. In earlier times persons have lost their lives in the mud, and in 1856 a newspaper reported that cattle stealing was unknown inasmuch as no thief could escape with such booty through the damp woods. Most of the trees in this forest have little economic value. The coihue (*Nothofagus dombeyi*) is too weak for lumber and too wet to burn. It simply keeps out the sun with its beautiful foliage and makes a quagmire of the ground. The alerce (*Fitzroya patagonica*) is, however, one of the useful giant conifers of America, sometimes 60 meters in height and nearly 5 in diameter. Trees of this species over 2000 years old are well authenticated. The wood is used in large quantities for shingles (Rudolph, 1929, 61).

Chiloé is lower than most of the large islands to southward of it, although the barely separated Isla de San Pedro, at its southeastern corner, attains an altitude of 975 meters. Its channels are also much shallower, and the easy gradient of the land sloping under the sea produces extensive mud flats, exposed at low tide. Owing to the relations of shore and water, the tidal rise is greater in the gulfs of Ancúd and Corcovado than elsewhere along the southern west coast. In places it amounts to 7 meters; tidal whirls, known as "rayas," are notorious in Reloncaví Sound, at the head of the Gulf of Ancúd, and terrific rapids rush back and forth through the Chacao Narrows, which divide the northern end of Chiloé from *terra firma*. All of the characteristics cited are favorable to teeming littoral life; the shoals, the currents, the extensive fields of kelp, the profusion of fish and shellfish, the many streams and the wealth of interior lakes and morasses, combine to make the island a paradise of waterfowl. On the flats off Ancúd, during early April, 1914, Beck saw enormous hordes of migrant shore birds from North America, including one flock of Sanderlings (*Crocethia alba*) numbering 5000, more or less. As the southern-hemisphere autumn advanced and the visiting species departed, their place was taken by flamingoes and other waders from breeding grounds close at hand.

To Darwin (1933, 231) the Chiloé country seemed much like Tierra del Fuego, but with incomparably more beautiful woodland. Instead of dusky uniformity, he found almost the quality of a tropical environment, particularly in the equability of temperature and the presence of tall arborescent bamboos. A calm day, with the snowy cones of the cordillera showing over an inland sea of glassy smoothness, rippled only here and there by a porpoise or a Loggerhead Duck—such a scene framed by ferns and parasitic plants and the trunks of sweet-smelling evergreens, enhanced the tropical illusion. However, the terrible surf that pounded the seaward coast after westerly gales reminded him sharply again of the cruel reaches to southward. The roar of such waves, according to Darwin, can be heard at night in Castro, across 35 kilometers of hilly wilderness.

Darwin also reports the attempt of a party from the 'Beagle' to reach the summit of San Pedro. The wood was so intricate, with its mass of dead and dying trunks, that for a quarter of an hour at a time the feet of the climbers never touched the ground, being generally two or three times a man's height above it. In other places they had to crawl like foxes, one after the other, under the confusion of rotten logs. Darwin remarks that the members of the party were like fish struggling in a net. At an elevation of 300 meters, or thereabouts, they found stunted examples of the beeches which, nearer the Strait of Magellan, grow at sea level.

Despite the picture thus far given, Chiloé is a seat of ancient human settlement. The eastern shore, along the gulf, is relatively populous, and long cultivation has given parts of the region an aspect reminiscent of islands in the Baltic. Farm and pasture have been burnt out of the forest. There are numbers of villages, "each with its little white church. To look from . . . pastoral slopes across the Gulf of Corcovado to the snowy wall of the Andes is like seeing the Rockies from New England" (Chapman, 1933, 360).

The climate of Chiloé is altogether characteristic of the west coast of South America, where mean annual temperatures tend to lower only slowly toward the south. The southern border of the Pacific high-pressure area oscillates seasonally, being a little to southward of its average latitude in summer and a little to northward in winter. Consequently the system of northerly winds extends during the winter as far north as Coquimbo, while in summer the southerly winds reach southward to Chiloé or even to the Gulf of Peñas. This means, however, that while winter temperatures remain approximately the same throughout ten degrees of latitude (as at Valparaiso and Ancúd), the summer, on the contrary, is not only more humid toward the south, but also much colder. The average temperature for the warmest month of the year is 19.9° C. at Santiago, but only 14.5° C. at Puerto Montt. Furthermore, winter temperatures tend to be slightly higher than in corresponding latitudes on the Atlantic coast, while midsummer (January) temperatures are markedly lower. It is less the lowering of the mean temperature than the lowering of the summer temperature which controls the distribution of many forms of bird life and likewise determines the southern limit of agriculture. In Chubút, Argentina, the wheat harvest is assured, while in Chiloé grain must be mowed before it is mature. The same meteorological factors in part control the asymmetrical distribution of coastal birds, such as geese, steamer ducks, shags, and oyster-catchers in southern South America. It is not surprising to find at Chiloé the approximate northern limit of a number of forms which, on our southward journey down the Atlantic coast we encountered for the first time in the higher latitude of the Falkland Islands and southern Patagonia.

If one can credit the pilot books, Chiloé is an island of picturesque weather phenomena. Waterspouts are frequently formed along the gulf coast. Thunder is rarely heard at sea, but is common above the forest, preceded by spark-like flashes of lightning. After brief periods of clear skies and calm air, the atmosphere toward the continent sometimes becomes peculiarly transparent, with a light green tint in the sky. Refractive stratification of the air causes promontories, rocks, islets, and houses to take on vibratory movements which distort or divide them, and to rise high or disappear in mirage. At such times visibility is often abnormally increased, so that details of trees and other features can be distinguished at a great distance. Then, as a rule, coffee-hued cumulus clouds begin to gather in the northerly sky, soon piling up and darkening into nimbus; the spreading curtain dims the scene to obscurity and the floodgates of heaven open with the tempest.

c. *The Gulf of Coronados to Valparaiso.*

The shores of the Gulf of Coronados, just north of Chiloé, are low where the Río Maullin meanders to the Pacific from Lake Llanquihue, but they soon rise to a high and rugged coast with timbered seaward slopes. Short streams are numerous, as are tiny islets or farallones, but the coast is exposed, and protected roadsteads are scarce. Even the mouth of a substantial river, such as the Bueno, is blocked off completely for navigational purposes from the ocean.

> Of the many brimming rivers that sweep down from the Andes across the Central Valley none is more beautiful in its lower course than is the Rio Bueno. It has in the course of ages cloven for itself through the hard rocks of the Coast Range a channel so deep that the tide comes up to the little town of Trumajo forty miles from the sea, and from that town small steamers can pass all the way to the bar at its mouth. In one of these little craft . . . we spent a long day in sailing down and back again. The hills on each side, sometimes hanging steeply over the stream, sometimes receding where a narrow glen opened, were clothed with the richest wood. It was a brilliant day in October, answering to our April, and the sun brought out an infinite variety of shades of green in the young foliage in these glens, the trees all new to us, and the spaces between them filled with climbing plants hanging in festoons from the boughs. Wild ducks and other water-birds fluttered over the water and rose in flocks as the little vessel moved onward, and green paroquets called from the thickets. As it nears the sea, the river spreads into a wide deep pool under a crescent of bold cliffs, and at the end of this is seen the bar, a stretch of sand on which the huge rollers of the Pacific break in foam. There is a lighthouse and a few houses near a flat stretch of meadow by the banks, the grass as green and the flowers as abundant as in Ireland. Specially vivid were the yellow masses of gorse, apparently the same species as our own, and, if possible, even more profuse in its blossoms than on those Cornish shores of which it is the chief ornament. I have seen few bits of coast more picturesque than this meeting of the still, dark river and the flashing spray of ocean under rocks clothed with feathery woods (Bryce, 1912, 242).

Galera Point, which is heavily wooded, marks the salient at which the coast turns northeastward toward Puerto de Corral, at the common mouth of several rivers. This is the seaport of Valdivia, which lies upstream hidden in a wood of apple trees. In this neighborhood the evergreens are considerably less numerous than at Chiloé, and the native forest is of a brighter, more lively green.

From Corral, Beck undertook important collecting during the Brewster-Sanford Expedition, making the city his last continental base until he reached Magallanes in the Strait of Magellan. He found the neighborhood of the whaling station at San Carlos to be particularly good hunting ground. Here, during September and October, 1913, he took many migrants from the south, such as Royal, Wandering, and Black-browed Albatrosses, Giant and Silver-gray Fulmars, the Cape Pigeon, Shoemaker (*Procellaria*), the Fuegian race of Wilson's Petrel, and Sooty Shearwater. Among visitors from the north, taken in the same waters and season, were the Peruvian Pelican, Cormorant, and Booby, the Gray Gull (*Larus modestus*), as well as the Red Phalarope and two species of jaegers from the northern hemisphere. More or less local species, mingling among those of the other two groups, included the Magellanic Penguin, the Bigüá, Red-footed, and Magellanic Shags, the Pink-footed Shearwater, Peruvian Diving Petrel, Cinnamon Skua, Kelp Gull, and South American Tern.

To northward of Corral the range of hills recedes from the ocean, and shoal and sandy shores, with occasional cliffs, lie in front of a broad fertile plain. Between Punta de Nihue and the latitude of Mocha Island a heavy surf breaks even in fine weather. Many areas of fresh water famous for their wild fowl, such as the extensive Laguna del Budi, nestle between the sea beach and the foothills, and some of the streams are broader and more impressive along their middle reaches than near their mouths.

Isla Mocha, which lies in latitude 38° 20′ S., 33 kilometers off Punta Tirúa, is one of the latest of the Chilean islands to be visited by an ornithologist. In

1932, Mr. D. S. Bullock, who has had long associations with the American Museum of Natural History, made a reconnaissance at Mocha, and has sent us a description of the island from which most of the following data are derived, as well as an excellent series of the resident birds.

Mocha is about 11 kilometers in length, with an area of 50 square kilometers, of which about half is mountainous and covered with virgin forest. The slopes are in many places so steep that it is impossible to climb them; the summit, Cerro Colmenares, has an altitude of 539 meters.

Encircling the greater part of the high central mass is a more or less level plain devoted to grazing and agriculture, the best terrain for the latter purpose being close under the foot of the hills on the northerly side. Farm and pasture land, and tracts of marsh, are crossed by numerous brooks, none of which can be regarded as perennial. Nevertheless, their lower courses remain damp, and support breeding sites for such birds as frequent the lowlands. The hills, with their woods and thickets, supply a totally different habitat, occupied mainly by a restricted avifauna.

The Mocha forest is made up largely of tique (*Aextoxicum punctatum*), intermingled in places with laurel (*Laurelia aromatica*), lingue (*Persea lingue*) and boldo (*Boldoa fragrans*), of which the last is most widely distributed. On the lower slopes there is much underbrush, in which the chilco (*Fuchsia coccinea*), the common wild fuchsia of southern Chile, is conspicuous. Whitethorn (*Rhaphithalmus cyanocarpus*) and maqui (*Aristotelia maqui*) also enter into the formation of thickets. The latter of these is able to germinate and thrive in the deepest shadow. It sprouts from the base of its stem with amazing speed. Its berries are the staple food of the native thrush of Mocha, which sows them far and wide. Several species of myrtles also flourish in the swamps and even among the hills.

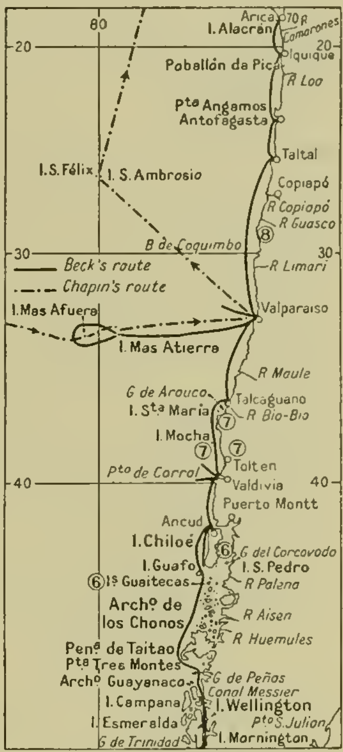


FIG. 38. Southern Pacific coast of South America and the associated islands. For detailed maps of the latter see figures 39 (Juan Fernández), 40 (San Felix and San Ambrosio). Beck's course and local collecting stations, and Chapin's voyage with Crocker in the 'Zaca' are indicated. Local field work of the American Museum is shown by figures in circles: 6, Chapman, Walcott, and Percy, at the Guaitecas Islands and in the Gulf of Corcovado; 7, Bullock, at Toltén, Mocha Island, and the Gulf of Arauco; 8, Hallinan, north of Coquimbo.

The coast presents an environment suited to many oceanic and beach birds. In certain places sandy areas with sparse vegetation afford nesting grounds to the Snowy and Falkland Plovers and to oyster-catchers. Rocky promontories are the resort of gulls and Red-footed Cormorants, while Blue-eyed Shags (*Phalacrocorax atriceps*) nest on small flat-topped islets just offshore. Isla Muerta is occupied by a dense colony of Cholos or Peruvian Cormorants (*Phalacrocorax bougainvillii*), which are here at their southernmost breeding station. The Isla de las Docas, being overgrown with a tangle of wild mustard, offers ideal nesting sites for the Magellanic Penguins. Shearwaters burrow into the forest floor on the slopes and heights of the main island.

The habitats, as will be seen, are highly diversified, and Mr. Bullock's list of birds comprises about 85 species, some of which are only transients (Chapman, 1934, 1). A few of the native passerine forms are endemic races. Certain birds very common on the opposite mainland are, however, wanting at Mocha, and for no understandable reason. Among these are three species of woodpeckers, a mockingbird, and the Loica (*Pezites*).

Visiting sea birds to the waters about Mocha include the Black-browed Albatross, Giant Fulmar, Cape Pigeon, Peruvian Booby, Cinnamon Skua, and Magellanic Gull (*Leucophaeus scoresbii*). Among waterfowl and waders of the pools, streams, and marshes, Mr. Bullock lists grebes, rails, gallinules, the Pintail Duck, flamingoes, ibises, and night herons, as well as many limicoline species, both resident and migrant. The breeding sea birds and littoral birds, of the groups to which this book gives particular recognition, are the following.

Penguins

Spheniscus magellanicus

Shearwaters

Puffinus creatopus
Puffinus griseus (probably a breeder)

Pelicans

Pelecanus occidentalis thagus

Cormorants

Phalacrocorax olivaceus
Phalacrocorax gaimardi
Phalacrocorax bougainvillii
Phalacrocorax atriceps

Oyster-catchers

Haematopus ostralegus pitanay
Haematopus ater

Gulls

Larus dominicanus

There are few other parts of South America in which four species of cormorants can be found nesting at a single station.

In the latitude of Mocha, blue skies may be said to begin. Mere fogs and mists here tend to supplant in part the pounding rains of Chiloé, and the continental mainland is less thickly concealed under trees. We have at length a suggestion of the pronounced stages of climatic space-succession which are further expressed at the Río Bio-Bio (37° S.), near which the distinctive character of the sub-antarctic forest ends, and at the Río Limarí (30° 45′ S.), where the woods are reduced to patches and the spell of the desert is foretold.

Northward from Mocha a more rugged coast, with many submerged rocks and a series of headlands, leads to Punta Lavarié, the tip of a great triangular peninsula which, with Santa María Island, shelters the Gulf of Arauco and its ports of Coronel and Lota. Santa María, although inhabited and well cultivated, supports many sea birds on its promontories and farallones. Here Mr. Bullock saw flocks of the sub-antarctic Blue-eyed Shag (*Phalacrocorax atriceps*) during the height of its breeding season, a northern record for this bird.

Bryce (1912, 226) thus describes the eastern side of the gulf:

> The shore, sometimes rocky, sometimes bordered by thickets or grassy flats behind the beaches, is extremely picturesque; and were it in the populous parts of Europe or North America, it would be lined by summer cottages and alive with children. But its vegetation and general aspect are curiously unlike those of the Atlantic coasts of either of those two continents, and remind one rather of California. At Lota, the hills rise boldly from the sea and a large island [Santa María] lying some way out gives variety to the ocean view.

The Bio-Bio, which flows into the northern end of the gulf, is not accessible from the ocean, and Concepción, a short distance upstream, finds its outlet through Talcaguano on the bay to northward. Here the Peninsula de Tumbes on the west, and the island of Quiriquina in the mouth, more or less repeat the form of the larger Gulf of Arauco. Coppinger (1884, 96) gives the following picture of the natural history of the bay as he found it in the year 1879.

> There was a long, low sandy island (Isla de los Reyes) lying across the head of Talcahuano Bay, and inhabited only by a couple of shepherds who were looking after a herd of cattle and horses. . . . On the mainland immediately adjoining the island, I found a great marshy plain of many miles in extent, and intersected in various directions by deep muddy ditches which communicated with the sea, and at high tide brought supplies of sea water to a chain of broad, shallow lagoons, the home of multitudes of waterfowl. Pin-tail ducks, widgeon, herons, curlew, flamingoes, turkey-buzzards, gulls, lapwings, and sandpipers found here a congenial home. The shrill, harsh cry of the spur-winged lapwing (the "terotero" of the Pampas so graphically described by Darwin) was forever scaring the other peacefully-disposed birds, and at the same time invoking maledictions from the sportsman. . . .
>
> When the first ebb of the tide left bare the mudbanks in the lagoons, the gulls and curlews collected in vast numbers for their diurnal meal. Of the gulls only three kinds were seen, viz., L. Dominicanus, L. Glaucodes, and L. Maculipennis. The latter were in various conditions of plumage; some birds having a deep black hood, and others with a head almost entirely white, while between these two extremes, there was every gradation. The turkey-buzzards derived a plentiful supply of food from the bodies of fish stranded on the beach. For some reason or other dog-fish were constantly coming to grief in this way, bodies of fish, two and three feet long, being met with sometimes, all along the beach, at average distances of about one hundred yards apart.

From this point a long stretch of coast without marked indentations, and with no islands other than small outlying rocks, continues its slightly easterly trend toward Valparaiso. Many rivers, of progressively reduced volume northward, enter the ocean, and here and there are standing waters behind the shore, such as the great lagoon of Vichuquen in latitude 34° 50′ S. Eigenmann (1927, pl. 1) has published graphic charts that show the lake and river systems of central Chile. South of about latitude 28° S., the coast is seen to be well covered with the dendritic designs of streams that flow for at least a part of each year. North of the rivers Guasco and Copiapó, however, an enormously long desert coast is broken only by the Río Loa.

Approaching Valparaiso from the south, one passes a rather desolate shore lined with flattish hills that are white with fossil shell-lime. Vegetation is scarce at most seasons, and algarrobo trees bespeak a climate far removed from that of Valdivia, although throughout the winter (April to October) there is more or less transitory verdure near the shore, supported by the rains brought by northerly winds. We are here north of the zone of permanent westerlies. The summer is a time of southerly and southwesterly winds, while the winter has variable winds and tempests from the north. There is also a daily alternating system in summer, the "travesia" or southerly wind beginning in the forenoon and blowing until evening, to be replaced then by the "terral" or wind from the heights. The latter is the cold breeze that produces the morning mists. Temperatures at the coast continue equable, as farther southward; the difference in the means of the warmest and coldest months at Valparaiso is only 6° C. The mean annual temperature is 2.1° lower than that of Montevideo, on the opposite coast of the continent.

Like most of the middle Chilean ports, Valparaiso is situated to northward of projecting points which furnish full shelter against all but northerly winds. The latter sometimes wreak much damage. It is usually calm in the bay during the morning, even when a strong breeze prevails out at sea but, on the other hand, the harbor is subject to violent southeast squalls from the hills when the southerly winds offshore are only moderate. Both of these phenomena seem to be characteristic of bays or coves lying below high hills from this point northward through Peru.

The harbor of Valparaiso is at times a marvelous resort of waterfowl, being often filled with combined companies of guano birds from the north and petrels or other wanderers from the south. Certain species, such as Skimmers (*Rynchops*) and Black-necked Swans, reported there in great flights a century ago (von Tschudi, 1846, 1, 35) might nowadays, however, be sought in vain.

To northward of the bay are picturesque rock formations that have evidently been elevated only recently from lower levels by the frequent seismic readjustments of this coast. Headlands are numerous, but there is none that shelters another great niche in the coast, like the bays of Arauco, Talcaguano, and Valparaiso, until we pass the mouth of the Río Limarí and reach the peninsula called La Lengua de Vaca, which stands to windward of the bays of Tongoi and Coquimbo.

10. The Pacific Sub-Tropical Islands

a. Juan Fernández.

The Juan Fernández Islands are in a latitude slightly south of that of Valparaiso, the inner island, Mas Atierra, being 667 kilometers from the continent. Mas Afuera is 167 kilometers farther west and a very little to southward. Mas Atierra is 22 kilometers in length, narrow, bent like a boomerang, and reaches an altitude of 916 meters. Off its southwestern tip lies the small, waterless island of Santa Clara. Mas Afuera is smaller than the main island, but higher (1650 meters), of roughly rectangular outline, and cut by very deep, east-west, gorge-like valleys. The latter island has been during recent years uninhabited. Mas Atierra is the seat of a fishery for clawless lobsters (*Palinurus*), which is responsible for regular communication with the mainland.

Many voyagers, such as Scouler (1826, 205) and von Tschudi (1846, 1, 38), have likened Juan Fernández, in form, climate, and the superficial appearance

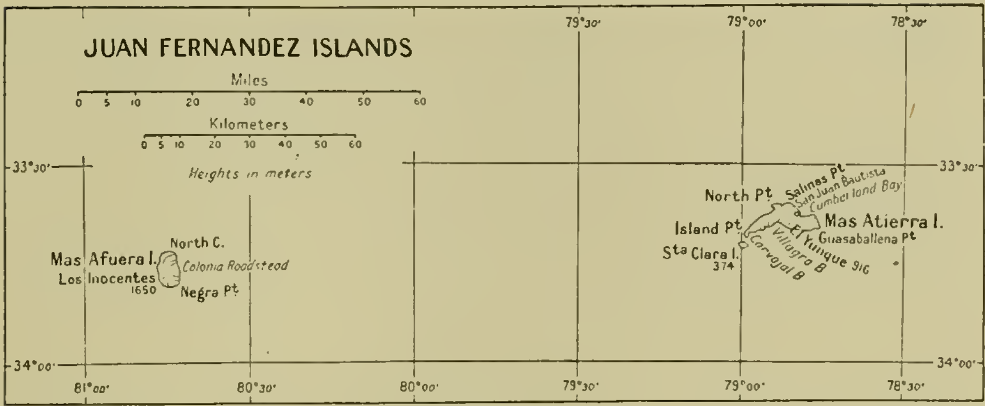


Fig. 39.

of the original vegetation, to Madeira, or to Flores of the Azores. The islands are built of greatly eroded, Tertiary, volcanic rocks, and from the wild peaks and crests forest-clad valleys descend toward the coast on one or more sides. Many of the seaward faces are, however, extremely precipitous; on the west, Mas Afuera, for example, drops away in a sheer steep of 1500 meters, more or less.

The climate of Juan Fernández is moister and milder than that of the opposite coast of Chile. The islands feel the influence of the warm circulation of the Mentor Current rather more than that of the cooler coastal water. The mean annual temperature at Mas Atierra is 15.5° C., the August and February averages being, respectively, 12.4° and 19°. Rainfall amounts to 1008.9 millimeters per annum. It is least in January and heaviest in June, and at all seasons is concentrated particularly on the higher eastern and central portions of Mas Atierra, where the air-currents condense their moisture after rising suddenly from the southerly shore. There are no adequate meteorological data from Mas Afuera.

The climate, the nature of the vegetation, and doubtless that of the animal life, cannot be discussed entirely in terms of conditions at sea level; the situation is complicated by altitude. The lofty upland of Mas Afuera, for instance, is an alpine tundra where, in 1908, Skottsberg (1918, 362) discovered a totally unsuspected Magellanic flora comprising such plants as a sub-antarctic bramble (*Rubus geoides*), a club moss (*Lycopodium magellanicum*), and a mountain aster (*Lagenophora*). Yet, as regards sea birds, it is apparently the temperature of the ocean surface, rather than of the terrestrial nesting site, which exercises full control. At Mas Afuera, which is the closer of the islands to warm oceanic regions, the petrel (*Pterodroma leucoptera masafuerae*) that breeds only on the coldest, sometimes frost-covered heights, is a bird of definitely pan-tropical affinities. At Mas Atierra and Santa Clara, which are nearer to cool Humboldt Current influences, this petrel is unknown, and is replaced by *Pterodroma cookii defilippiana*, a bird of sub-antarctic affinities which, notwithstanding, nests at much lower and warmer altitudes than the petrel of Mas Afuera.

The flora of Juan Fernández has been studied by Skottsberg, who finds on one or another of the islands both a sub-antarctic and a tropical American element, as well as a strange endemic moiety which offers only doubtful hints of relationship with plants in distant parts of the Pacific. The vertical zones comprise forest, grassy meadows and fern-beds, and mountain heath, with large sterile areas on the precipices and unfavorable exposures. The forests, which ascend to 700 meters or thereabouts, are of sub-tropical type, with evergreen forms predominating; lianas are lacking, their place being taken by ferns with winding rhizomes reaching high up the trunks of the trees. Myrtles, tree ferns (*Dicksonia*), and a large endemic chonta palm (*Juania australis*) are characteristic. The native sandalwood, known nowhere else in the world, has been extirpated, and weeds and continental thicket-plants are winning a slow victory over the aboriginal flora. Toward the upper limit of the dense forest are a number of peculiar miniature trees of endemic genera, belonging to ordinarily non-arborescent families. Some of these also flourish on the grass-grown steppe of Santa Clara.

Goetsch (1933, 26) lists Collembola, ichneumons, termites, Neuroptera, Hemiptera, grasshoppers, beetles, and Lepidoptera among the insects of Juan Fernández. Many species, he states, are endemic but, except for cosmopolitan types, they are all related to South American forms. Fifteen of 31 species of land mollusks are endemic, most of these showing Polynesian relationships. There are neither reptiles nor amphibians, and no mammals other than the practically exterminated seals. Goetsch computes the percentage of endemism in the total fauna of the island, from lower invertebrates to birds, to be 44.5 per cent, although the figure can be taken only as a rough approximation.

Both islands of Juan Fernández were recently visited during the cruise of Mr. Templeton Crocker's yacht 'Zaca.' The following notes are freely transcribed from the journal of my colleague, Dr. James P. Chapin, who was a member of the party.

January 30, 1935. The southern side of Mas Afuera is very lofty and steep, with levels above a thousand meters hidden this morning in cloud. The cliffs do not drop so directly into the sea as at many of the Marquesas Islands, and there are a few grass-covered taluses Above an altitude of about 600 meters the slopes at this end, even where nearly vertical, are clothed with green shrubbery and a few trees.

The eastern side is less precipitous and more grassy. Goats are grazing on the lower hillsides. The recently abandoned penal settlement forms a group of about ten buildings at the mouth of a narrow gorge. One pine of some European species and a few large eucalyptus trees stand near the structures. Elsewhere the scanty vegetation gives clear evidence of relative drought at this season, which is the driest part of the whole year.

On either side of the empty penal buildings—probably the only human colony ever established at Mas Afuera—trails zigzag up the steep hills. Behind, a road runs into the gorge, where the brook is dry save for a few stagnant pools. There are no woods in the floor of this valley, but small trees and large ferns grow rather thickly on the steep hillsides toward its head.

Along the trail to northward of the buildings, the slope is grassy except where the turf and soil have been eroded down to the underlying lava, probably as a result of grass fires. At an altitude of about 400 meters are the first clumps of large ferns, resembling tree ferns without trunks. Above this level, trees with very small leaves also become numerous, and just below 500 meters is a gully filled with a forest of such trees, among which are mingled tree ferns standing five meters tall and with fronds measuring up to nearly three meters in length. There are also a few trees with acacia-like foliage, and here and there a maqui to which the native thrushes come for berries.

Still farther on, the road winds through woodland and then through more open grassy stretches, with scattered trees. In this belt, close to an altitude of 550 meters, are many burrows of *Pterodroma externa*. The trail ends in a grove on the gradual slope, away from any ravine, and here is a rough shack presumably occupied at times by men from Mas Atierra who come to hunt goats.

Above this altitude the slopes are more open and grassy, with many clumps of ferns, and with small patches of forest only in the ravines. In a few of the dampest spots at the bottoms of these, one sees the enormous leaves of *Gunnera peltata* which may have a length of three meters and a breadth of more than one. Above 700 meters and below 400, there are evidently no real woods on Mas Afuera, the forest zone therefore forming a fringe like the hair on a tonsured head. Despite the aridity of the season, as shown by the parched grass and the state of the streams, none of the trees has shed its leaves. In the wooded belt, the thrush (*Turdus falcklandii magellanicus*) is the most common land bird. At lower and predominantly grassy parts of the island there are almost no birds except the hawk and, in the stream beds, the *Cinclodes*.

January 31. As we approach Mas Atierra in early morning from its western end, it looks barren, as does also the same aspect of Santa Clara. There are patches of bare earth, much dry grass, a little shrubbery, but very few trees. Steep cliffs rise from the ocean. The top of Sugarloaf is capped with woods, in which five or six palms (*Juania*) are conspicuous.

The lower parts of the valleys opening on the northerly shore are also barren but, after passing Selkirk's Cave, it becomes apparent that the bases of all the high central mountains along this side of the island are far more extensively forested than any corresponding part of Mas Afuera. The low ground near the village of San Juan Bautista seems parched, though many shade trees have been planted there. Large patches show where soil has been blown away by the wind. The road leading inland toward the base of the high peak called El Yunque is, however, well shaded by a low wood composed mainly of the maqui, introduced from the continent, which is steadily crowding back the native arborescent vegetation.

At a distance of two and half kilometers from the shore, the present limit of the maqui is reached, and one enters a large level area with an altitude of about 300 meters which stretches toward the base of the mountains. Here is a small farm in the heart of a beautiful forest, with a goodly variety of indigenous trees, including a large *Zanthoxylum* reaching a height of 20 meters. This sylvan cover of this interior depression of Mas Atierra is not only far richer than that of Mas Afuera but it also extends very much nearer sea level. A richer land bird fauna reflects the condition, for hummingbirds of two species are abundant, especially about a certain blue-flowered tree (*Raphithamnus longiflorus*). I am informed, too, that a barn owl, which has not been recorded in the literature, inhabits these forests. The large native *Pterodroma*, which is a different species from that of Mas Afuera, is said to nest only at altitudes above 500 meters.

In swampy portions of the woodland are large patches of the remarkable *Gunnera* and many kinds of ferns. One of the latter climbs the tree trunks to a height of six or seven meters, and others are epiphytes among the branches above. A native cycad grows throughout the forest belt, and in the upper parts there are two or more species of tree ferns.

According to Chapman (1934, 5) the indigenous land birds of Juan Fernández number eight species, of which three are specifically and three others subspecifically endemic. One hummingbird is represented by a distinct subspecies at each of the two main islands. The native buzzard (*Buteo polyosoma exsul*) is reported to fly regularly from its principal headquarters on Mas Afuera across the long stretch of ocean and back again (Lönnberg, 1921, 10), rarely remaining at the larger island for more than a day or two at a time. This hawk shares more or less of the tameness and lack of caution of its relatives at the Galápagos Islands, suggesting long isolation of its stock. Two introduced species flourish in a feral state, namely, the Rock Pigeon (*Columba livia*) and the California Quail (*Lophortyx californica*). The former nests on the cliffs, close to the native petrels. Casual visitors to the islands include both land and water birds from the continent, while the surrounding ocean is within the regular migratory range of many pelagic birds from the south, the islands of the Pacific to westward, and the northern hemisphere. The highly characteristic gulls, pelicans, cormorants, boobies, and diving petrels (*Pelecanoides*) of the Chilean cool-water littoral are, however, unknown at Juan Fernández. The resident and breeding sea fowl are as follows:

PENGUINS

Spheniscus magellanicus

PETRELS

Puffinus creatopus	*Pterodroma neglecta*
Pterodroma cookii defilippiana	*Pterodroma externa*
Pterodroma leucoptera masafuerae	*Fregetta grallaria grallaria*

Of the above, only *Pterodroma externa* and *P. l. masafuerae* are known certainly to breed at Mas Afuera. It is highly interesting that these two Procellariiformes are definitely sub-tropical members of the assemblage, while all of the other four species except *P. neglecta* have a certain sub-antarctic cast.

During Mr. Beck's field work in the neighborhood of Juan Fernández, in December, 1913, he began to encounter examples of most of the resident sea birds when at a distance of 150 kilometers or thereabouts from the islands, although De Filippi's Petrel was met with much nearer the continent. On the inter-island voyage, the most abundant species, by far, was the Pink-footed Shearwater. On his small boat trips offshore from Mas Atierra, he rarely found petrels of any sort within 5 kilometers of the shores.

Among the transient sea birds known to have been taken on the Pacific within sight of Juan Fernández are the following, species captured by Beck being marked with an asterisk:

"Albatross," "Gray-headed Albatross," **Diomedea exulans*, *Diomedea melanophris*, **Macronectes giganteus*, *Daption capensis*, *Priocella antarctica*, **Procellaria aequinoctialis*, **Puffinus carneipes*, *Puffinus griseus*, **Pterodroma cookii orientalis*, *Oceanites oceanicus*, **Phalaropus fulicarius*, *Stercorarius* sp.?, *Sterna paradisaea*, **Sterna fuscata*.

b. San Ambrosio and San Felix.

These small islands lie on the same submarine ridge as Juan Fernández, but 780 kilometers farther northward and about opposite Chañaral on the Chilean coast. The ridge is defined by the 2000-meter line and to eastward is the Richards Deep, descending to 5000 meters. The islands therefore represent the summits of volcanoes comparable in height with the Andes. They are at a slightly greater distance from the nearest point of the continental shore than Mas Afuera, and are about 18 kilometers apart.

San Ambrosio is an imposing rock of black basalt, rising 254 meters in a sheer precipice on its southern side and sloping to cliffs 100 meters high on the north. Landing is possible at one place, Covadonga Cove. The altitude of the

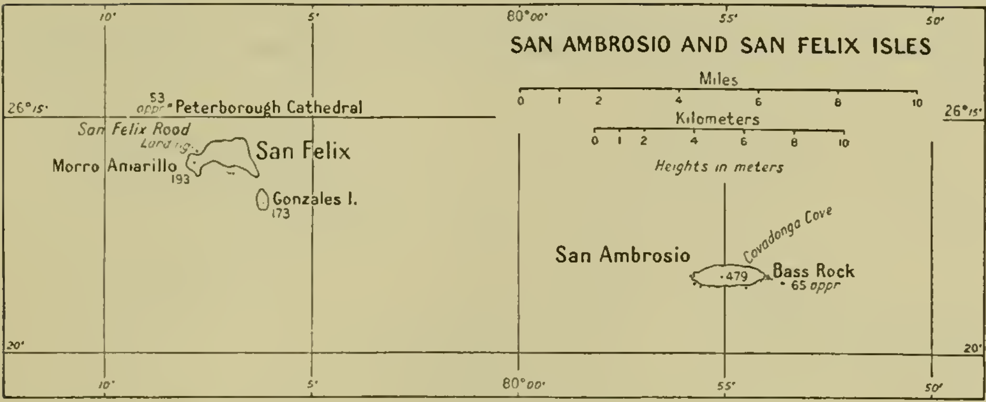


Fig. 40.

summit is 479 meters, and there the mists of adiabatic condensation support spreading shrubs and a few other plants. Dr. Ivan M. Johnston, of the Arnold Arboretum, writes me not only that the flora of San Ambrosio is considerably richer and more luxuriant than that of the lower island of San Felix, but that its green top is also the haunt of a number of insects and other native invertebrates.

San Felix, to northwestward, is a low crescentic platform. A rounded hill, the Cerro Amarillo, is 193 meters in altitude and of a cinnamon color. At the southeastern extremity is a separated hill of the same decomposed tuff, known as the Islota González, and to northward is a single stack, the Roca Catedral or Peterborough Cathedral. The length of San Felix is about 3 kilometers, its width nowhere more than 1000 meters. The cliffs along the southern coast are of jet-black lava (Willis and Washington, 1924, 365).

Little is known of the characteristics of the ocean about these islands, but their desolate aspect would indicate abnormally low temperatures for the latitude even at this considerable distance from the zone of upwelling along the South American coast. Precipitation must be scanty, judging not only by the relatively slight plant-growth but also by the fact that San Felix formerly yielded guano rich enough in nitrogen to warrant its transportation to Chile. The coasts of both islands abound with the same edible lobsters which support an industry at Juan Fernández, and which are absent or scarce in corresponding latitudes of the mainland.

After the Chilean earthquake of 1922, San Felix was visited by Professor Bailey Willis, whose report has been drawn upon above and who has courteously supplied me with some interesting notes on the natural history. He states that when Captain Stuart Campbell put in at the island for lobsters in October, 1922, its surface was covered with guano and the boobies were so numerous that the seamen "had to kick them out of the way." During the seismic disturbances of the following month, gases of volcanic origin issued from the crevices of San Felix and destroyed or drove away the greater part of the bird life. When Captain Campbell returned in February, 1923, there were only dead birds at the island, and he himself was overcome by gases upon his ascent to the basalt plateau. Likewise the spiny lobsters on the surrounding banks had been killed in large numbers, as reported by a diver who found the bottom strewn with their carapaces.

Professor Willis arrived on a Chilean corvette in May, 1923. At that time a sulphurous odor and puffs of bluish vapor were still noticeable, but he satisfied himself that there had been no active flow of lava from the crater of San Felix since the date of the original discovery of the island by Juan Fernández in 1574. Small bushes were still growing on the old lava at the summit. Willis counted "twenty-five live birds and fifty dead ones on the entire island, where formerly there must have been many thousands."

My colleague, Dr. Chapin, who landed only at San Felix, collected there four species of plants, namely a sea-blite (*Suaeda microphylla*), a mallow (*Cristaria insularis*), a salt bush (*Atriplex*) of a new species, and a love-grass (*Eragrostis*) of a new species or new variety. The last is the first grass ever found at either of these islands; it seems to be a close relative of *Eragrostis peruviana* which thrives along the maritime ranges of the mainland from Lima southward to Taltal. Dr. Johnston, who has identified these specimens, informs me by letter that the plants of the two islands comprise about 14 species, of which all but three or four are apparently endemic, although the relationships of several are still dubious. With the exception of an endemic genus of composite (*Thamnoseris*), the affinities of the plants are clearly with elements in the flora of the coastal hills of Peru and Chile. *Thamnoseris* may perhaps have closer connections with endemic genera of Juan Fernández and Polynesia, and hence may be a representative of an "Old Pacific" flora.*

Until the recent cruise of the 'Zaca,' our information about the birds of San Felix and San Ambrosio had been woefully scant. The islands are an ornithological station of particular interest because of their somewhat anomalous zonal position. They belong neither to the Humboldt Current nor yet to the fully tropical Pacific, and, while they share two or three of the native sea birds of Juan Fernández, the avifauna has been alleged to have other components that would make an odd mixture. References to birds in the literature are disappointingly casual, and specimens have been extremely scarce and scattered. Morrell (1832, 117) states that ship's provender in the form of eggs of sea birds may be gathered in any quantity at San Ambrosio during the months of December and January. Those of the "shag and gannet," he adds, are nearly equal in taste to hens' eggs.

It is highly improbable that any kind of shag or cormorant ever inhabited these islands. The presence of a gannet or booby has been known from photographs of downy nestlings, and that of a Gray Ternlet (*Procelsterna*) and a petrel (*Pterodroma cookii defilippiana*) from one or two specimens of each. The native

*Dr. Johnston has since written me that the *Eragrostis* proves to be a continental form, that *Thamnoseris* is represented by distinct species at San Felix and San Ambrosio, respectively, and that the affinities of the latter genus are American. Its relationship with the Polynesian *Fitchia* is illusory, and its only known close kin is *Dendroseris*, of Juan Fernández. The important point is that the San Felix and San Ambrosio flora is definitely and entirely American, though with a remarkably high degree of endemism as to species and genera.

birds, which are all sea fowl, are now determinable from comprehensive collections made by Dr. Chapin and Mr. Jaques of the 'Zaca' party. They are as follows:

Petrels	Terns
Pterodroma neglecta	*Sterna fuscata*
Pterodroma cookii defilippiana	*Procelsterna albivitta*
Fregetta grallaria grallaria	*Anoüs stolidus*
Boobies	
Sula dactylatra	

The assemblage is, in the main, sub-tropical but, in view of the presence of the Masked Booby, Sooty Tern, and Brown Noddy, it is somewhat surprising not to find other boobies, man-o'-war birds, and fairy terns (*Gygis*). The islands are doubtless to be regarded as a sub-tropical outpost at the verge of the cool littoral water. There is not a single resident species suggestive of the Humboldt Current avifauna.

There remains for disposition the apparently well-substantiated record for San Ambrosio of a nesting colony of an American "marsh tern," *Sterna trudeaui* (Bent, 1921, 228). The account is fully specific as to the discovery of these birds, and the collection of numerous eggs, at this island on December 17, 1907. Mr. Crocker's party saw no trace of the species in February, 1935. It is hardly necessary to cite such negative testimony as evidence, however, for the zoögeographic probabilities are overwhelmingly against the presence of breeding Trudeau's Tern at these islands at any time of year. The record is doubtless based upon either an error or a hoax; if the former, it is possible that "San Ambrosio" refers to another locality in Chile, or that the collector's eggs of Sooty Terns or Noddies had become transposed with Trudeau's Tern eggs from the mainland.

Both San Felix and San Ambrosio, of course, need thorough inspection in search of the still undiscovered breeding grounds of a number of petrels known only from waters off the Chilean and Peruvian coasts.

The following account is freely transcribed from the notebook of Dr. James P. Chapin, who visited San Felix and San Ambrosio in the 'Zaca' as the guest of Mr. Templeton Crocker.

February 18, 1935. As we approach Gonzáles Island from the southeast, both it and San Felix seem wholly bare, but a nearer view shows small clumps of pale green plants on some of the slopes. There is no visible patch of grass, and nothing approaching the dignity of a tree or even a tall bush. The terrain appears more barren than any at the Galápagos except that of young lava-fields. The western end of San Felix is a hill of soft yellow-brown volcanic rock and the lower part is made up of brownish-black lava cut into a sea cliff. An old cable hanging from the rock above the landing place enables one to reach the summit of the island, where there is a little soil resulting from the disintegration of the volcanic rock and the droppings of sea birds.

Nearly the only vegetation consists of widely scattered plants with small succulent leaves, which turn from green to dark reddish as they age, so that the whole shrub often has a purplish appearance (*Suaeda*). Radiating from a central root, some of these plants are more than a meter in diameter, but they average about half that, with a height of 25 centimeters. Less common is a small, spiky, green herb, most examples of which prove to be completely dried out (*Cristaria*), and in one spot are numerous little grass plants pressed against the ground and long since desiccated (*Eragrostis*). A fourth species grows on and about the Cerro Amarillo, at the western end of the island. This is the one first observed from sea. It has small gray-green leaves and tiny greenish or yellowish flowers (*Atriplex*). It, too, radiates from a central root, reaches a diameter of upwards of a meter, and its woody stems are very brittle. Many feathers are entangled in all the plant clumps.

All down the gentle slopes on the northern side of San Felix, flocks of sooty terns rise and fill the air, leaving on the ground, however, a few fledglings not developed quite enough to fly. The only traces of eggs are broken shells and a few ancient, infertile examples. Old booby nests are recognizable by the radiating streaks of white, but only one occupied site has been seen. On this two birds are squatting, one of them attempting to incubate a thoroughly addled egg. The only present bird of the island that could have laid down such guano deposits as have been described would appear to be this species. Yet *Sula dactylatra* is at best never a truly colonial booby, such as *Sula variegata* of the Peruvian coastal islands. Even under conditions of maximum population, its nests tend to be somewhat widely scattered, like those of *Sula nebouxii*, rather than compactly placed like those of typical guano-producing sea fowl.

On small piles of rock, especially in slight hollows, the gray ternlets are alighting freely, though no eggs or young are to be found. *Pterodroma cookii defilippiana* evidently nests in small cavities of the rock, particularly on the slopes of the Cerro Amarillo, where the soft stone weathers in such a manner as to provide innumerable little niches. In some such cavities there is gray down from nestlings that have departed, and in others the skeletons of birds that have died. No chicks are in the holes, but one has been shot on the water near shore and a second captured on a flat ledge above our landing place. A few adults are flying about over the ocean, and others along the high cliff that forms the southern edge of San Felix. One has even flown into a large cave close to the landing place.

Approaching San Ambrosio from the westward, in afternoon, we can see that its lofty but rather level summit has considerably more vegetation than any part of San Felix. Certain plants appear to resemble the gray-green ones of the other island, but they grow so closely as to be almost in contact one with another. Some that project over the brink of the cliff look particularly bushy.

Late in the day, hundreds of large petrels (*Pterodroma neglecta*), of which we have seen only a single example near San Felix, are circling about above the greenish plateau of San Ambrosio. The great bulk of them are of the dark phase, which is the opposite of the condition in the colony of the same species which we have visited at Ducie Island, in southern Polynesia. Flocks of the ternlets (*Procelsterna*) are flying about the base of the cliffs, the birds frequently alighting on projecting rocks, close to examples of the booby, and also sometimes resting on the water in groups. Shortly after sunset, storm petrels (*Fregetta grallaria*) begin to appear over the ocean, fluttering about until darkness conceals them.

Dr. Chapin's observations and collections indicate that *Pterodroma cookii defilippiana* inhabits only San Felix and its outliers, while the larger petrel, *P. neglecta*, is confined to San Ambrosio. This is interesting because of a somewhat analogous division of adjacent island territories at Juan Fernández by four species of the genus *Pterodroma*. In the latter instance, however, it so happens that *P. neglecta* and *P. cookii defilippiana* share the same island (Mas Atierra), while Mas Afuera is given up to another pair of species, likewise large and small, namely, *P. externa* and *P. leucoptera masafuerae*.

(1) POLYNESIAN SOURCES OF WEST COAST WANDERERS

The Chilean islets of Sala y Gomez, in latitude 26° 25′ S., longitude 105° 25′ W., are outside the South American region and the scope of this account. They may be mentioned, nevertheless, as a breeding station of certain pan-tropical types of sea birds which have been unable to establish themselves in an extensive area of Humboldt Current influence. To find these species as breeding birds anywhere within about a thousand kilometers of the west coast of South America we must, in fact, go north of the equator. MacFarlane (1887, 209) visited Sala y Gomez on March 5, 1884. He states that the islets resemble St. Paul Rocks in the Atlantic, being a nearly inaccessible cluster of low black pinnacles against which the swell breaks high. The three species of birds he found in residence were noddies (*Anoüs*), fairy terns (*Gygis*), and man-o'-war birds (*Fregata*).

Easter Island, beyond longitude 109° W., has a limited but typical Polynesian avifauna. It is of present interest only as a possible source of the errant Sooty Terns (*Sterna fuscata*), elsewhere recorded from the neighborhood of Juan Fernández and from the Peruvian coast at Independencia Bay. As we now know, however, these might have come from San Felix.

11. The Desert Coast—Coquimbo to Point Pariñas

To northward of Valparaiso the isotherms of both atmosphere and coastal ocean space out, further enhancing the equability characterizing the seaboard farther southward. Between Cape Horn and Valparaiso the mean air temperature increases approximately one degree Centigrade for each two degrees of latitude; but between Valparaiso and Callao the increase is less than one degree Centigrade for each five degrees of latitude. In fact, Antofagasta (24° S.) and Callao (12° S.) show a difference of only 0.7° C. in their annual average temperatures. Compared with stations at the respective latitudes on the Atlantic side of the continent, the differences are even more striking than those of Patagonian South America. Thus the mean at Antofagasta is 4° C. lower than at Rio de Janeiro; that at Callao 5.6° C. lower than at Bahia.

The last forests supported by rains appear on the coast along both banks of the Río Limarí. They are dense clumps of tique, already noted at Mocha Island, but here forming only smaller trees, well covered with epiphytes and with an undergrowth of ferns and mosses. Woods of this type fill up the gorges through the coastal plateaus but the remainder of the country is covered chiefly with brush and cactus. Most of the subsidiary streams along the lower course of the Limarí, incidentally, enter through its left bank; on the right or northern bank is the waterless Quebrada Seca.

As far northward as latitude 26° S., a winter rainfall system rules, but in progressively decreasing amount. The valley of the Guasco has no entirely dry years, but at Copiapó rainless years are frequent, even though occasional downpours between June and August give an annual mean of 21 millimeters. The winter mists, so characteristic of the Peruvian coast, also occur in Chile as far south as latitude 29° S. Known as garúas in Peru, and camachancas in Chile, their distribution evidently depends upon relief, for they are particularly marked south of Antofagasta where the slope of the coastal plateau is abrupt. According to Ball (1887, 129), they are practically unknown northward toward Iquique, which is the part of the coast attaining the maximum aridity.

Between the Río Copiapó, south of Caldera, and the Ríos Camarones and Lluta, near Arica, there is a stretch of nearly a thousand kilometers in which only one river, the Loa, cuts the coastal pampa to flow throughout the year into the Pacific. It would be difficult to imagine a region more desolate than this portion of the Atacama Desert—a wind-swept surface, sunburnt and sterile, broken here and there by the grimy white of the "salares." Through it twines the hidden green canyon of the Río Loa (Rudolph, 1927, 553).

The true desert zone, interrupted only by the valleys of Andean streams, may be regarded as extending from the neighborhood of Caldera (27° S.) to Point Pariñas (4° 30′ S.). The lower limit of the summer rains on the western slopes of the mountains comes at about 2200 meters near the northern end of Chile and at 1600 meters in the latitude of Lima, while at Tumbez, in northernmost Peru, it reaches the sea. Throughout much of this zone, however, the desert is bordered toward the ocean by an ephemeral fringe of herbage composed of annuals brought into bloom for a few weeks by the winter mists.

The islands on the coastal shelf partake, of course, of the climatic character of the mainland, but only those high enough to cause marked adiabatic cooling of the sea winds have sufficient moisture to share the transient vegetation of the "tiempo de lomas." The Chilean coastal islands are mostly inconsequential. The largest of those along the desert shore lie between Coquimbo and Caldera, plantless, waterless, and of potential value only as sources of guano. As to their occupation by the requisite number of sea fowl, I have no recent information. The island of Alacrán off Arica has, however, been well covered with guano birds during the last few years.

And what of the adjacent ocean along the arid shores of Peru and Chile? Darwin (1933, 329), when bound northward in the 'Beagle,' wrote:

> Here in the Pacifick, although the water is never agitated by storms, it never rests quiet, but feels through the unbroken continuity the violence which reigns in the South. Now, in the winter, a heavy dull bank of clouds intercepts during successive days even a glimpse of the sun. The temperature is by no means warm; in approaching these low latitudes I did not experience that delicious mildness, which is known for a few days in the Spring of England, or in first entering the Tropics in the Atlantic.

A century ago Swainson (1836, 1, 261) could write, with a temerity which time has not justified, that "Chile and Peru are too arid and naked to excite great expectations regarding their ornithology." As a matter of fact, the bird life of the desert zone has proved extraordinarily rich and interesting. Aside from the land birds, moreover, the probability has developed within recent years that certain little-known sea fowl, including especially petrels and shearwaters of the Humboldt Current region, have their breeding grounds in remote parts of these continental wastes, where predatory animals are reduced to a minimum. Stresemann (1924, 61; 1929, 80) has called attention to mummies of downy young and adults of Hornby's Petrel (*Oceanodroma hornbyi*) and of the Sooty Shearwater (*Puffinus griseus*) found in the Chilean saltpeter fields and neighboring parts of the hinterland. No other nesting grounds of Hornby's Petrel are known, and there are related species peculiar to the littoral ocean off the west coast of South America, such as *Oceanites gracilis gracilis* and *Oceanodroma markhami*, the nesting stations of which are still undiscovered.

The supposed nesting localities just referred to are (1), near Santa Luisa, 50 kilometers back from the coast and 1600 meters above sea level; (2), at a similar altitude 30 kilometers from the coast in latitude 22° 22′ S., longitude 70° W.; and (3), on the Pampa del Toco, inland from Tocopilla and north of the sites previously mentioned. Wetzel (1925, 284) reports many petrel mummies unearthed through blasting away of the surface crust, and others in the bottom of a dry water-course. He assumes that at a period when the climate was somewhat less arid, sea bird breeding grounds were widely distributed in the nitrate region, especially in the flat and relatively soft beds of the seasonally dry arroyos. Probably the nestlings, and even the adults of burrowing species, were surprised by sudden floods and buried beneath the rubble. Such floods still occur in the system of the Río Loa.

However, the evidence is not all related to the discovery of ancient birds. Sea fowl of sorts not yet properly identified still make their home in the dry valleys and gulches leading toward the nitrate pampas. An old resident of the Pampa del Toco informed Wetzel of a kind of "gull," locally called "Garruma," which nests in such situations. The adults return only at night, bringing fish, and their cries are heard all through the hours of darkness. Such birds are unquestionably petrels. Furthermore, an engineer, Mr. Harry D. Ball, has written me from Tocopilla that on the "biologically bankrupt" pampa, high above the narrowly green banks of the Río Loa, there are "several nesting colonies of gulls or guano birds" upon which the wild dogs, or so-called foxes, of the Chilean desert prey at certain seasons. Mr. Ball continues as follows, with reference to his researches in this field:

> Frequently during the excavations and mining operations here I have come across "pockets" of guano. These pockets are loosely cemented sands, dark brown in colour and smelling very strongly of iodine. In these pockets can always be found small bird bones (chiefly the leg bones), although I have found one almost complete skull, bits of egg shell and very numerous brown insect carapaces. The guano-pockets are often found below 2 or 3 feet of hard cemented caliches and costras, and it is evident that they were formed at least previous to the final concentration and redeposition of the valuable salts of the pampa. These deposits of guano may throw light on the economically important problem of the origin of the nitrate deposits.

Newton (1890, 375) long ago reported upon bones of small sea birds found in guano-like earth beneath the nitrate beds. A comparison of the limb bones, fragments of the bills, and other elements, suggested that they represented small petrels of the genus *Oceanodroma*, perhaps *O. markhami*.

Philippi's (1895, 11) original discovery of the present-day breeding grounds of Hornby's Petrel, inland from Taltal (25° 30′ S.), was long obscured by the fact that he gave his specimens a new and hence unfamiliar scientific name. In a paper immediately following his description, the same author discussed (p. 14) bird bones from Mejillones, which had been found in guano of great age. For reasons which must surely be regarded as inadequate, Philippi believed the deposits to be much older than the underlying guano of the Chincha Islands in

Peru, and perhaps to date from Tertiary times. He described five brain-cases of a booby as a new and extinct species, *Sula antiqua*. His plate, however, reveals no more than extremely slight or negligible distinctions from *S. variegata*, the common booby along this coast today. In nitrogenous guano from Tarapacá he found remains of a cormorant distinct from the four Chilean species with the bones of which he compared it. The supposedly extinct bird he named *Phalacrocorax sulcatus*, but the measurements, description, and figures indicate that it is nothing else than the modern *P. bougainvillii*. Philippi evidently misunderstood Taczanowski's measurement of the length of the bill in the common Guanay, or Peruvian Cormorant, for the figures refer not to the culmen but to the distance between gape and tip.

Another erroneous record for the desert region is that of a "penguin mummy," assumed to be several thousand years of age, and found under deep beds of guano at Huanillos, Chile (Lambrecht, 1933, 239). This specimen has even been assigned to a definite genus, *Aptenodytes*, but reference to the original source (Ribera, 1904, 339) shows that it was merely the downy chick of some sea bird, possibly a cormorant, and certainly not a penguin of any sort.

The conclusions to be drawn from this discussion are that the ancient remains of sea fowl from the north Chilean desert region belong, so far as known, to present-day species of this coast; and, furthermore, that many facts of the utmost interest, including discovery of the first known nests, eggs, and young stages of a number of species, are likely to reward the first thorough reconnaissance within the area.

As summarized by Aikman (1892, 439), one of the theories put forward to account for the great beds of nitrate of soda in the desert of Tarapacá is that the substance owes its origin to immense deposits of the guano of sea birds originally covering the shores of large salt lagoons. Such lakes, through an eventual overflowing of the shores, are supposed to have effected a mixture of guano with the salts and thus, by a process of slow decomposition, led to the formation of nitrates. The actual occurrence of small quantities of guano in the nitrate fields would seem to lend further support to this hypothesis.

A serious objection to the theory, however, is the absence of calcium phosphate from the deposits. It would be hard to account for the lack of such an insoluble salt while the easily soluble nitrate of soda remained. Again, if the theory were correct, we should expect to find further evidence in the form of portions of guano in the transition stage. Finally, there seems to be little doubt that the traces of birds' nests, remains of birds, and the undifferentiated guano now found in the nitrate beds were left there subsequent to the formation of the sodium nitrate. Ball, however, in a manuscript communication quoted above presents evidence not wholly in accord with the last opinion.

The most probable supposition, concludes Aikman, is one first advanced by Nöllner to the effect that the nitric acid is to be ascribed to the decay of great masses of seaweed driven into the ancient lagoons at a time antedating the uplift of the land. The presence of large quantities of iodine in the raw nitrate of soda furnishes strong confirmation of this theory. Furthermore, the presence of small bits of still undecomposed seaweed within the salt constitutes additional support.

Smith (1904, 1) and Wetzel (1925) likewise discount the function of guano in the production of the still puzzling nitrate wealth. The former authority writes:

> Recent geologic changes are evidenced by the remains of 12 successive beach marks in 2,500 feet elevation on the hills back of the port of Mejillones. The amount of salts remaining is much too great for a simple impounding of an arm of the sea. But it is suggested that a tide may, at frequent intervals, have re-filled it, and that great accumulations of seaweed furnished the nitric acid necessary to convert the sodium into nitrate of soda. The presence of iodine (a component of seaweed) helps bear out this theory, as does the presence of fragments of undecayed seaweed. The location of the richest deposits on the sides of hills is further evidence of beach deposits.

Brüggen (1934, 236) proposes a more advanced form of the earlier hypothesis, and holds that the nitrare deposits may be due to the action of bacteria, during an earlier period, in the presence of ammonia gas given off by abundant guano beds which formerly existed on the pampas.

From Tarapacá to the northern end of Peru the coastland and the littoral waters are, on the whole, more uniform than along any equivalent stretch of shore line in the world. The relatively low temperatures for the respective latitudes continue northward from the tropic of Capricorn to Cape Blanco and the Galápagos. Antofagasta and Paita are farther apart than Cape Cod and Cuba, or than Norway and Gibraltar, and yet these Chilean and Peruvian ports are characterized by amazingly similar temperatures of air and of surface waters, which are affected little more by season than by latitude. This is the true zone of the Humboldt Current, of continuous upwelling, of secular uniformity in the desert shores, in the physical character of the littoral ocean and its associated life. As hinted previously, longitude here replaces latitude in dividing the climatic and faunal zones. I mean that one may skirt the land from Arica to Sechura Bay without meeting strikingly new diurnal or seasonal changes of weather and without finding more than trifling variation in the flora and fauna of the desert and the sea. An hour's journey to westward in the Pacific, on the other hand, will reveal changes more profound than a week's travel north or south. The Humboldt Current is responsible for a peculiar biota of its own and, from a map-maker's point of view, zonal distribution may be said to become vertical instead of horizontal. So far as sea birds are concerned, the current establishes a magic wall between the cool-temperate inshore water and the outlying bands of oceanic water which are, successively, sub-tropical and tropical. The respective longitudes of the coast, of San Felix and San Ambrosio, and of Sala y Gomez have, as we have seen, their own distinctive and largely exclusive avifaunas.

During the cruise of the 'Vénus,' a century ago, du Petit Thouars found ocean temperatures of 15.2° C. at Valparaiso, 16.7° at Callao, which is twenty-one degrees of latitude closer to the equator, and 17.7° at Paita, seven degrees of latitude still nearer the equator, during the early days of June. But in Post Office Bay at the Galápagos, at the end of June, the surface temperatures were 22.8° C. In other words, the temperature rose 5.1° C. during a journey covering four degrees of latitude and ten degrees of longitude between Paita and the Galápagos, although it had increased by only 2.5° C. throughout the previous voyage covering twenty-eight degrees of latitude and ten degrees of longitude between Valparaiso and Paita. From such observations de Tessan (1844, 443) concluded that in the Peruvian Current surface water is constantly being refreshed along the length of the continental coast by water from lower levels. This was perhaps the first direct reference within the region to the phenomenon we now call upwelling.

A comparison of thermometric conditions between places actually at the shore and those a short distance inland shows the effect of the ocean upon continental climate. It is especially marked during the verano or summer season. Thus at Caldera, Chile, on the coast, the mean annual temperature is 15.9° C., while at Copiapó (altitude 400 meters) it is 15.3°; but the mean for January at Caldera is only 19°, while that at Copiapó is 20.4°. The annual mean at Callao is 19.3°, at Lima (altitude 158 meters) 19°; but the February temperatures are, respectively, 21.2° and 23°. Santa Elena, Ecuador, has summer means of from 23° to 24°; Guayaquil, inland on the river, 27°.

The coast has a régime of regular alternating breezes, the "virazon" blowing toward the land during the day, and the "terral" toward the sea at night. The former wind is generally southerly, the terral an east wind. If one goes sufficiently far offshore, the standard southeast trades will be found holding sway over the high sea. The most definite temperature effects produced by upwelling are conditioned by the topography of the submarine areas, for the sharpest lowering of temperatures of the surface waters corresponds in position with the oceanic deeps close to shore and with places where the continental shelf is reduced to a minimum. The morning garúas are produced by the abrupt cooling of air in contact with the sea at an hour when the land breeze still holds. Although these mists are particularly intense and seasonally prolonged in the south, they extend all the way northward along the coast to the Silla of Paita or, in midwinter, even to western Ecuador.

In explanation of the normal inability of the air from the sea to bring rain to the land, Jefferson (1926, 285) writes that

> there cannot be much evaporation from the cool water or in the cool air that overlies it; if in the afternoon the land becomes hot enough to attract a sea breeze, the land must warm the cool air that blows against it enough to neutralize the adiabatic cooling produced by ascent to a considerable height. That is, air at 65° F. may be warmed 25° by the land it is blown against if the ground has only the moderate temperature of 90°. It would take an ascent of nearly 5000 feet to cool the air by that 25°, leaving it nearly a mile in the air at the same temperature with which it started and with no progress made toward the condensation of water vapor. Almost the only onshore winds of the coast have this cause—the afternoon heating of the land; and the land is doubtless always hotter than 90° when the sea breeze sets in. The conditions are therefore very unfavorable to rainfall.

But, although the rain forbears to descend except at intervals of decades, the "appearance of rain" is all but constant. Darwin in his 'Beagle' journal refers to the immense pall of still and low clouds covering the coast of Peru and northern Chile. Bowman (1916, 143) writes:

To the traveler on the west coast it is a source of constant surprise that the sky is so often overcast and the ports hidden by fog, while on every hand there are clear evidences of extreme aridity. Likewise it is often inquired why the sunsets there should be often so superlatively beautiful during the winter months when the coast is fog bound. Why a desert when the air is so humid? Why striking sunsets when so many of the days are marked by dull skies? As we have seen . . . the big desert tracts lie east of the Coast Range, and there, excepting slight summer cloudiness, cloudless skies are the rule. The desert just back of the coast is in many parts of Peru only a narrow fringe of dry marine terraces quite unlike the real desert in type of weather and in resources. The fog bank overhanging it forms over the Humboldt Current which lies offshore; it drifts landward with the onshore wind; it forms over the upwelling cold water between the current and the shore; it gathers on the seaward slopes of the coastal hills as the inflowing air ascends them in its journey eastward. Sometimes it lies on the surface of the land and water; more frequently it is some distance above them. On many parts of the coast its characteristic position is from 2,000 to 4,000 feet above sea level, descending at night nearly or quite to the surface, ascending by day and sometimes all but disappearing except as rain-clouds on the hills. Upon the local behavior of the fog bank depends in large measure the local climate. A general description of the coastal climate will have many exceptions. The physical principles involved are, however, the same everywhere. . . .

Three typical positions of the fog bank are shown in the figure, and a fourth—that in which the bank extends indefinitely westward—may be supplied by the imagination.

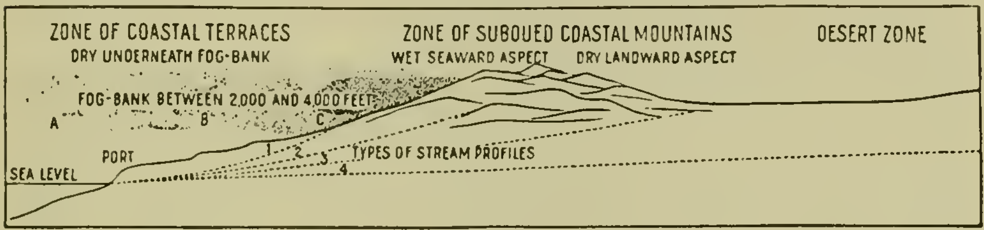


Fig. 41.

If the cloud bank be limited to C only the early morning hours at the port are cloudy. If it extend to B the sun is obscured until midday. If it reach as far west as A only a few late afternoon hours are sunny. Once in a while there is a sudden splash of rain—a few drops which astonish the traveler who looks out upon a parched landscape. The smaller drops are evaporated before reaching the earth. In spite of the ever-present threat of rain the coast is extremely arid. Though the vegetation appears to be dried and burned up, the air is humid and for months the sky may be overcast most of the time. So nicely are the rain-making conditions balanced that if one of our ordinary low-pressure areas, or so-called cyclonic storms, from the temperate zone were set in motion along the foot of the mountains, the resulting deluge would immediately lay the coast in ruins. The cane-thatched, mud-walled huts and houses would crumble in the heavy rain like a child's sandpile before a rising sea; the alluvial valley land would be coated with infertile gravel; and mighty rivers of sand, now delicately poised on arid slopes, would inundate large tracts of fertile soil.

If the fog and cloud bank extend westward indefinitely, the entire day may be overcast or the sun appear for a few moments only through occasional rifts. Generally, also, it will make an appearance just before sunset, its red disk completely filling the narrow space between the under surface of the clouds and the water. I have repeatedly seen the ship's passengers and even the crew leave the dinner table and collect in wondering groups about the port-holes and doorways the better to see the marvelous play of colors between sky and sea. It is impossible not to be profoundly moved by so majestic a scene. A long resplendent path of light upon the water is reflected in the clouds. Each cloud margin is tinged with red and, as the sun sinks, the long parallel bands of light are shortened westward, changing in color as they go, until at last the full glory of the sunset is concentrated in a blazing arc of reds, yellows, and purples, that to most people quite atones for the dull gray day and its humid air.

At times the clouds are broken up by the winds and scattered helter-skelter through the west. A few of them may stray into the path of the sun temporarily to hide it and to reflect its primary colors when the sun reappears. From the main cloud masses there reach out slender wind-blown streamers, each one delicately lighted as the sun's rays filter through its minute water particles. Many streamers are visible for only a short distance, but when the sun catches them their filmy invisible fingers become delicate bands of light, some of which rapidly grow out almost to the dome of the sky. Slowly they retreat and again disappear as the rays of the sun are gradually shut off by the upturning curve of the earth.

The following quotations refer further to the peculiar character of the coast, its appearance, and its charm to the naturalist.

No one complains of the Grand Cañon because it is treeless, and I have small patience therefore with those writers who describe the coast of Peru as monotonous and lacking in interest because of its aridity, when from the sea to the summit of the Andes there stretches a panorama as varied in feature as it is vast in size.

It is true that fogs and low-hanging clouds at times prevail on this coast, and when they persistently shut out the view of mountain ranges arising to snow-clad peaks they accentuate the impression of desolation which the barrenness of the foreground, seen alone, may produce. But, on the other hand, when they disappear before the heat of the ascending sun or are penetrated by its setting rays, they reveal the weird, impressive world which lies behind them, and create effects of singular and indescribable beauty (Chapman, 1919, 157).

In comparison with the spell of the interior, . . . the appeal of the long, shining coast of Peru seems to have been felt by few. The voyager gazes at bare, dead, cloud-topped ranges, colorful indeed, and faced at evening by matchless sunset skies; but the endless succession of parched mountain and parched desert, of blistering coastal terraces and dark, forbidding cliffs, may ultimately become monotonous. Calls in the unsheltered roadsteads of small ports fail, perhaps, to bring the anticipated relief; for the inhabitants, their dwellings, and the intermingled green, still seem somehow to be swallowed up by the illimitable aridity around them. The voyager encounters, moreover, a littoral ocean which, although practically stormless, is rolled up by steadfast southerly winds into great swells and surf which at many points render embarking and disbarking a serious inconvenience. Of the extremely profuse wild life of this coastal ocean, he may chance to observe no more than sea-lions and vast flocks of birds; and if he seeks a traditional product of the waters which can compare in importance with the marvels of the interior, he finds only guano, the ammoniacal smell of which strikes his nostrils whenever the steamer draws into the lee of bird-inhabited islands (Murphy, 1925, 27).

The bird life, both resident and transient, is the most spectacular feature of the coastal waters. For a characteristic glimpse of it we may call again upon the talented pen of Dr. Chapman:

As for the birds, who can describe them in their incalculable myriads? Visible link in the chain of life that begins with diatoms nourished by the cool, highly oxygenized waters of the Humboldt Current, they animate both the air and the sea. No other coastline of similar extent can show an avian population equaling that of the waters off Peru.

On November 20, 1918, off the port of Salaverry where my Red Cross mission had taken me, whichever way one looked from our anchorage, birds could be seen in countless numbers fishing in dense, excited flocks, passing in endless files from one fishing ground to another, or massed in great rafts on the sea. Toward the shore long, waving whip-like streamers and banners passed in endless undulating lines sharply silhouetted against the coast range.

Seaward, like aërial serpents, sinuous files crawled through the air in repeated curves lost in the distance, while low over the water processions passed rapidly, steadily, hour after hour, with rarely a break in their ranks during the entire day. At times the flocks were composed of Cormorants with, at intervals, a white-bodied, brown-winged Booby. At others, they were composed of Boobies accented, here and there, by a Cormorant.

When the birds stopped to feed, the scene commanded the untiring and often excited attention of every passenger aboard the ship. The Cormorants fished from the surface in a sea of small fry. Swimming and diving they gobbled voraciously until their storage capacity was reached. Then they floated in dense, black masses waiting for the processes of digestion to give space for further gorging.

The Boobies fished from the air, plunging into the water with great force from an average height of fifty feet, to disappear in a jet of spurting spray as they hit the surface. In endless cataracts they poured into the sea. It was a curtain of spearheads, a barrage of birds. The water became a mass of foam from which hundreds of fishers took wing at a low angle to return to the throng above and dive again; or, their hunger satisfied, they flew by thousands to some distant resting-place. It is difficult to understand why the birds near the surface were not impaled by their plunging comrades.

But the most amazing maneuver in all this astounding spectacle was the instantaneous disappearance from the air of flocks of 500 to 1,000 Boobies that chanced to pass over a school of fish. Then, as one bird, they plunged seaward and the sky, which a moment before seemed full of rapidly flying birds, was left without a feather. This evolution, the most surprising I have ever seen in bird-life, was witnessed repeatedly during the day. When we left Salaverry late in the afternoon there was no apparent decrease in the numbers or activities of the winged fishers; but I could look at them no longer without a feeling of confusion and dizziness; for the first time in my life I had seen too many birds in one day! (Chapman, 1933, 256).

In view of the general topographic and faunal sameness of the long desert coast, and the scarcity of bays or other marked indentations, we may now voyage rapidly northward, pausing only to consider conditions at certain islands and other points of special interest.

At Arica the coast bends sharply northwestward, and the south-wind surf begins to pile high against the shores of Peru, as all know who have landed at Mollendo—perhaps in the half light of the moon, as I did—from a bobbing launch by way of an armchair dangling from a steam-crane. Here surf days, such as those described in connection with Ascension and St. Helena, are frequently "declared" by the port captain, and traffic between shore and steamers is suspended. Mighty rollers come pouring over the sea wall, and have been known to carry away forty-ton freight cars, to uproot concrete piers, and to twist iron rails like wire. Between the town and the bare coast hills of rather even altitude are salt-encrusted terraces cut by quebradas which either end on broad beach plains or come down to the booming breakers. A short distance to southward of the port, the wall of the coastal range is breached by the fertile Tambo Valley, through which in clear weather the cone of El Misti can be seen from the Pacific.

Barclay (1917, 53) speaks of the phenomenally rapid erosive effects of the steady winds and the rare rains on the shoreward slopes at Mollendo, and adds:

One of my most vivid recollections . . . is a vision, against the early morning sun, of a great flame-coloured hill that seen through the coast fogs presented almost the appearance of a city on fire. This flame effect was, as I afterwards ascertained, due to sand and dust blowing across its upper ridges.

During the middle of January, 1925, a season fated to be memorable because of the subsequent rains, I last voyaged along the Peruvian coast from Mollendo, departing from the roadstead at noon of the 12th. The 'Santa Elisa' first turned sharply out to sea from the anchorage, then swung parallel with the low cliffs of the strandless shore, and rolled in a broadside swell along her northwesterly course. The landward view was at first relatively uninteresting for the reason that no high mountains could be seen beyond the tops of the monotonous coast hills. But the ocean itself was alive with birds, exhibiting all the diversity of origin that I have so often stressed. An actual tabulation from my notebook of the species seen along the route during this afternoon and the next day yields the following result, which is no more than typical except for the fact that the Sooty Terns represent a new record for this coast:

Native breeding species: Peruvian Penguin; Diving Petrel; Peruvian Storm Petrel (*Oceanodroma tethys*); Guanay, Red-footed, and Bigüá Cormorants; Piquero; Pelican; Kelp, Belcher's, and Gray Gulls; Inca, South American, and Lesser (*Sterna lorata*) Terns.
Breeding grounds unknown: Markham's and Elliot's Petrels.
Migrants from the Andes: Mountain Gull
Migrants from the tropical or sub-tropical Pacific to westward: Sooty Tern.
Migrants from not distant islands, such as Juan Fernández: Pink-footed Shearwater.
Migrants from the Sub-Antarctic or Antarctic: Black-browed and Gray-headed Albatrosses; Giant and Silver-gray Fulmars; Cape Pigeon; Shoemaker (*Procellaria aequinoctialis*); Sooty Shearwater, Wilson's Petrel; Chilean Skua.
Migrants from the Galápagos: Swallow-tailed Gull.
Migrants from North America and the Arctic: Franklin's Gull; jaegers; terns (*Sterna paradisaea* or *hirundo*); phalaropes.

Two hours to northward of Mollendo we sailed through one of the familiar "red seas" of the coast, the organisms responsible for the maroon color being in this instance invisible and distributed in long parallel bands like the stripes of a flag. The land, too, became more interesting and picturesque when we were abreast of the olive-growing gorges through the coast range, such as those of Quilca, Camaná, and Ocoña, the last, opening southward, being shut off by its seaward wall from the rays of the low sun. The late afternoon light was ideal for illuminating the maturely eroded relief of these imposing and dream-like valleys, and their irregularities looked from our distance as smooth and rounded as the convolutions on a brain. The sea offshore, around the steamer, had fallen calm, but close to the far-away beaches we could see, but could not hear, violent winds whipping the water—a phenomenon I had long before learned to associate with the coming of a summer evening on the coast of Peru.

After a night of rolling, the breakfast hour found us off the Río Ica and approaching Doña María Point, a sandy, repellent section of the coast, with low, flat-topped ranges and with puckered rocks sticking up like nunataks through the wastes of sand. By the middle of the morning we had reached lofty Vieja Island, which hides the great basin of Independencia Bay, and here, as part of a huge concentration of bird life, were many Sooty Terns (*Sterna* *fuscata*), unfamiliar visitors to the Peruvian coast, the presence of which at this season doubtless had a special significance which is discussed elsewhere in this book.

Independencia Bay had been a station of my field work during 1919, when I found this vast and lonely harbor to be a place filled with pristine, undisturbed life, and bristling with unsolved problems of natural history. Like most of the few well-sheltered bays of the Peruvian coast, it has extensive sandy beaches along its windward margin, where flamingoes and both native and migrant shore birds flock to feed upon hippas and other denizens of the strand. Multitudes of surface fish, moreover, seem to be forever pouring into the southern inlet of the bay, school after school, only to pass through with the current and to stream back into the Pacific by way of the Trujillana Channel at the northern end. The fish, in turn, lure in hordes of cormorants and boobies from nesting grounds on the conveniently located islands of Santa Rosa. Furthermore, when gusts beat the water of the bay into whitecaps, the transient Sooty Shearwaters and other petrels play and feed by tens or hundreds of thousands over the choppiest areas of the surface.

Of the territory at the windward end of Independencia Bay I had written:

> We landed upon the flood plain which stretches southeastward in the form of a triangle between the hills. Its surface was mostly dry, but thousands of stranded mummified mullets, five or six inches in length, lay on the baked, gritty mud, and bones of seals, porpoises, and whales were scattered everywhere. The larger whales on the flood plain, represented by three or more skulls, several half-buried spinal columns, and numerous ribs and vertebrae, were apparently humpbacks. I could not but wonder as to the agency which had distributed such huge carcasses hundreds of yards behind the present ridge of the beach. Was it accomplished by floods due to high spring tides, by earthquake waves, by the excessive piling up of waters driven before prolonged westerly winds, or by an even more profound cause—such as the sudden uplift of the bottom of the bay due to some rapid change in the unstable coast? (Murphy, 1925, 104).

Such phenomena are but a few of many that indicate violent movements at sea level along the west coast. Perhaps the true explanation of high and dry whale skeletons is indicated by Darwin's (1933, 278) notes upon earthquakes in relation to tides and vibration-waves. At Quiriquina Island, in the bay of Concepción, he found slabs of rock 2 meters in length that had been cast far up the beach by the water in an upheaval of the year 1835. During the same earthquake, moreover, the flow and ebb of the tide had completed its full course in a fraction of the time ordinarily required, resulting in currents of extraordinary strength.

The first port of commercial importance north of Mollendo is Pisco, and toward noon of January 13, 1925, or twenty-four hours after beginning the voyage, the 'Santa Elisa' was approaching the Boquerón, which is the broad passage between Paracas Peninsula and the mountainous uninhabited island of San Gallán, both of which serve to shelter Pisco Bay. San Gallán was topped by mist, as I had known it of old. Such

> vapor is condensed before the moving air comes into actual contact with the peaks, so that the pennons of fog stretch forth in an apparently anomalous manner, namely, directly into the wind. The stiffer the breeze, the longer are these windward weathercocks. The water particles, travelling

with the speed of the column of moving air, are reëvaporated as soon as they pass beyond the summits, so that no leeward streamer forms; but in times of high wind cloud-scraps are sometimes torn away bodily, and whisked off a considerable distance before they are melted by the warm atmosphere of the low strata. The cloudcaps of the peaks are, through continuous condensation and resolution, made up of entirely new bodies of moisture every few moments, but since the form remains the same, they have the appearance of being fixed and motionless. At times when even the high clouds are rapidly crossing the sky, it is curious to note the stationary streamer of San Gallán, which varies only in ratio to the strength of the breeze, and which vanishes only during periods of calm (Murphy, 1925, 145).

The bay of Pisco was on this January morning of a yellow-green color, and in places the water appeared to be crammed with jellyfish. A late morning fog was rising like a theater-curtain, displaying a circle of mountains and islands, the like of which is to be seen nowhere else along the coast of Peru. The Ballestas, perhaps the most enchanting to the eye of all the guano islands, were black with cormorants. At the more distant Chinchas, bird life was beyond the limit of vision, but smoky puffs of guano-dust floating northward told us that great flocks were taking wing. Let us avail ourselves of the privilege of standing on the highest peak of the central Chincha Island for a more comprehensive view of this historic region.

As a lookout, the summit presents a panorama so beautiful that an observer must be stolid indeed if he can resist a feeling of exultation when he beholds it. The two sister isles, especially the lower and more distant North Island, round which a hundred square-riggers used to rock their spars, seem to lie at one's feet like white stars in the blue field of the sea. The western half of the circle of vision is taken up with the ever-varying Pacific, often covered with netted foam-streaks, and by the prevailingly cloud-filled sky in which feather-wisps and mare's-tails form all summer above the Humboldt Current. The off-shore layers of cloud usually hang low in the west to hide the sun just before it nears the horizon and blazes forth again at the end of day. On this side, too, beyond South Island, stand the picturesque twin cones known as La Goleta (The Schooner). To the northeastward one looks toward Tambo de Mora, the Pampas de Noco, and the crests of the cordillera, beyond which still higher crests, of a thinner and colder blue, reveal themselves on the clearest days. In the southeastern quarter lies the bay of Pisco; the mountain-in-the-sea of San Gallán, with its westerly peak always hidden under a mantilla of fog; the Ballestas and Isla Blanca; the red hills of Paracas Peninsula, which all but conceal the deep cove behind them; and the desert south of Pisco, blocked at the southern end by coal-bearing ridges, but stretching inland toward the vine-growing country of the Ica Valley. When the weather is calmest and brightest, the great Indian symbol of the *Tres Cruces*, which is carved on the seaward mountain slope, can be seen with the naked eye from Central Island, although its distance is 11 sea miles. Heightening the charm of land and ocean and atmosphere, is the fact that the circumambient whole vibrates eternally with life. The bay of Pisco is dotted with ruffled or shimmering areas where schools of anchovies or herrings are moving near the surface, the myriads of individual fishes straining out with their gill-rakers the invisible plant life which thickens the water; birds and seals in turn pursue the massing fishes, and oftentimes one can watch from the hilltop small groups of humpback whales which breach and blow, and then point up their flukes for the "long dive." Finally, the white hillsides about one are likely to be darkened by vast, huddled crowds of guanayes, while waving lashes of the same birds are silhouetted against the sky in all directions (Murphy, 1925, 119).

Pisco Bay, particularly the calm inner cove under the shelter of Paracas Peninsula, had proved excellent collecting ground for both Mr. Beck and me, at opposite seasons of previous years. Here, in November, 1919, I found many

North American shore birds, such as the Ring-necked and Black-bellied Plovers, Ruddy Turnstone, Hudsonian Curlew, Spotted Sandpiper, Wandering Tattler, Semipalmated and Western Sandpipers, and Sanderling, all mingling with the resident Oyster-catchers, Snowy Plovers, Skimmers, and Gray Gulls. At the end of June, 1913, Beck encountered not only several of these same visitors but also a good-sized flock of the arctic Surf-bird (*Aphriza virgata*), in company with forty or more Andean Flamingoes and bands of native shags and gulls. In connection with this first discovery of the southern-hemisphere range of the Surf-bird, he writes (1919, 190) of his surprise at finding the species at the edge of mild waters on a protected shore, for his previous experience had led him to associate it only with dashing breakers and cold winds from the open sea.

The first migrant shore birds from the northern hemisphere annually begin to appear at Paita, in northern Peru, about the end of August (Verrill, 1923, 303). It goes without saying that all the Surf-birds and other species that Beck took at Pisco in June, the season of their normal nesting close to the arctic circle, proved to be birds which had not experienced the cyclic enlargement of the gonads incident to migration. They were, indeed, physiological exiles from Alaska or other parts of the northern hemisphere, matched exactly by equally barren shore birds of several other species collected during July by Chapman (1926, 192) in the Gulf of Guayaquil.

During my own field work I had been interested to learn upon what the migrant shore birds feed on the beaches of Peru. I therefore preserved a series of stomachs which were later examined by Dr. W. L. McAtee, of the United States Biological Survey. The Western Sandpiper (*Ereunetes mauri*), which at Pisco was at least ten times as abundant as its relative *E. pusillus*, had subsisted in part upon vegetable matter, especially the seeds of the tassel-grass (*Ruppia maritima*), one of the very few flowering plants of marine waters. Ten out of 18 examples shot on a lagoon south of Pisco contained remains of this pond weed. Other items of their diet included Nereid worms, Sciomyzid fly larvae and pupae, beetles, ostracod and other crustaceans, and gravel.

The Sanderlings (*Calidris leucophaea*) and the Ring-necks (*Charadrius semipalmatus*) had also eaten *Ruppia* seeds, sometimes in quantity. The former species had furthermore picked up isopods and Tenebrionid beetles; the Ring-necks, Nereids, flies, small crabs (*Pachycheles*) and mollusks (*Petricola*). Spotted Sandpipers (*Actitis macularia*) had devoured surprisingly large hippas or sand-bugs (*Emerita analoga*), as well as tiny Chironomid flies and Delphacids; Curlews (*Numenius hudsonicus*) had eaten crabs of four species, small bivalves, and barnacles. The Andean Flamingoes had been satisfying their appetites entirely with hippas, to judge by the well-filled stomach of the single specimen I collected. Independencia and Pisco Bays, and the salt-pits near Huacho, were the three coastal localities at which Beck and I met with Flamingoes.

In the Pisco Bay region, particularly at San Gallán Island, both Beck and I collected a number of Condors, which regularly descend to sea level along desert coasts, although they keep to high altitudes in rainy and forested parts of South America. Throughout my travels I noted that the Condors are much given to soaring just above the brinks of sea cliffs and in the same relative position over seaward ridges of the coastal hills. Examination of a number of stomachs confirmed the supposition that these birds depend largely upon food cast ashore by the sea. The strategic significance of their lines of flight did not occur to me until I came across Grinnell's (1933, 164) recent study of similar behavior on the part of the Turkey Vulture in North America. He finds that the latter bird habitually follows flyways on the western or windward side of successive ridges above the Californian coast. During the portion of the day when the sea breeze blows, the Vultures are seen wheeling up into the wind but at the same time steadily drifting along the axial trend of the ridges. By keeping just above the windward brinks of the latter, the scavengers ride aloft on the rising air-currents with no need for wing-beats. Taking into consideration recent investigations into the sense of smell in vultures, Grinnell concludes that such flyways not only supply the birds with soarable air, but also put them in the best possible place for obtaining olfactory notice of food on the slopes and beaches below them. Upon the receipt of such stimuli, the vultures then seek the food through their scouting flight, the open nature of the ground offering every advantage to their eyes.

The stomachs of my own five Peruvian Condors contained in the aggregate large pebbles, unidentifiable fish remains, bodies of diving petrels (probably obtained at San Gallán), parts of a penguin, the hoof of a pig, fresh eggs of guano birds, small bits of kelp, and the femur, radius and cartilages of a fur seal (*Arctocephalus australis*). The last material represents a rare and almost exterminated mammal, at least within the Humboldt Current region.

In January, 1925, I continued my northward voyage in the 'Santa Elisa' along practically the whole length of the coast of Peru, reaching Callao on the morning of the 14th, Salaverry on the 15th, and Talara, where I disbarked, on the 16th. I forbear, however, to give a running description of the long shore line, chiefly because of the general sameness in the physical aspect of land and water. Furthermore, the numerous groups of islands, which especially concern us as the known breeding places of a large proportion of the oceanic birds of Peru, are listed elsewhere (p. 290, 291). In general, it is the low and utterly bare islands that furnish nesting grounds for the great colonies of economically important guano birds, particularly the Guanay, Pelican, and Peruvian Booby. The high islands, such as San Gallán, and the tiny precipitous islets around many of the guano centers, share the bulk of the nesting population of petrels, gulls, terns, oyster-catchers, and other species of little commercial importance.

One tiny cluster of rocks deserves special mention. This is Hormigas de Afuera, 70 kilometers to westward of Callao, at which, as previously noted, both Beck and the members of the 'Zaca' party unsuccessfully attempted to land. The Hormigas are several times farther from shore than any of the other Peruvian islands, and are among the smallest islets lying beyond the continental shelf in any ocean. They are prevailingly inaccessible because of the swells that surge against them, and are consequently poorly known either as to geology or biota.

Fortunately, both Beck and Chapin have set down observations which indicate that the Hormigas de Afuera group marks the seaward limit in the distribution of Humboldt Current birds. The Peruvian Pelican and a considerable number of other coastal species probably never go so far offshore, but the Piquero (*Sula variegata*), the Guanay (*Phalacrocorax bougainvillii*), and the Inca Tern (*Larosterna inca*) are residents, as is probably the Kelp Gull (*Larus dominicanus*). Small petrels, the nesting grounds of which are yet unknown (for example, *Oceanodroma markhami*) should also be looked for at these islets during midwinter, which is their breeding season.

Beck observed *Oceanodroma hornbyi* and *O. tethys kelsalli* in the surrounding waters, as well as such migrants from admittedly distant breeding grounds as the Galápagos Albatross, petrels of the genus *Pterodroma*, and Wilson's Petrel. Chapin reports Sooty Shearwaters, jaegers, and storm petrels of uncertain identity.

Owing to the physical difficulties, the Peruvian guano administration does not work Hormigas de Afuera. At the date of the visit of the 'Zaca,' all the rocks were white with guano. Boobies were occupying the islets in greatest force, with Inca Terns second, and the Guanays represented by only one or two very small settlements.

San Lorenzo, which forms the windbreak for Callao, is one of the three islands upon which vegetation, in the form of epiphytes near the high crest, can be seen from the ocean. All the low islands of the Peruvian and northern Chilean coasts are quite plantless, except Lobos de Tierra, which is at the verge of the transition zone between the Humboldt Current and tropical water. Even this island is so close to plantlessness that its vegetation is overlooked by most visitors. Johnston (1931, 26) has reported upon the vascular flora of the Peruvian islands, basing his studies upon my own collections.

We can say with confidence that higher plants are present on only four or five of the coastal islands, namely Vieja, San Gallán, San Lorenzo and the associated island of Fronton, and Lobos de Tierra. All but the last-named are high, with vegetation confined to the fog zone. Lobos de Tierra is low, but it lies near the northern end of the cool water and owes its vascular flora of only two species to the occasional visits of equatorial storms. On the mountainous islands, writes Johnston,

> the flora is dependent upon and directly correlated with the clouds that bathe their rarher lofty crests. These fogs, brought about by the cooling of moisture-laden sea-winds which have been upwardly deflected by obstructing headlands or coastal hills, are characteristic features of the littoral of Peru and northern Chile. Forming at between 300 and 400 meters altitude over the islands, and somewhat higher, at about 1000 meters, over the coastal hills on the mainland; they bathe the favored peaks and slopes in wet clouds. On the coastal hills the localized effects of the protection they give from the sun and the moisture brought by them to the soil results in a rather sharply defined zone of lush green vegetation on otherwise barren seaward slopes. This winter and spring fog-correlated vegetation, so conspicuous on the coastal hills of Peru and northern Chile, has been called the Loma Formation. It is one of the most distinctive plant associations in South America. Belonging with it, both ecologically and phytogeographically, are the floras of San Lorenzo, San Gallan and Vieja.

Johnston believes that the new elements in the flora of the high Peruvian islands will also be found on foggy summits of the mainland. While some of these plants have affinities which appear to be Chilean rather than Peruvian, he thinks that they have been discovered first on the islands merely because the headlands of the southern Peruvian coast have not yet been botanized. The 17 species of plants that I found on the summits of San Gallán and Isla Vieja include a polypod fern; three species of grasses; two Bromeliads, one of them the pineapple-like *Tillandsia latifolia* which is so conspicuous in and below the zone of mist on all the Peruvian coastal hills; members of the nettle and goose-foot families; a geranium, a wood sorrel, a mallow, two species of the parsley family; two of the Solanaceae or potato family, one being a new species; and a pink-flowered composite of the genus *Polyachyrus* which is also new.

Lobos de Tierra is unique among all the low islands of the Peruvian coast in that it has what may by courtesy be termed a terrestrial flora. Minute algae cover a few of the higher rocks, and a small fleshy-leaved sea purslane (*Sesuvium Portulacastrum*) grows sparingly along the beaches. This is a sea-dispersed halophyte, widely distributed in tropical America. But the outstanding, almost startling, botanical feature of the island is a thorny mimosa or algarrobo (*Prosopis chilensis*) which stands in a sandy sink not far from the lighthouse. Deriving its water presumably from ocean seepage, this anomalous plant—the single example of a single species—has contrived to eke out a lengthy existence. According to the most venerable of the Indians, its twisted trunk and bent branches, which reach barely a meter above the ground, have had their present appearance as far back as memory and tradition go.

January is high summer on the Humboldt Current, and by the date of my final voyage in 1925 I had coursed up and down the coast of Peru so often that I knew the daily régime by heart, and had no inkling of the amazing and catastrophic weather conditions that were shortly to follow, after a lapse of thirty years and more. Each night the wind blew gently from the landward side of south until the calm of daybreak, after which soft fogs rested upon the unperturbed Pacific. Out of the haze came, from time to time, the bewildered calls of land birds which had inadvertently strayed offshore. Sooty Shearwaters and other sea fowl along the course slapped the water with their wings and plunged frantically in order to put themselves clear of the advancing ship. Flocks of phalaropes leaped up lightly from the foam-streaks, to fly ahead so that they might be overtaken once more. Silvery flotillas of anchovies and pejerreyes, packed almost like sardines in a tin—except that their heads all pointed in one direction instead of alternating—could be seen to good advantage in the still water. Later, when the day wind arose, it was interesting to observe how effectively such great shoals of tiny fishes at the surface broke down wave action, diverting the energy of forward movement into overcoming friction. In the lee of their seething masses there was always a relative calm. And nearly always, as heretofore, I observed that the afternoon half-gales blustered hardest close to shore, piling up a lively surf while, out beyond, the deep waters seemed scarcely stirred.

At the same season the "Painter" was in evidence at some of the ports. The renowned Callao Painter is a sulphuretted emanation from the ocean which stains the white paint of ships, tarnishes silver in houses close to shore, and afflicts the residents with headaches. It has been known from the earliest times along the coast of central and northern Peru, and has very commonly been attributed to submarine volcanic activity, with which, of course, it has nothing to do. It is rather concerned with temperature changes and stagnation in the coastal water, and with the death of vast numbers of organisms which then give off the gases of decomposition. Sometimes the water of the harbors in which the irruption is experienced turns a muddy white, and again the symptoms may be somewhat different. The term "agua enferma" (sick water) is a familiar one among the coastal folk of Peru, and the Painter is but one of its expressions which, when widely distributed by an incursion of the countercurrent from the north and consequent cessation of cool upwelling along the shores, may lead to the ultimate death of great numbers of fishes and birds as well as of the microscopic life.

Allen (1934, 176), who has exhaustively studied the diatom flora of the California coast, considers it possible that certain kinds of these minute plants may be poisonous to animals just as certain land plants are known to be, and that when they are present in great abundance they may interfere with the respiration of some animals by clogging the gills. In southern California the commercial fishermen say that fishing is not good where diatoms are so abundant as to discolor the ocean. Examination of samples of "stinking water" elsewhere, such as fishermen said indicated absence of mackerel, has shown a preponderance of phytoplankton over zoöplankton. Since it is known that certain kinds of dinoflagellates (other phytoplankton often occurring with diatoms) sometimes cause great destruction of inshore forms of animal life, it is reasonable to suppose that diatoms may also become deterrent or deleterious under certain circumstances.

Professor George Sheppard (MS) has reported upon similar conditions in the ocean water off the coast of Ecuador, between the headland of Santa Elena and Esmeraldas, during the month of February. He writes:

> The normal blue and clear waters of the ocean along the littoral zone have been replaced by turbid, yellowish brown lenses of water which emit a most disagreeable and foetid odor suggesting stagnant swamp conditions. These discolored patches, which occur not only along the shore line but have been reported in the steamship lanes from Panama southwards, indicate that they have been possibly induced by the equatorial current from the north, El Niño, which is in evidence at this time of the year.
>
> An examination of the discolored water under the microscope has revealed the fact that it is full of plankton material, the greater part consisting of spores of some marine alga, and there is no suggestion of mud or other detritus of a sedimentary nature. The idea has been put forward that the normal plankton of the Humboldt current has succumbed owing to the higher temperature of the equatorial current; on the other hand it is possible that the sudden increase in temperature of these waters, caused by the influx of the warm waters from the north, may have been responsible for an abnormal fructification of the larger marine algae with a consequent dissemination of spores in sufficient numbers to discolor the water.

Despite my previous emphasis upon the uniformity of climate and life along the coast of Peru, there are, of course, new signs and symbols as one approaches the critical zone in the north, where Humboldt Current meets tropical water and where desert begins to give way to land that knows a rainy season. At the islands of Lobos de Afuera and Lobos de Tierra, for example, the rock exposures show a curious glazing so that they glisten in the sun. This glasslike coating, which is so thick as to round off the points and edges of good-sized outcrops and loose stones, is composed of a whitish deposit of some exceedingly hard substance. Similar glazing is familiar in many continental deserts and upon certain islands such as St. Paul Rocks in the tropical Atlantic, and Barrington Island of the Galápagos. It seems to be due in part to the action of moisture upon guano, and for this reason it is lacking at the Peruvian islands south of Lobos de Afuera. Aridity is the foremost climatic characteristic of islands in the Humboldt Current, and most of them are absolutely rainless; but the two Lobos, which are not far from the belt of humid tropics, are at rare intervals subject to precipitation.

Furthermore, although Pacasmayo lies close to one of the barest desert sections of the entire Peruvian seaboard, I found that the thickets in the neighboring dry valley of the Río Jequetepeque rang with the songs of tropical land birds that I had not heard in the green bottom lands of more southerly rivers. The nearness of the equatorial savannahs was further indicated by the presence of a great variety of Iguanid and other lizards unknown in the central part of the coast. The transition zone was impressed upon me with particular force when I visired the mouth of the Río Chira, close to Point Pariñas, in January, 1925.

The Chira comes down behind the Amotape Mountains, turns westward at the southern end of the range, and weaves a broad green ribbon through the desert. Upstream, fine haciendas draw upon its muddy waters; nearer the mouth the banks are swamp and jungle, bordered in places by groves of large and evenly spaced algaroba trees which spread back across the flood plain to the edge of the valley.

When the river approaches the sand dunes of the shore, it breaks into streamlets like the veins of a leaf. Each little capillary shoals rapidly, seeming to climb with effort over the crest of the beach before it tumbles down a pebbled sluiceway into the surf of the Pacific.

A feeble rivulet is the Chira in the eyes of the horseman who crosses its bubbling outlets without a thought of danger. Yet it is, after all, more mighty in effect than many a prouder stream. The only through-flowing river in the northerly Peruvian deserr, it supports the agriculture of a populous and historic valley, while its trickling waters give to the ocean mysterious nutriment which enables marine life about its mouth to develop with a richness noteworthy even in the richest of seas. It is as though the river were a gland in the physiological make-up of the coastal Pacific; all the teeming chemicals and foodstuffs of the ocean avail nothing until life is quickened by enzymes from the water of soil and melted snows.

We reached the Chira . . . on the morning of January 24. . . . Near the northern mouth . . . bands of naked Indians were hauling their seines in pockets of the beach. A hundred yards upstream we met others carrying casting nets along the banks and upon the exposed bars—splendid, bronze, broad-chested men from Vichayal or sunny Colán, going about their business with all the incurious dignity which seems to be characteristic of primitive toilers. The fish that they were taking, in the terminal pools of the river, were of such salt-water sorts as flounders and mullets, and the explanation of their presence in the fresh water came unasked, for of a sudden the Pacific breathed a deeper, ninth-wave swell, and a seething layer of brine slid up against the outgoing stream, over the wave-built barrier, and on and on until it disappeared among reedy channels. Forty minutes later a second wave followed the first, and the line of demarcation between river and ocean was soon lost. Such tiny tidal bores had but a four-inch front, but they were, none the less, expressions of a movement which goes around the world.

On the sand bars of the Chira, or floating upon the surface of the diffuse streams among which we slopped, was an assemblage of birds the sight of which paid well for the exertions of the journey. Brown pelicans, the identical species of Florida shores, were packed shoulder to shoulder near the middle of little islands, while black cormorants, with wings spread to the morning sun, stood in single rows along the river's brim. Both pelicans and cormorants were evidently resting, perchance waiting for the tide to lure new schools of mullets into the estuary. A stone's throw across a branch of the river were a hundred or more egrets, with plumes at the peak of luxury, and near by, partly mingling with them, half their number of roseate spoonbills. As we walked over a steep-shored rise of the bank, we came upon four of the latter exquisitely colored waders feeding at the margin of the shallow water only a few paces away. Our presence caused no interruption in the snapping of their double spades, and we watched, spellbound. . . .

On flats beyond the egrets and their rosy companions we saw clusters of wood ibises, many standing with legs in a figure four. Upstream, against a background of green vegetation, were more of these great white, black-headed, black-legged creatures which, despite the inconsequential fact that they are storks rather than true ibises, can hardly fail to conjure up an image of what the Nile ought to be like. When a flock in Indian file flew close overhead with stately wingbeats, it created in my imagination the latest of many resemblances between the old empires of the Incas and the Pharaohs.

For a time the striking and somewhat unfamiliar marsh fowl absorbed us to the exclusion of other observations, but as soon as we were in a mood to make a complete census of the visible bird life, it was quickly impressed upon me that the mouth of the little river beside which we stood was near the corner post of four great realms of life—two of the land and two of the sea. Over the Pacific, in plain view, were groups of various guano birds, which go northward but a few miles beyond the Chira, and which are attracted by banquets due in part to precious compounds poured out of its horn of plenty. Among these sea birds was the huge pelican of the Humboldt Current, which here meets the West Indian pelican at the southern limit of its range, but which, unlike the latter, clings exclusively to the salt sea. Here, too, the Peruvian and the blue-footed gannets, birds which mingle throughout a broader belt of latitude than the pelicans, were in the air together.

Spotted sandpipers, an osprey, laughing gulls, and royal terns from North America; tropical man-o'-war birds, the range of which is one with that of the brown pelican; both the black and the turkey vulture; a condor soaring over the yellow upland beyond the vegetation of the river valley; kelp gulls flying in from the Pacific and up the Chira on their maraudings—all these, and more, we could see by merely turning on our heels. Years before I had found the nests of the kelp gulls in the snow, beside the bleak borders of antarctic glaciers. How strange it now was to watch one of the oceanic freebooters alight beside a wraithlike egret on the mud of an equatorial river!

The contrasts might be continued, for scarcely less startling was the meeting of brown pelican with Andean condor, or that of Peruvian booby with roseate spoonbill. Nor did the birds which we saw complete the picture entirely, for up the valley of the Chira, so near that we might almost have heard the songs and bell-like calls, we knew that the musical *chalala* or ovenbird (*Furnarius*) was building its adobe nest in the great algarobas, and that parakeets, woodhewers, and green and azure jays came down in thickets of the river border that led back through mountain passes and, ultimately, to forests of the Amazon. Here we were as close as one can come to the magical contact of desert and jungle, to the junction of the warm ocean water with the cold (Murphy, 1925, 436).

Forty or more such oases mark the passage of rivers across the Peruvian coastal desert. Most of the streams have but a feeble flow as they approach the shore, and several never reach the ocean because of the high evaporation and the quantity of water drawn off for irrigation. The freshet period is the invierno of the sierra, that is, the hot season of the coast. Waters swelling in the beds between November and March announce the annual rise and the traditional beginning of agricultural activity; by June or July the rivers have waned again and the dead season reigns.

The importance of the rivers from our special point of view has to do with their enrichment of the ocean by supplying nutritional material. There is abundant evidence that the high sea is not strongly productive of plankton. Along most continental coasts the richest waters are certainly within 50 to 100 kilometers of the shore, and there is much to be said for the hypothesis that the abundance of plankton in the coastal water—and which from there may spread far out to sea—is first of all dependent upon a permanent supply of certain nutritive substances from the land. Flood years are, therefore, in many places especially favorable to the production of plankton, which we may regard as synonymous with bird-food.

The truth of these assumptions is strikingly illustrated by the collections of the yacht 'Ohio' during January and February, 1924, between Lower California and Callao, and including the Galápagos district. In only one section, namely between the Gulf of Guayaquil and latitude 8° S. in the Humboldt Current, did the combined catches of diatoms and dinoflagellates reach one hundred thousand cells per liter of sea water. As a matter of fact, only 29 out of a total of 148 catches during the entire cruise showed a combined total as high as 1000 diatoms and dinoflagellates per liter; in the Galápagos section no haul showed more than 286 of these organisms per liter (Allen, 1925, 24).

Allen goes on to report that the richest catches during the southbound trip, numbering close to 200,000 cells per liter, were made off the mouth of the Río Chira. The whole series of results indicates that regions near shore are more productive than those offshore, and that the high productivity of the Humboldt Current is augmented by sediments from the land. The Galápagos region is very evidently not highly productive of diatoms throughout the year. Probably the irregularities of the ocean floor off the Peruvian coast aid in the "formation of seed beds and reservoirs of decomposition products equivalent to organic fertilizers on land."

The large catches in the Guayaquil section of the cruise were made on January 20 and 21. It is very significant, Allen concludes, that ten days later catches in these same waters were enormously reduced, the surface temperatures, incidentally, showing an increase of from 3° to 5° C. over those at the time of the earlier hauls. This makes it permissible to suppose that the Countercurrent, El Niño, had come into operation in the interim, with an injurious effect upon the unicellular flora.

Between the Río Chira and the Río Tumbez lies a coast more than 200 kilometers in length in which not even the smallest stream enters the sea. The adjacent ocean is therefore relatively free from silt; limestone is produced quite close to land, and the few waterworn beach pebbles to be seen have all been brought by the slow process of wave transportation from the southward. In normal years there is no available source of pebbles near at hand, despite their abundance on the neighboring tablazo which was once under the sea. During the rare flood periods, however, both the Chira and the Piura sweep down a great supply of such stones.

Bosworth (1922, 275), from whom the above information is taken, states that during the century preceding the date of his work there had been only three wet weasons to set the rivers of the northern Peruvian desert pouring into the Pacific, and that footprints made on the floors of some of the valleys a quarter of a century earlier were still intact! He also reports that the well-defined cycle of advance and retreat of the sea, with reference to the land, is probably still in operation, despite the fact that the movement has been imperceptible within the centuries of human record. He concludes that not one ten-thousandth part of Quarternary history can have taken place in this region within the last five hundred years. Since the orographic and meteorological complex responsible for what we call Humboldt Current phenomena doubtless dates back at least to the middle Tertiary, we have here a clue to the ample time that has been available for the evolution and firm establishment of the peculiar biota and the uniform, delicately balanced ecological conditions which I have briefly reviewed.

By great good fortune, my visit to northern Peru at the beginning of 1925 coincided not only with the first rainy season for 34 years, but also with what there is evidence to believe was the wettest period during at least six centuries (Murphy, 1926, 260). Here, as related in the earlier account of the field work (p. 28), I was close to the final landmark of the Humboldt Current on the coast, where Point Pariñas, the Verdun of sea-lions and other cold-water creatures that range up from the south, displays a sign which reads, "Ils ne passeront pas." Following is a record from my own notes of the extraordinary events of 1925.

In early January the weather and the ocean along the coast of Peru had all the characteristics which an experienced seafarer would have expected. Sunshine, wind and water, clouds and temperature, all were seasonable; all, indeed, were probably very much as they have been during the greater part of time which has no record in human history and which goes back ages before the Spaniards or the builders of Pachacamac.

The breezes came steadily, sometimes briskly, from the southward, and thick mists veiled the windward headlands of high islands. The cool waters of the Humboldt Current rolled along their wonted, leisurely course toward the Line. The Pacific was here and there reddened by acres of living jelly, or streaked with a Milky Way of swimming crablets perhaps no less numerous than the stars. And the unbelievable flocks of guano birds, always the same yet never monotonous, spread out over the coastal ocean and gorged upon its harvest. For five days I skirted the long shore from Mollendo to Point Pariñas, while every sign held. If the Inca Sun God had walked as a cosmic watchman along the wall of the cordillera, he would have cried each hour, "All's well"!

On January 17, when we began our marine work at Talara, six miles north of Point Pariñas, the weather was only slightly less equable. Here there had been experienced during the preceding week brief spells of northeasterly winds, with uncomfortable increases in heat and humidity; but so near the equator such vagaries are not considered remarkable at the New Year season. At any rate, when we first put out to sea, the environment was in all respects substantially normal for the month and the latitude. Southerly winds, with the usual diurnal swing and cycle of velocities, still prevailed; the ocean waters along the northerly border of the Humboldt Current were of temperatures close to 65° F., with higher ranges offshore; and all the species of guano birds, except the Peruvian pelican, had worked northward to Point Pariñas, the westernmost projection of the continent, or had rounded this frontier mark to feed along the coast toward Cape Blanco. Except for the abundance of man-o'-war birds, the bird life off Talara was, in fact, not very different from what one would encounter south of the Lobos Islands.

By January 19, familiar weather conditions had altered more definitely; the wind was blowing from the west, and the cessation of upwelling of water from deeper and cooler layers of the ocean, together with the inward drift of warm water from offshore, were reflected in higher surface temperatures, which averaged above 72° F. throughout a wide expanse off Talara and the coast to northward. A great flock of guanayes, or Peruvian white-breasted cormorants, guano birds peculiar to the cool waters of the Humboldt Current, and which are, indeed, a visual index of its extent, was observed off Point Pariñas, where large numbers of the birds spent the night on the rocky shore. With the advent of unfavorable circumstances, however, they all moved off to southward on the morning of January 20, and, except for a few individuals, some of which were sick, no more appeared in these latitudes through the winter. The reactions of the guanayes were doubtless more delicate than any human premonitions. Their departure, as we later realized, coincided with the beginning of a change of such magnitude that it occurs but once in a generation, a change which endured from that date until the end of May, and which had a profound, even though temporary, effect upon the whole climatic character of the Peruvian seaboard.

By this time it was evident to local mariners and fishermen that El Niño was flowing—El Niño, "The Child," even though Christmas was nearly a month behind us—El Niño, the warm current from the north, which rarely keeps its seasonal appointment precisely, but which may come at any time between December and April, and occasionally at other periods of the year. Its arrival is usually associated with northerly winds, and when it has raised the temperature of the surface waters until they are warmer than the air, rain is likely to follow along the desert coast. Moreover, its warmth brings sickness and death to the population of the Humboldt Current, beginning with the annihilation of vast numbers of microscopic organisms which cannot endure the rapid heating of the sea, and culminating in the destruction of such guano birds as fail to retreat to safer regions down the coast.

On January 20 the fickle winds were back in a southerly quarter, but the prodigious oceanic movement which had set in was not to be stemmed by any transitory counter breeze. El Niño was running southward past Cape Blanco, past Point Pariñas, and the temperatures of the ocean for a distance of twelve miles from shore averaged above 76° F. Now we encountered the first flying fish, which are always common in the outlying tropical waters but which are rarely or never seen close along the Peruvian coast while the Humboldt Current prevails. On the same day, too, the hammer-head sharks appeared in exceptional abundance. Five miles from the beach we entered a zone which seemed to be filled with them, for thousands upon thousands crossed our course. Their line of march was perhaps two miles broad and of indefinite length, for we cut through it at widely separated points when outward bound and upon our return to port. Scores of fins were visible at a glance, the whole legion moving down the wind, or against the current, the fishes paying little attention to the launch until it was upon them. Finally, on this same afternoon, we met with sea birds from the more northerly ocean—species rare in these waters or even, so far as the records go, new to the Peruvian coast.

On January 21 we put our scales upon El Niño. At noon we anchored the 86-foot launch "Chiralite," courteously supplied by the International Petroleum Company, in nine fathoms of water a mile west of Point Pariñas, well clear of any coastal influence upon the oceanic circulation. A fresh breeze from west of south covered the Pacific with whitecaps. To our surprise the vessel immediately began to swing about before the strong current from the north, and within a few minutes she was resting with her stern directly against the wind. At the same moment we noticed a group of laughing gulls sitting on the water offshore, and, as we watched them, they too drifted southward into the breeze. It seemed remarkable that the current should have more power than the wind upon the light-bodied birds.

As soon as our craft had steadied to thirty fathoms of cable, we put into operation the current-recording log line, and made ten readings during the course of an hour, which showed a southward flow of the water ranging in rate between one and one and one-quarter knots. Following these measurements, we weighed anchor and headed due westward to a position nineteen miles from the Point. The southerly wind increased slightly in strength during the afternoon, but by the bearing of Pariñas Light we were able to determine that the launch was being deflected to southward by a current approximately the force of that at the anchorage. The same procedure was followed and the same effects observed on the return trip, and the continuous records of more than ten hours prevented the confusion of possible tidal movements with those of a demonstration of El Niño. The action of the wind, whatever it may have been, was obviously against that of the current.

How can I picture the dramatic accompaniments of such a great reversal of generally stable oceanic conditions as we so fortunately witnessed off the oil fields of Pariñas? The first, amazing enough to one who has been afloat for weeks at a time in the phenomenally cool and little-varying waters which bathe the sunburnt shores of Peru, was the rise in ocean temperature, amounting to an increase of 10° F. within forty-eight hours, and a subsequent rise of at least six degrees more which endured throughout the remainder of the winter. No less remarkable, particularly in central and southern Peru, was the replacement of the reliable southerly winds, upon which seafarers have banked from immemorial time, by fitful and yet recurrent rain-bearing winds from the north. And finally, most impressive of all, were the changes in the oceanic life which no naturalist could overlook—the immigrating cohorts of hammer-heads, the jumping mantas or giant rays, the schools of large flying fish pursued by equally alien tropical dolphins, and the presence far down the coast of such novel birds as migrant laughing gulls and royal terns from North America, and of Ecuadorean white boobies and tropic birds from the island of La Plata.

From the middle of January gossip at the Talara club house related chiefly to the weather. The counter-current was scarcely above the commonplace, for El Niño was expected to make at least a brief visit almost every year. But the breathless days, and the gathering of clouds, dark as volcanic smoke, above the Amotape Mountains, turned back men's thoughts to greater rhythms of time. Engineers who had been long in the petroleum service spoke vaguely of the wet, seventh year. Weather-beaten skippers and port masters, who had spent most of their lives on the West Coast, turned back their memories still farther, and talked about the season of 1891—of deluges, lightning and thunder, and other impossible things, of the washing away of buildings and oil derricks, of the cutting out of new rivers, and of the *año de abundancia* which followed, when cotton crops were grown on the bare desert.

The first spatter of rain at Talara occurred on the evening of January 19, after the wind had switched to east of north, parallel with the main trend of the coast line from the Gulf of Guayaquil. For a week it had been raining in the Amotapes, fifteen miles inland, and the pall of stormy clouds had worked down the Pariñas and Máncora valleys toward the sea. The upper trails were already flooded, and by January 25 water had reached the Pacific through *quebradas*, blocking the road between Talara and Lobitos, and limiting transportation to the sea route.

What followed is now history. The real rains began at Talara about daybreak of January 27, before a northerly wind, the fall continuing until nearly noon, and then resuming at sunset. The baked soil became a horrible, gluey mess, and large ponds rapidly accumulated. Then, southward along the flat shores and the arid slopes of the Andes, the precipitation followed in the wake of El Niño to unheard-of latitudes, until cities and haciendas which are content with their normal abundance of river water became glutted and laid waste with the excess. The mountain railroads were swept into the gullies, and the bridges carried away. Ocean temperatures rose to 79° F. at Mollendo, and to 70° F. at Antofagasta. The Indian fishermen found their livelihood gone. Dead fish, mingled with untold numbers of birds, strewed the tide lines for hundreds of miles as the ocean turned sour, and thirty-five thousand tons of new guano were washed from the islands by falling water. The northern coves became choked with flotsam from engorged stream beds, and sea snakes, alligators, and strange lizards were cast upon unfamiliar strands. Mullets came out of the ocean to swim about in the squares and roadways of the petroleum towns, and, when the rains began to diminish, mosquitoes, and the *caballitos del diablo* or dragon flies which prey upon them, were engendered in such swarms as had never been known.

All this, however, is ahead of my story. What I saw of the great rains and their results was reserved for a second visit to northern Peru, in March. When we sailed from Talara in the "Silver Spray" on the evening of January 27, rain was falling, and all night it pattered on the shelter above the afterdeck. But next morning we knew that the deluge had not quite come, for the sky over the Pacific was clearing, and a sunrise of pure gold was breaking above a gray cloud bank beyond the northern Amotapes (Murphy, 1925, 431).

a. Guano.

In popular understanding the history of guano and its use has become somewhat distorted. Its place in antiquity among the Peruvian Indians is generally known, for specific record of this is contained in the Royal Commentaries of the Inca, Garcilasso de la Vega, which were first published at Lisbon in 1609. Thereafter, however, the properties of guano are sometimes alleged to have been overlooked or forgotten by the conquerors of Peru and northern Chile until Alexander von Humboldt advertised the substance anew in the first half of the nineteenth century, and led to its introduction as fertilizer into Europe.

That this opinion is far from the truth is shown by a large number of references in the literature, dating back at least to the year 1716, when the original French edition of Frezier's 'Voyage to the South Seas' was published. The following quotations are from the first English translation of this work, which appeared in 1717:

> The island of *Iquique* is also inhabited by *Indians* and Blacks who are there employ'd to gather *Guana*, being a yellowish Earth thought to be the Dung of Birds, because besides that it stinks like that of the Cormorants, there have been Feathers of Birds found very deep in it: However it is hard to conceive, how so great a Quantity of it could be gather'd there; for during the Space of a hundred Years past, they have laden ten or twelve Ships every Year with it, to manure the Land, as shall be observ'd lower; and it is scarce perceivable that the Height of the Island is abated, tho' it is not above three Quarters of a League in Compass; and that besides what is carry'd away by Sea, they load abundance of Mules with it for the Vines and plow'd Lands of *Tarapaca*, *Pica*, and other Neighboring Places; which makes some believe, that it is a peculiar Sort of Earth; For my part, I am not of that Opinion; for it is true, the Sea Fowls are there so very numerous, that it may be said without romancing, that the Air is sometimes darken'd with them. In the Bay of *Arica*, infinite Multitudes of them are seen, rendezvousing every Morning about ten o'Clock, and every Evening about six, to take the Fish which at that time comes up to the Surface of the Water, where they make a Sort of regular Fishery (147).

Later (152), when referring to the great trade in "Guinea pepper," grown in the valleys of Arica, Sama, Locumba, and "others ten Leagues about," Frezier adds:

> Considering the Smallness of the Place, it is hard to believe that such vast Quantities should go from them; for, excepting the Vales, the Country is every where so parch'd up, that there is no green to be seen. This Wonder is produced by means of that Bird's Dung, which, as was said before, is brought from Iquique, and fertilizes the Earth in such Manner, that it yields 4 or 500 for one, of all Sorts of Grain, Wheat, *Indian* Corn, etc. but particularly the *Agi*, or *Guinea* Pepper, when they know how to manage it right.

In 1748 Juan and de Ulloa, writing of conditions in the central part of the Peruvian coast, answered Frezier's doubts as to why the guano seemed to be inexhaustible. They write (English edition, 1760, 2, 98):

> The lands in the jurisdiction of Chancay, like the other parts of the coasts of Peru, are manured with a dung of certain sea birds, which abound here in a very extraordinary manner. These they call Guanoes, and the dung Guano, the Indian name for excrement in general. These birds, after spending the whole day in catching their food in the sea, repair at night to rest on the islands

near the coast, and their number being so great as entirely to cover the ground, they leave a proportionable quantity of excrement or dung. This is dried by the heat of the sun into a crust, and is daily increasing, so that notwithstanding great quantities are taken away, it is never exhausted. Some will have this Guano to be only earth endowed with the quality of raising a ferment in the soil with which it is mixed. This opinion is founded on the prodigious quantities carried off from those islands, and on the experiment made by digging or boring, by which the appearance at a certain depth, was the same as at the superficies; whence it is concluded, that the earth is naturally endowed with the heating quality of dung or Guano. This would seem less improbable, did not both its appearance and smell prove it to be the excrement in question. I was in these islands when several barks came to load with it; when the insupportable smell left me no room to doubt of the nature of their cargo. I do not however pretend to deny, but that it may be mixed with earth, or that the most superficial part of the earth does not contract the like Virtue, so as to produce the same effect. But however it be, this is the manure used in the fields sowed with maize, and with proper waterings is found greatly to fertilize the soil, a little of it being put close to every stem, and immediately watered. It is also of use in fields of other grain, except wheat and barley, and, consequently, prodigious quantities of it yearly used in agriculture.

A hundred years after Frezier's account, an American, Captain Amasa Delano (1817, 483), in notes covering the year 1804, mentions the Chincha Islands, which he calls the "Tinkers," and states that they afford bird manure which had become a leading article of trade all along the coast of Peru. He estimates the total tonnage of vessels employed in the traffic during that year at from seven to eight thousand, and states that they were mostly brigs of less than two hundred tons' burden. After loading at the Chincha or other islands, he goes on, they carry the product to the best market, where it ordinarily sells for upwards of a dollar a bushel. He had seen eight or ten vessels loading at one time, and he fully describes the current process of exploitation. He was also acquainted with the fact that for most soil guano is the best known manure, and that the profits to the owners of a vessel in the trade sometimes amounted to $10,000 from a single trip.

As early as 1825, Stevenson (1, 357) made the following excellent report on guano operations at the Chincha and Ballestas Islands, accompanied by the first indisputable description of the cormorant (*Phalacrocorax bougainvillii*) which is the principal producer:

Some small islands at the entrance to the bay of Pisco are famous for the manure which they produce, and which is embarked and carried to different parts of the coast, and often into the interior on the backs of mules and llamas. The quantity of this manure is enormous, and its qualities are truly astonishing; of this I shall have occasion to speak when treating of the cultivation of maize at Chancay. Several small vessels are constantly employed to carry it off; some of the cuts, where embarkation is convenient, are from forty to fifty feet deep, and their bottom is yet considerably above the level of the sea.

This valuable production appears to be the excrement of sea birds, immense numbers of which frequent and breed on the islands; and the accumulation is doubtless owing to the total absence of rain. It is of a pale brown colour when dry, and easily reducible to powder; when fresh it has rather a reddish appearance; the surface stratum for a foot deep is whitish, and contains feathers, bones of birds, and shells of eggs. It is asserted, that the huano, the name by which this production is known, is certainly fossil earth; but the quality of the upper stratum, which although at first white, gradually inclines to yellow, being incontestibly the excrement of birds, and equal to the other, the subject seems to demand a stricter scrutiny.

A species of birds frequenting these islands in great abundance is called huanay; hence the original name of the matter now used as manure. The bird is of black plumage, is as large as the seagull, and breeds during the whole year, with this peculiarity, that each nest, being only a hole in the huano, contains a fledged bird, an unfledged one, and one egg; whence it appears, that there is a constant succession . . . . The indians take many of the young birds, salt them, and consider them a great delicacy; however they have a strong fishy taste.

A few years later, Captain Benjamin Morrell (1832, 121) referred to the guano of Lobos de Tierra, and alleged that the island would yield enough of the richest manure in the world to load a thousand ships. Despite the fact that guano from this northerly region was never the equal of the Chincha product, the statement was a modest one for this redoubtable and justly maligned seafarer.

Guano is said to have been introduced into the United States as early as 1825, but the first importations received no extensive recognition and were soon forgotten.

In 1840, twenty barrels were received in England. But notwithstanding the astonishing results from its application to the soil, the fear that the enormous crops realized under its stimulus might exhaust the land of its productive elements, deterred the great body of the farmers from availing themselves of so valuable a fertilizer. Repeated experiments, however, at length convinced the most sceptical of the error of this prejudice, and at the same time that the new commodity was the safest, cheapest, and most potent of known manures. Its consumption now became general, and the guano trade expanded rapidly into a vast commercial and industrial interest (R. S. F., 1859, 181).

From Great Britain the fame of the substance quickly spread to the United States. In 1848, 869 tons were imported; in 1849, 21,243 tons. By 1853 the annual importations through North American ports had risen to the neighborhood of 200,000 tons per year. The West Indies, and the French island colonies in the Indian Ocean, also rapidly became large consumers. An official Peruvian survey of 1847 had ascertained that there were more than 23,000,000 tons of guano on an unstated number of islands along the central part of the country's coast. This was estimated to be sufficient to supply the world for a period of 170 years, the chief fallacy here being the usual one, involved in the phrase "at the present rate of consumption." In 1853, 8,600,000 tons were computed to remain upon the already partly impoverished Chincha Islands. Four years later, guano sales were bringing into the treasury of the Republic of Peru the sum of $5,296,952 out of a total public revenue of about $8,500,000. The beginnings of exportation may be dated at 1840; the exhaustion of the ancient accumulations, so far as a world market was concerned, occurred in 1874.

At the time of the first introduction of guano to the Old World and North America, it was popularly supposed to exist only along the west coast of South America. Its value stimulated search, however, and deposits of a more or less similar character, though lesser quantity, were found in Patagonia, in the Caribbean Sea, and on islets off the arid western coast of southern Africa. A general and none too responsible exploratory scramble spread, in fact, among seafarers throughout the world, and guano beds, most of which subsequently proved to be nearly worthless, were reported from numberless islands scattered throughout the South Seas.

Along the coast of Patagonia, guano-loading by British vessels began very soon after 1840. The richest deposits were on the Penguin Islands off Puerto

Deseado, but many other islets, as far north as the Río Negro, were examined and scraped clean. The traffic continued at least until 1885. St.-Johnston (1920, 51) notes that as far back as 1851, guano of New Island, in the Falklands, was being exported under Government license. Because of the abundant moisture in this region, such guano, although doubtless rich in phosphates, must have been deficient in nitrogen in the form of ammonium oxalate and urate, which is the most valuable and essential element in Peruvian guano.

Von Tschudi (1846, 1, 327) estimated the average depth of the guano layers on the Peruvian islands at about 13 meters. In 1853, however, a Peruvian commission of which the naturalist Raimondi was a member, found by borings and triangulation that the greatest depth at the north Chincha island was not less than 55 meters (Castañón *et alia*, 1928, 187).

According to Hutchinson (1873, **2**, 128), 433 vessels loaded at the Chinchas during 1860. This is approximately the date of the photographs made by Captain Charles S. Merriman, of Brunswick, Maine, which accompany this text. When, after the exhaustion of the Chinchas, Hutchinson visited the Guañape Islands in November, 1872, about fifty vessels were loading and nearly a million tons had been removed during the preceding three years. Operations at the Macabí Islets, farther north, had begun, he states, in September, 1870. The subsequent history was one of a rapid opening up and depletion of all the other ancient supplies of guano without any attempt at planning, at least until four decades later, toward converting the exploitation into a permanent industry through conservation of the producing birds and control of the periodical extraction.

The presence of guano upon the Peruvian islands in glacier-like accumulations, which had reached the maximum thickness possible under the laws of physics, and its perfectly conserved richness in essential organic compounds, were both dependent upon the rainlessness of the region. Even moderate precipitation would have washed the ancient beds into the sea as rapidly as they formed and would, moreover, have brought about a chemical reduction of the nitrates, permitting loss of the chief virtue of guano through evaporation.

Guano owes its value to the peculiar manner in which its components are united, by the alchemy of the bird's intestinal tract, into a compound more easily absorbed by plants from the soil to which it is applied than any fertilizer synthetically composed. To put the matter as simply and forcibly as possible, it may be said that, if the value of fertilizer be calculated according to nitrogen content, the best Peruvian guano is more than thirty-three times as effective as farmyard manure (Murphy, 1925, 51).

It is not my purpose to present an exhaustive treatise upon this most precious of fertilizers, but rather to indicate, as I have already done, its continuous use in Peru from prehistoric times up to the present; to emphasize the vast quantity of this substance, derived entirely from fish and other marine organisms and laid down during countless thousands of years upon the arid islands of the Humboldt Current; to indicate the order of rank among the more important producing sea birds; to refer in passing to the modern efficient and scientific administration of the guano industry in Peru; and to point out certain sources

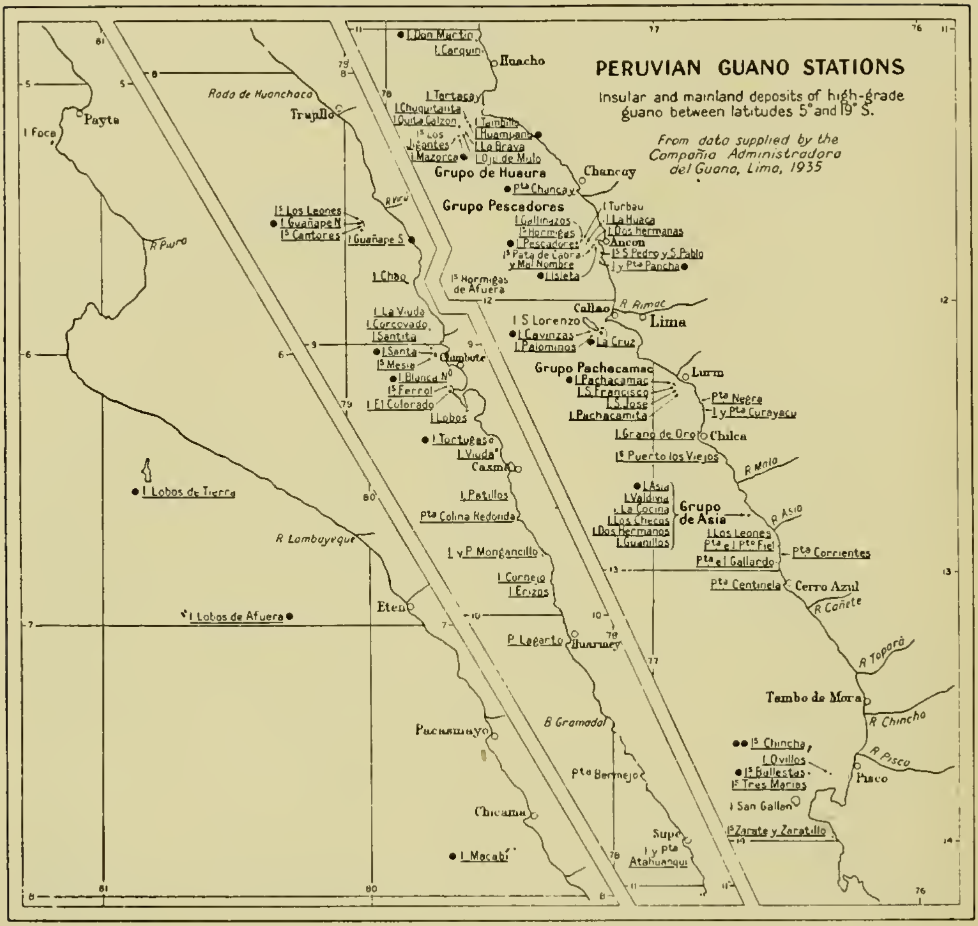


Fig. 42a.

of information relating to the whole subject, the definitive history of which yet remains to be written.

Von Tschudi made one of the first critical examinations of the supplies of guano and their distribution in Peru and Chile. He pointed out earlier exaggerations regarding the thickness of the layers, and argued that since the more important guano birds cling to the sea, and do not form colonies upon the coastal headlands, the deposits upon some of the latter must hark back to a time when the sites had been insular instead of part of the mainland. In view of the fact that many existing species of shells are found on this coast in strata now far above sea level, such a hypothesis is not necessarily fantastic. Von Tschudi credited the guano accumulations mainly to boobies, gulls, diving petrels, and skimmers, giving first place to the Peruvian Booby (*Sula variegata*). Curiously, he failed to recognize the peerless position of the Guanay, or Cormorant, and he misidentified certain other species.

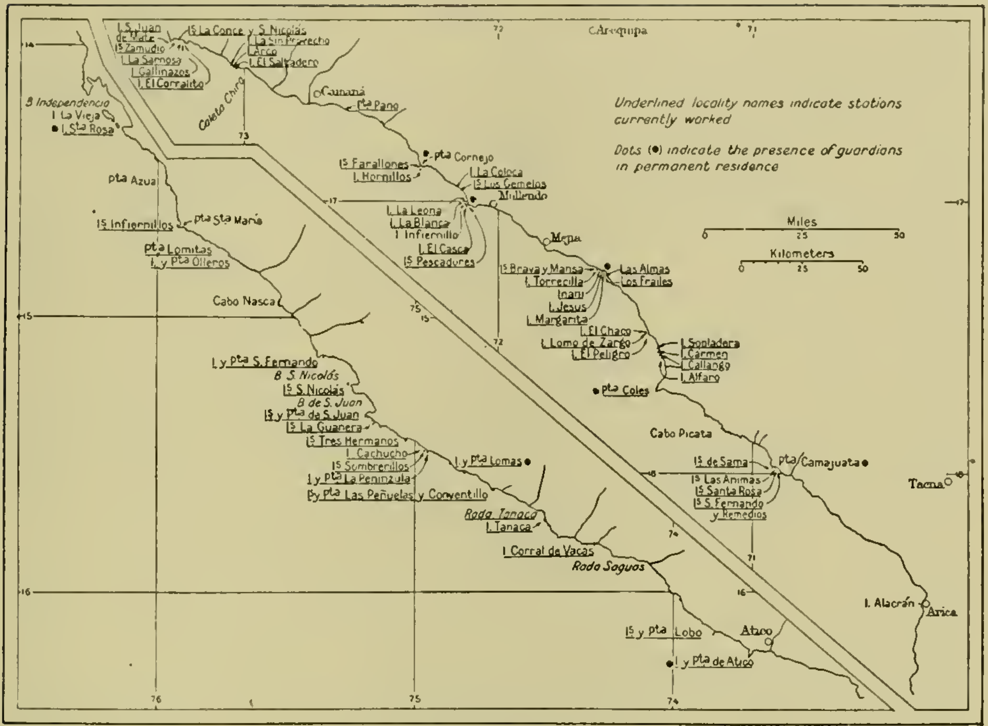


FIG. 42b.

Raimondi (1856, 735) made a special study of the place of the various birds in production, though he, like von Tschudi, persistently mistook the Black Cormorant (*Phalacrocorax olivaceus*) for a snake-bird (*Anhinga*), no form of which occurs on the Peruvian coast, unless possibly in the extreme north, near Tumbez. He, too, assigned first place to the Booby, although he pointed out that one or two other species undoubtedly deserved an even higher rank at certain islands. Raimondi's full list of important guano producers in the neighborhood of the Chincha Islands comprises—making the correction for the anhinga—three cormorants, the Booby, Pelican, Penguin, Diving Petrel, Gray Gull, Skimmer and Inca Tern. All of these are still to be found about these islands, though several of them have become scarce.

The Inca Tern was evidently extremely abundant at the Chinchas in Raimondi's day. At the south island of the group, Peruvian Penguins were scarcely less numerous, but they had already been driven away from the north island by the riotous work of the laborers and the crews from great fleets of ships. Diving Petrels were likewise residents of the Chinchas in incredible numbers, producing at the time of Raimondi's visit more guano, he concluded, than any other species. Little by little they, too, were being ousted from the north island by the excavating projects, but their burrows still riddled the outer crust of guano on the other members of the group. Furthermore, quantities of ancient eggs of the size of those of Diving Petrels and Penguins were being recovered from the deeper layers, where they may have lain *in situ* for thousands or tens of thousands of years.

During one of my visits to northern Peru I obtained similar eggs, unfortunately lacking precise data, which had been unearthed in the guano of Lobos de Tierra. Other specimens believed to pertain to Pelicans, Diving Petrels, etc., have long ago been reported upon by Hayes (1855, 165) and Clark (1882, 573). Such eggs show every indication of being very old, sub-fossil products. Their interiors have become completely mineralized, resulting in a hard, translucent, silky, crystalline, water-soluble compound of potassium sulphate, ammonium sulphate, and ammonium oxalate, which has been given the special name of guanapite, or oöguanolite.

It should be pointed out that it has never been possible to determine the age of guano strata on the Peruvian islands by the simple process of dividing the total depth of a deposit by the thickness of the yearly average increment. If Chincha guano had a depth of 50 meters, and if the annual new layer amounted to 5 centimeters, calculation would indicate the passing of only a thousand years since the beginning of the process. There are several imponderables here, however, of which the most important is the fact that rhe guano supply ages ago became heaped up on the islands until the slopes had reached the extreme angle of repose. The entire mass, therefore, lay characteristically in the form of a great lens upon the pampa of any given island—thick at its center, thin toward the edges where it crumbled and dropped away into the sea, with the result that the natural loss, from centrifugal pressure, wind-erosion, and the constant treading, scratching, and wing-beating of numberless birds, fully balanced the gain.

As for the guano-mining operations of the prehistoric Indians, who are estimated to have taken about three hundred tons a year from the Chinchas alone, it is possible that the total for the entire coast may have amounted to a thousand tons or more annually. The effect of such moderate and well-distributed withdrawals would, however, be negligible. The most deeply buried human artifact of which I find record is a piece of pre-Inca textile lying under the body of a penguin, at a depth of 10 meters, in the guano of South Guañape Island (Hutchinson, 1873, **2**, 131).

Many changes in the composition and proportion of the bird life have taken place at the guano islands since the time of Raimondi. The transformation has largely been determined by human activities and it is by no means certain that a final, more or less artificial, ecological balance has yet been reached. Under the present régime birds regarded as "useful" are protected; those considered harmful are persecuted; the rest are more or less ignored. At least two new controlling factors are in operation and are destined to remain so. The first of these has to do with the fact that the deep beds of guano have all been removed, while the renewed thin crusts are cleaned off at intervals of at most a few years. This means that burrowing species, such as Penguins, Diving Petrels, and Inca Terns, suffer a permanent disadvantage, since they obviously cannot dig holes in the granite that lies beneath a thin sheet of guano. The surface-nesting species of a dominant, gregarious type, on the other hand, are as well off as they ever were, or better, because they now have fewer competitors on the feeding grounds.

The second factor is related to the influence upon the nesting birds of periodical large-scale engineering projects. Such colonial species as tolerate with the most equanimity the temporary presence of a crowd of workmen upon their islands, will be sure to increase gradually at the expense of species more timid and hence more easily frightened into departing from their normal régime. For these last reasons the Pelican has suffered in competition with its more stolid relatives, the Peruvian Cormorant and Booby.

Further information on historic changes among the birds will be found in the biographies of Part II. For the present I may say that, as matters stand today, three species far outweigh all others together as producers of guano at the Peruvian islands. These, in the order of their contemporary importance, and listed under their native as well as their technical names, are the following:

1. Guanay (*Phalacrocorax bougainvillii*)
2. Piquero (*Sula variegata*)
3. Alcatráz (*Pelecanus occidentalis thagus*)

Only the most general conclusions have thus far been reached in Peru with reference to the quantities of fish taken by birds from the coastal waters, the proportion of this that is subsequently stored upon the islands in the form of guano, and the proportion that is lost in the sea which, nevertheless, it serves to enrich. Thus, indeed, is started again the ecological cycle that begins with chemical compounds and diatoms, and progresses step by step toward birds, agricultural crops, and man. A few comments upon this subject by Coker have been quoted earlier (p. 98). Portenko (1931, 52) has recently investigated from this point of view the avifauna of the arctic island of Nova Zembla, which lies relatively close to a continental coast. He finds that the elements carried into the sea by river waters accumulate within the organism of fishes, and afterwards of birds, upon a scale that staggers the imagination. The guillemots (*Uria*) of Nova Zembla, for example, occupy cliffs extending for a distance of 20 kilometers along the coast. Their first laying in the spring amounts to about 200,000 eggs. Portenko's preliminary calculations indicate that the total weight of fish consumed by the guillemots of the island, during the period of 120 days that they remain in residence each year, reaches a total of 120,000 metric tons.

Since the establishment in Peru of the Compañia Administradora del Guano, the official agency which controls and operates the islands, many investigations in pure and applied science have been undertaken. These have ranged from oceanographic studies to research concerned with the life history, pathology and hygiene of the birds (de Lavalle, 1917, 61; 1918, 205; Gamarra, 1934, 43). The entire industry, furthermore, has been conducted with reference to the welfare and perpetuation of the valuable sea birds. The extraordinary commercial success of the company, following more than half a century of wanton waste, is indicated by the accompanying graph of guano production over a course of years.

Coker (1935, 11), referring to a recent comprehensive report of the Peruvian Guano Administration, writes as follows:

> The extraction from year to year must vary considerably, not so much because of fluctuations in avian population as because of the policy of rotation of areas of operation with corresponding rotation of areas of absolute non-molestation of the birds; but if the total period covered by the report be divided into five periods of five years each and the average annual yield for the successive five-year periods be arranged in chronological order, the following instructive series is obtained:
>
> | | |
> |---|---|
> | 1909–1914 . . . . | 50,916 toneladas (metric tons) |
> | 1914–1919 . . . . | 63,866 toneladas |
> | 1919–1924 . . . . | 75,280 toneladas |
> | 1924–1929 . . . . | 113,749 toneladas |
> | 1929–1934 . . . . | 121,131 toneladas |
>
> Even from such a rough statistical analysis, it is apparent that the good results of the protective measures have been generally progressive up to the present time (with over 157,000 toneladas in the last year). It is also indicated that the results of the protective measures may not yet have come to full fruition. It takes time for nature to restore a balance that man has blunderingly upset. Perhaps this story has a general biological interest.

I have already published a brief general account of the modern guano industry ('Bird Islands of Peru,' 1925), together with a record of certain observa-

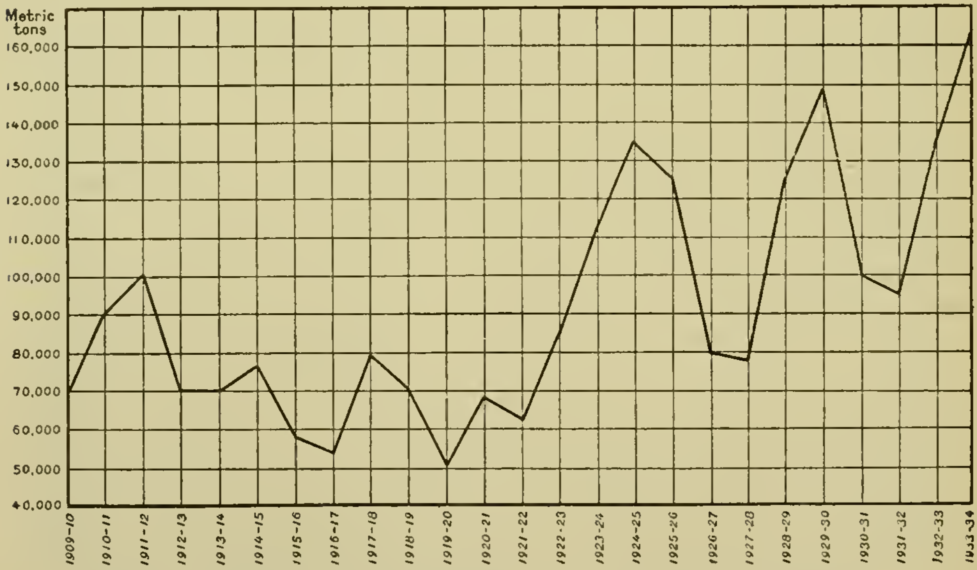


Fig. 43. Annual extraction of guano from the Peruvian islands, 1909 to 1934. From the 25th Memoria of the Compañia Administradora del Guano, Lima (1934).

Successive lows in the more recent portion of the graph appear to reflect the mortality of sea fowl which follows cyclic incursions of the warm countercurrent from the north at intervals of ±seven years. The effect is partly obscured by other factors, such as the particular areas of heaviest exploitation, for the southerly islands are likely to be least influenced by meteorological aberrations. Nevertheless, the sharp drop after the great Niño phenomena of 1925 is noteworthy.

tions dating from the heyday of exploitation, and a bibliography listing the important work of Forbes, Coker, and others. Recent data of importance are given by Lambrecht (1933, 825), and still more in the annual 'Memoria' and the monthly 'Boletín' published at Lima by the Compañia Administradora del Guano. The latter periodicals not only present a running contemporary digest of research and progress, much of which deals directly or indirectly with sea birds of the Humboldt Current, but they have also made available priceless documents dealing with the historical period of the middle of the last century, when "inexhaustible" supplies of guano still covered the islands, and when the frenzied demand for fertilizer led to a strange combination of interests representing agriculture, politics, finance, slave-raiding, and shipping. Such papers, some of which had lain in manuscript for seventy-five years, and which are invaluable to all interested in guano or correlated subjects, are those of de Piérola, Castañón, Faraguet, and others cited in the bibliography of this book. In these is given a wide variety of information, including detailed descriptions of the ingenious methods of extracting guano and loading ships. It is astonishing to learn from de Piérola (1928, 155), for example, that a steam-digger, invented and operated by an American engineer, was used at the Chincha islands as early as 1853.

The wild story of the early years of guano exportation, which Peruvian historians refer to as a "saturnalia," is not likely to be familiar to many readers of today. The death of the whole trade, and its phoenix-like rebirth under newer and better auspices, have been at least suggested in the present short account. The accompanying photographs of square-riggers, assembled to fill their hulls, turn back our thoughts to a time when guano-fever burned as fiercely as ever did gold-fever, and when the Chinchas were a focus of greed and corruption, a forgotten center of dust-gagged misery and slavery, as well as of important business ventures represented by calculating Yankee and British sea captains and by costly ships with towering spars. Behold now the source of the magical stinking powder craved by all nations, and behold the wooden bottoms in which it was once carried from the despoiled Chinchas to the ends of the earth.

What a picture these venerable windjammers make! Some are light, awaiting their turn, but others, such as the bluff-bowed ship moored to a shore-ring in the North Island view, are already well laden, with lighters alongside. Fast by bower and kedge, the staunch vessels rest in the strait, with awnings and windsails set for comfort. Careful skippers, with the prospect of a long delay, have unbent their canvas and, in some instances, have sent down their upper yards. What a galaxy of proud shipmasters within hail of each other! What courtesies and amenities exchanged each quiet tropical evening! For guano fetched ninety dollars a ton in Liverpool or Charleston, and to captains and crews life was a jolly song. It was not strictly necessary to heed the accompaniment to this song, rendered on the plateaus of the islands by coolies who sweated out their lives under the lashes of black drivers, or dashed themselves over the precipices into Lethe (Murphy, 1927, 439).

12. The Galápagos Archipelago

It has been indicated in earlier sections of this book that the Galápagos Islands lie at the crossroads of currents which go far toward controlling the climate, the vegetation, and certain aspects of the animal life of the group. From the time of the visit of the 'Beagle,' and even from long before, the low average temperature of the geographically tropical ocean around the Galápagos, and the extraordinarily mixed character of the surface waters, have been noted by many visitors. Within the area between latitudes 3° N. and 5° S., and longitudes 85° and 100° W., the Equatorial Countercurrent from the west, which is characterized by clear pelagic water of a temperature ranging between 25° and 28° C., mingles with warm but less clear and saline water from the northward, and with cool Humboldt Current water from the southeastward. The mixture sometimes results in alternating bands of surface water which differ in temperature by 5° or 10° C. or even more. Surface temperatures as low as 14.7° C. on one coast of an island, with very warm water on the other, were observed with astonishment by Darwin and Fitz Roy. The cooler waters about the Galápagos have usually a greenish tint quite different from that of the blue equatorial water. The cool waters, moreover, are persistent and extensive enough to suppress the growth of reef corals along the coasts of the islands except at a few favored and very restricted points. Mangroves, on the other hand, thrive along many protected beaches and flats, as on the coast of Narborough Island which faces the strait toward Albemarle. As a result of the anomalous variability of ocean water at the Galápagos, we find there an intermingling of faunas almost without parallel, and marked by the presence of creatures of such diverse origin as fur seals and penguins, on the one hand, and flying fish and tropic-birds on the other. The particular phenomena of intermingling surface streams, the striping of the ocean, the shifting "current doldrums," the foam-lines, the "boiling" effects, etc., have been graphically described by many visitors to the ever-alluring archipelago.

Colnett (1798, 45), after crossing from Point Santa Elena to the Galápagos, wrote on June 24:

> In the course of our passage, we fell in frequently with streams of current, at least a mile in breadth, and of which there was no apparent termination. They frequently, changed the ship's course, againsr her helm, half the compass, although running, at the rate of three miles and an half an hour. I never experienced a similar current, but on the coast of Norway. The froth, and boil, of these srreams, appear, at a very small distance, like heavy breakers. . . . Birds, fish, turtles, seals, sun-fish and other marine animals kept constantly on the edge of them, and they were often seen to contain large beds of cream-coloured blubber, of the same kind as those of a red hue, which are observable on the coast of Peru.

The following detailed observations were written on February 12, 1838, in latitude 2° 26′ S., longitude 96° 27′ W., during the cruise of the 'Vénus,' under command of du Petit Thouars. The position is some distance southwestward of the Galápagos.

> Dans la journée, nous avons traversé des lits de courants très-marqués. La mer était divisée en gues bandes parallèles alternantes. Dans les unes, la surface de la mer était clapoteuse, sonore

et d'un bleu très-foncé; dans les autres, elle était lisse, striée et à reflet blanchâtre. Dans ces dernières, la mer présentait l'aspect d'un vaste bouillonnement, analogue à celui qu'on remarque en aval des culées d'un pont, avec cette différence, seulement, qu'ici le bouillonnement paraît d'une étendue sans borne. Les bandes où la mer était clapoteuse se détachaient très-sensiblement en relief sur les autres. La largeur commune de ces bandes était d'environ 3 à 4 encablures (600 à 800 mètres), et se succédaient en alternant dans la direction de l'est à l'ouest. Le vent était faible du S. E., et la frégate filait 3 noeuds vers le S. O. (de Tessan, 1844, 216).

Schott (1935, 308) has recently stressed the fact that in the Galápagos region, as also along most of the west coast of South America, an unusual relation for such latitudes prevails between the mean temperatures of the atmosphere and of the waters of the ocean. In most tropical oceanic districts the surface water averages from 0.3° to 1.0° C. warmer than the air, but in the vicinity of the Galápagos Islands the relationship is either "negative," or at most zero, depending upon season or other circumstances. The figure derived by subtracting mean air temperature from mean water temperature is known to German oceanographers as the "positive Anomalie" or "negative Anomalie," according as to whether it represents a plus or a minus quantity. In English idiom the best equivalent terms would perhaps be "positive or negative departures." The German "Isanomalen" would then be rendered "lines of equal departure."

In any event, the negative relationship is always accompanied by profound, and sometimes startling, corollaries in biotic distribution, and examples of these are nowhere more impressive than at the Galápagos. The islands lie, indeed, in the coolest equatorial region of the whole world; the negative departure in the water-air thermometric balance normally exists during all months of the year, and it changes only in surface waters far to westward of the archipelago. Only during times when the border line between the northeast and southeast trade winds and the zone of minimum barometric pressure shift over temporarily into the southern hemisphere does a positive departure begin to hold sway. Such are the periods of grand-scale Niño phenomena.

The Galápagos are purely oceanic islands, and the results of recent studies have not changed the conclusions of Darwin that the flora of the archipelago is eminently American, while the fauna overwhelmingly discloses an affinity with Mexican, Central or South American and West Indian types, perhaps derived mainly while the continents of North and South America were still separated by water. Notwithstanding the distance that divides the islands from the mainland, McBride (1918, 229) points out that they are well situated to receive contributions of plant and animal life from the continents. Two of the ocean currents impinging upon the Galápagos come from coasts that might supply part of this life. During the three-fourths of the year in which the southeast trade wind blows, the constancy and velocity of the Humboldt Current are such that under favorable circumstances a space of two weeks or less might suffice to carry drifting objects from the mainland to the islands. The warm current from the general direction of Central America might have a similar effect during the northeast trade wind period of the northern-hemisphere winter months, which is the time of doldrums, rains, and prolonged calms at the Galápagos. The fact that the current from the southeast is relatively cold, and that it flows along a desert coast on which few streams enter the sea, while the current from the north, on the contrary, has a higher temperature and proceeds from a shore along which numerous torrents bear down flotsam and sediment, probably accounts for the predominating resemblance of Galápagos fauna and flora to those of Central America. The 'Albatross' observers reported the ocean floor to be covered with decaying vegetable matter far out along this northern drift. Such facts seem sufficient to explain the presence and the character of life upon the islands, without presupposing a former land connection. It is worth noting that Colnett (1798, 58) found along the southeast coast of Chatham Island driftwood of a larger size than any of the trees growing locally, and also bamboos, sugar-cane, and coconuts.

Swarth (1934, 214) summarizes conflicting opinions regarding the source of the Galápagan biota, his own conclusion being that it arrived fortuitously after emergence of the islands and not as a result of former continental connection.

The rainy season at the Galápagos extends from January to May or thereabouts. It is, however, variable and undependable, presenting a parallel with the irregular meteorological régime at the island of Fernando Noronha off the opposite coast of South America. Darwin (1933, 341) remarked, in fact, that the drier parts of the Galápagos during October reminded him strongly of Fernando Noronha, an affinity due to similarity of climate, volcanic soil, and a flowering leafless vegetation in an intertropical region. During the dry season at sea level in the Galápagos, the upper parts of the high islands continue to receive moisture, in the form of drizzle at least, so that these altitudes have a very different aspect from the lower levels which are subject to a characteristic "trade wind drought." The months between November and February or March cover the period of thunderstorms about the clouded summits of the lofty islands. These are responsible for the rapid accumulation of certain natural reservoirs of rainwater, such as El Junco, the mountain lake of Chatham. This island, incidentally, is the one best supplied with running water and has a perennial stream which tumbles over a fall into Freshwater Bay. Charles, James, Indefatigable, and Albemarle also have dependable springs, but on most of the islands the water supply is poor and uncertain except during the wet season, and most of the sources near sea level are brackish.

The Galápagos Islands are affected precisely like the mainland during years such as 1891 and 1925, when factors of long-term periodicity bring torrential rains. Throughout the long intervals, however, the archipelago bears the same climatic relation to humid and forested Cocos Island that the semi-arid terrain and xerophilous vegetation of southwestern Ecuador do to the perpetually rainy Pacific coast of Colombia. Except for the extensive thundersqualls of the rare wet years, storms are practically unknown in the waters about the Galápagos.

Atmospheric temperatures at the islands range between monthly means of from 21° to 27° C. February and March are the warmest months but even at this season the noon temperature at sea level seldom exceeds 29.5° C., although the

Fig. 44.

dark lava and the surface soil may become extraordinarily heated under the direct rays of the equatorial sun. The coolest season of the year comes between July and September.

According to the computation of Bognoly and Espinosa (1917), the Galápagos group consists of 13 principal islands, 19 islets, and 47 rocks, or a total of 79 distinct units. With the exception of the two distant northwesterly members, Wenman and Culpepper, the limits of the archipelago are between latitudes 0° 38′ N. and 1° 27′ S., and longitudes 89° 16′ and 91° 41′ W. The total land area is about 7433 square kilometers, of which Albemarle comprises more than half. Wenman and Culpepper are isolated, as noted, besides which the small islands of Abingdon, Bindloe and Tower lie upon a distinct common platform, separated by depths in excess of a thousand meters from the main southerly group of ten islands which, except for the northern tip of Albemarle, are south of the equator.

The English designations of the islands, in current use, are chiefly names applied by the buccaneers and dating from the 'General Draught' of W. A. Cowley, 1687. Most members of the archipelago had received earlier Spanish names, besides which various subsequent names have been applied on maps and in texts. Indefatigable, for example, has borne no less than eight names, and this island, as well as James and Charles, each have two official Ecuadorian names. The current Ecuadorian names of the 13 principal islands have been internationally adopted in the Millionth Map of Hispanic America published by the American Geographical Society. The correlations are as follows, the first six islands being listed in order of size.

British Names	*Ecuadorian Names*	*Greatest Elevation*
Albemarle	Isabela	1432 meters
Indefatigable	Chavez	700
Narborough	Fernandina	1134
James	Santiago	518
Chatham	San Cristobal	759
Charles	Floreana	542
Hood	Española	195
Barrington	Santa Fé	274
Duncan	Pinzón	
Jervis	Rábida	
Brattle	Tortuga	
Crossman	Crossman	
Abingdon	Pinta	594
Bindloe	Marchena	244
Tower	Genovesa	64
Culpepper	Culpepper	169
Wenman	Wenman	253

Two of the larger islands, namely Indefatigable and Narborough, each consist of a single volcanic peak. On Albemarle and Chatham several peaks along continuous ridges have been the source of lava-flows which now make up a good deal of low-lying land. Darwin estimated that there may be 2000 distinct craters throughout the group, but only Albemarle and James Islands display present volcanic activity. Narborough, the westernmost island, is most heavily covered, even to its peak, with sterile, undecomposed lava, parts of the extensive flows dating from periods as recent as the nineteenth century. Stratification of different sorts of volcanic ejecta, such as lava, tufa, ash, etc., can be seen particularly well in cross-section on the high cliff that makes up the westerly coast of Abingdon Island. A cream-colored enamel on the rocks at sea level, similar to the "guano glass" of St. Paul Rocks and the Lobos Islands, has been reported at Barrington Island by Mann (1909, 41).

The typical condition of the higher islands, such as the first five in the accompanying tabular list, is as follows: a wide band of rocky, unproductive, cactus-grown, and thickety growth surrounds a central mass from sea level to an elevation of 250 meters, more or less. Above this the vegetation increases in proportion to altitude, so that the summits are in certain instances beautifully luxuriant. More than half the plants of the Galápagos Islands are endemic. Swarth (1934, 214) writes with reference to the meteorological, edaphic, and floral correlations:

> . . . at sea level there is little in the plant growth that is suggestive of the tropics. There are wet and dry belts, mainly altitudinal, with rain falling mostly on the summits and southern exposures of the mountains; and there are wet and dry seasons of the year, though these periods are very irregular both as to dates and amount of precipitation. In some sections there are large areas of lava flow, barren of vegetation or nearly so, but for the most part the islands have a dense growth of shrubbery. At low elevations this consists of a conspicuously large proportion of cactus, thickets of mesquite and other plants of similar habit, with mangrove along many of the shores; higher up, in the rain belt, there is a jungle of larger trees, and on the higher summits many square miles that are grass grown or covered with large ferns. The islands present widely different aspects seasonally, due largely to the host of annuals that springs up with the rains, to wither away in the dry heat of the rainless period. The Galapagos are almost destitute of fresh water, the porous lava absorbing the rainfall, so that any surface run-off is of the most temporary nature.

To the famous giant tortoises and other reptiles of the Galápagos, and the disputed points concerning their probable origin, I can give no space. Amphibians are lacking, and the native land mammals comprise only one bat and four or five species of small rodents. The latter are now said to be rapidly disappearing as the introduced house-rat spreads. According to Osgood (1929, 21), the endemic rodents all belong to the American genus *Oryzomys*, or to a very closely related genus; it is more conservative to speak of the Galápagos representatives as four peculiar species than as one generic group. Two of the species live together on Indefatigable Island. All are related to widely distributed South and Central American rodents, of which no competent taxonomic revision has yet been undertaken. Therefore, while the relationships between Galápagos and continental rodents cannot at present be adequately pointed out, the number and diversity of the island forms indicates, in Osgood's opinion, long isolation.

Introduced mammals living in a completely feral state include cattle, horses, asses, hogs, goats, and dogs. The last are highly destructive to the native fauna. A particularly noteworthy characteristic of these descendants of domesticated animals is their wildness, which contrasts amazingly with the utter confidence and lack of sophistication shown by nearly all the autocthonous animals. Since such temperamental traits or reactions are in large part genetic, it is not unjust to conclude that the total period of domestication in human history for the introduced animals named above is but as yesterday, and that wildness is a condition to which these creatures may revert within a single generation. The endemic Galápagos animals, on the other hand, have probably enjoyed a relative freedom from terrestrial enemies for an incalculably longer period than the millenia of domestication. As a result of this, the determinants of such responses as we term "shyness" have been actually eliminated from the germ plasm of many Galápagos animals, including the majority of the birds.

Swarth (MS) writes that the fearlessness of Galápagos birds is a trait that makes them a constant delight to visitors, practically all species being as readily approachable as any domesticated birds. Such inherent trustfulness, of course, has made them liable to suffer at the hand of anyone disposed to kill them, a feat which can be accomplished with sticks or stones, and which has been ruthlessly carried on by ships' crews during several centuries.

Of the Galápagan avifauna as a whole, the same author (1934, 225) states:

> There are 112 species and sub-species of birds in the Galapagos list, of which 89 breed upon the islands. Of the 89 breeding birds (divided among 26 families) the overwhelming majority are clearly differentiated from their nearest relatives. Including even the wide-ranging sea birds, I find only ten that have escaped subspecific naming at one time or another. It is not possible to make definite lists, as some names have been applied on grounds that it has not been possible to investigate, and there are one or two species still bearing the name of the mainland form that some systematists would separate with little hesitation. But at any rate, there are only a few of the residents, like the Cuckoo and the Brown Pelican, that have thus far defied recognition of any differentiation, and there is a respectable list (Black-necked Stilt, Oyster-catcher, Great Blue Heron, and some of the sea birds) that can be arranged in a graded series showing advancing degrees of distinctness, leading to the 70 or 80 per cent. of the population that is so strikingly peculiar. There is one family, the Geospizidae, and four genera of four other families, *Nannopterum*, *Creagrus*, *Nesopelia* and *Nesomimus*, that are practically restricted to the Galapagos. (The exceptions consist in the occurrence of a Geospizid on Cocos Island, of *Creagrus* on Malpelo Island.)

In the same illuminating paper are found also the two following paragraphs bearing, respectively, upon problems of isolation with reference to genetics and consequent subspeciation, and upon distribution as controlled by the character of oceanic surface waters:

> There are enough species on the Galapagos characterised by being in what appears to be an arrested stage of plumage development to be worthy of comment. Conspicuous among these is the Red-footed Booby (*Sula piscator websteri*). Most of these birds on the Galapagos are not in the white and black adult plumage, but are in the dull, uniformly brownish garb of immaturity. The ratio of white birds to brown on the breeding grounds is at the most one to fifty; on the Mexican islands where the species also nests, the breeding birds are practically all in the adult white and black plumage. This Pacific coast sub-species, *websteri*, is distinguished from the typical form by having, even in the adult plumage, brownish grey instead of white tail feathers. The black and white pattern of normal adults over most of the range of the Red-footed Booby is in the evolution of the species presumably a later development than the uniform brown coloration of the young bird. Do the usually brown Galapagos birds, and the white but usually brown-tailed Mexican birds, illustrate stages toward the ultimate assumption of the adult white and black stage? Or, is there in the Galapagos strain an inhibition that commonly obtains against the assumption of the normal adult plumage?
>
> The presence of a breeding colony of the Sooty Tern (*Sterna fuscata crissalis*) upon Culpepper, the northernmost island of the group, affords an instructive commentary upon the frequent obscurity of factors governing the distribution of species. This strong-flying bird has bridged the wide gap between the Sooty Tern metropolis off the coast of Mexico and the north end of the Galapagos, but for no obvious reason it has not taken the additional easy step toward the unlimited nesting grounds afforded by the other islands. Occasional individuals stray to the southward but that is all. The rare occurrence off the northern Galapagos of the White Tern (*Gygis alba*), which nests commonly upon Cocos Island, is perhaps of similar significance. It is possible that in some manner the presence of these birds is dependent upon the warm Panama current, which sweeps southward about this far. However the place was reached, and for how long a period occupied as a nesting ground, it should be noted that there is here an outlying southern colony

of a Middle American bird; and that there is not on the Galapagos any outlying western colony of a single one of the sea-bird species that swarm along the South American mainland coast.

Furthermore, Swarth refers to curious anomalies of local distribution. Thus the Galápagos Albatross is, in modern times at least, restricted to Hood Island; the Penguin and Flightless Cormorant are each confined to the western part of the archipelago, the Cormorant within very narrow limits; the hawk is strangely absent from Charles Island, etc. Since my own analysis of the provenance of Galápagos oceanic birds has been recorded in an earlier section of this book (p. 101), no more need be said here upon the subject. I wish, however, to quote in closing Swarth's (*ibid.*, 223) astute remarks concerning non-resident species and migration routes:

> The Galapagos are visited regularly by a number of migrants from the north. So far there have been recorded one duck (the Blue-winged Teal), the Osprey, fifteen species of wading birds, Barn, Cliff and Bank Swallows, and Bobolink. The seasonal migration of birds appears to form a problem quite separate and apart from the slow shifting and adaptation of the breeding habitat, continued through the ages. Many of the northern waders remain upon the Galapagos through the year, but never to breed, a common occurrence with such birds in other parts of the world. The breeding range of a species appears never to be suddenly extended through migrants remaining to nest at distant favourable localities. So the migration routes followed by the several northern visitants to the Galapagos have undoubtedly a history that is quite different from the circumstances that have established rhe residents thereon. Some of the waders clearly come south over the Pacific; the Bobolink certainly, the Blue-winged Teal probably—both are species of the Mississippi Valley—travel due south over Mexico on a line that, continued, brings them to the Galapagos. Other species may come either way.

13. Northern Peru to Panama

North of the high stretch of coast between Point Pariñas and Cape Blanco lies tropical water and the beginning of a new zone. On the shore the semi-desert continues for a time, though marked by growths of cacti, algarrobos, and shrubs in all the valleys and sinks, and even on the coastal hills between them. The last of the completely plantless water front of Peru is, in fact, along the lofty cliffs of the Cerro de los Órganos which rear their pipe-like columns a little to northward of Cape Blanco. At Malpelo Point, which has a bushy covering, the Gulf of Guayaquil opens up, and the green and dense gallery-forest and mangrove growth of the Tumbez delra come into view. From this point toward the equator the coastal arid zone prevails only along the western-most projection of Ecuador, the headlands and islands of which conrinue to receive during most of each year southerly and westerly sea winds that have crossed the cool waters of the Humboldt Current. These are felt, indeed, as far norrhward as Cape Pasado, though with constantly decreasing influence. At Guayaquil such cool and drying breezes, which blow only during the verano (June to September), are known as the winds of Chanduy because they proceed from the direction of the long, straight, bare coast of that name which srretches from Puná Island toward Point Santa Elena.

In January, 1925, while weather conditions were still usual and uneventful, and again in March after the phenomenal rains had turned the desert green, I skirted the northern Peruvian coast from Talara to Tumbez and the gulf. During my second trip, unwonted lightning and thunder shattered the dark sky above the tablazos; the pale coastal water was thick with flotsam from the north, and at night a blue phosphorescence marked the wake of the launch. The fauna of equatorial waters, such as leaping mantas or giant rays, halfbeaks (*Hemirhamphus*) that skittered along the surface of the ocean on their tails, flying fish, Man-o'-war Birds, Blue-footed Boobies, and Royal Terns were much in evidence. Farther offshore were enormous flocks of migrant phalaropes, such as Beck had observed and recorded in his notes, along the steamship lane between the Gulf of Guayaquil and Paita, during early January, 1913. At the time of my March trip, it was odd to see, moreover, small numbers of such typical Humboldt Current birds as the Peruvian Cormorant also scattered about through the unduly warm coastal waters. Many of these birds, however, had died and their carcasses were afloat in the foam-lines, while the survivors all appeared to be more or less bewildered or sick. On March 4, off Zorritos, for example, a lone cormorant of this species, which had quite evidently gone "loco," came aboard the launch 'Silver Spray,' alighted on a coil of rope beside me, bit my finger playfully when I stroked it, and finally climbed upon my knees. For five hours this bird elected to remain on the vessel without restraint, being freely handled and petted by three or four persons throughout this period. Strange, indeed, is the effect upon all such cool-water sea birds as do not retreat southward before the invading warm waters and the rains, especially during the exaggerated meteorological phenomena of the long-term rhythms. The latest account of these effects by an eye witness is that of Sheppard (1933, 210), who writes of observations made during a more recent wet season:

True to the seven years' cycle recognized as obtaining in southwestern Ecuador, the rainfall of this region was abnormally heavy in 1932, repeating the phenomena of 1925. . . .

After the rainy season exceptional movements of birds were noticed in the Santa Elena region, the species observed being rarely seen in this district during normal years, the last occurrence of such phenomena being noted by the writer during the heavy rainy seasons of 1925 and 1926. A few birds were seen about the first week in May, or possibly earlier. During the first two weeks in June they appeared in great numbers. Most of these birds, probably all, traveled from the south; and in the majority of cases the flighting was generally northwards. Occasionally, however, large contingents followed the open expanse of the Gulf of Guayaquil inland; hundreds of birds, described in the local press as *patos cuervos* [= Peruvian cormorants], were left stranded in the city of Guayaquil and its immediate district, and not a few penetrated inland almost as far as the Andes at Bucay and Huigra. During the 7th, 8th, and 9th of June the numbers reached their maximum. On the coast near Chanduy an endless succession of thousands upon thousands of birds, all flying low and in the same northerly direction, was seen throughout most of June 9. Dead and dying birds littered the beach and almost every small cliff or sheltered crannie in the rocks was seen to be occupied by melancholy groups of twenty or thirty birds huddled together in a weak or dying condition. The small inlet to the north of the settlement of Puerto Chanduy was literally black with a concentration of them, the majority being too emaciated to raise themselves from the surface of the water. Generally speaking, the birds appear to be of three varieties, most of them being guano birds (*Phalacrocorax bougainvillii*)—black cormorants with white breasts, which walk after the manner of a penguin—others include a large booby (*Sula variegata*) with white head and breast, slate-colored bill, and speckled wings and tail of a brownish color, and finally a small smoke-colored sea bird [probably *Puffinus griseus*]. No frigate birds were present, and pelicans were rare.

There is little doubt that the physically weak state of the birds has been caused primarily by the lack of suitable food, a condition of starvation which has been responsible for the wholesale migration in search for waters containing the essential varieties of fish life that form the principal food of these creatures. According to the writer's personal observations, which are corroborated by the opinions of the inhabitants of the district, such manifestations of bird movement only occur after seasons of heavy rainfall; and it is clear that this climatic factor has been the cause of the abnormal phenomena described above. There are two causes that may be responsible for the destruction of the food supply of these birds, (1) the displacement of the Humboldt Current by the warm "Niño" current from the north, and (2) local lowering of the salinity of the sea near the coast by the sudden influx of enormous volumes of fresh water from a land surface normally dry.

Bearing to the Gulf of Guayaquil and the Pacific the waters of a relatively extensive tropical basin, the Río Guayas is by far the most imposing and important of all South American streams of the westward slope.

The Guayas is a small mark on a map of the Americas, yet it is the greatest river of Pacific drainage between the Colorado and Cape Horn. On the narrow western watershed of the Andes it is a sort of counterpart in miniature of its big transmontane neighbor which carries, it is said, one-fifth of all the running water in the world. As the Amazon and its tributaries spread a network throughout the grandest of alluvial basins, so the system of the Guayas deploys on the shorter slope of western Ecuador, and few hamlets in the lowlands are remote from waterways navigable for launches and barges. If, for example, a steamer is lacking to carry you from Guayaquil to the coast of Manabí, you have the choice of an inland passage up the Daule and the Puca, or some other branch, then taking a short land trip which will bring you to backwaters of the western coast. By this route the mail is not infrequently transported.

When you first enter the Guayas by ocean-going steamship, the river is sure to seem impressive beyond expectation. A vast volume of water evidently flows in the wide channel between the corridors of forest or the low-lying savannahs on either hand; the floating tree trunks and the numberless rafts of water hyacinths and other green plants, which rush down toward the Gulf only to return with the incoming tide, help further to invest the stream with the appearance of a main artery of the continental tropics. And when, after thirty or more miles of wilderness, you approach the long and bustling waterfront of Guayaquil, with ten-thousand-ton ships at anchor and the dwellings of Las Peñas and Santa Ana piling up above the business structures of the Malecón, you can look on up the still broad belt of shining water and almost believe it as endless as the Mississippi.

It was in the blackness of early morning that I arrived at the mouth of the Guayas after an absence of five years. Rain was falling thickly but softly—without being torrential, it was peculiarly soaking. The "Silver Spray's" whistle shrieked, her engines slowed and stopped, her head swung toward the lighthouse and the luxuriant woodlands of Puná Island. As darkness began to fade, the river turned milky yellow. Leaden clouds, with every indescribable wash of silver and gray, closed in the whole horizon. Islets appeared in the scene much as images burst into view during the development of a photographic plate. The low mangroves on bars and spits loomed up like tall trees, each with its magnified reflection. Pointed canoes, which had begun to sally forth from misty shores, also were enlarged and lifted into the air by the peculiar light.

Other vessels were waiting with us for their respective customs guards from Puná; a native sloop or two, the crews asleep; a quaint, brightly painted little river steamer from Santa Rosa, with women passengers gazing wearily out of the ports as they rested on their arms; and, downstream, a diminutive green fisherman of Yankee rig, which proved to be the "Sea Lion," just from San Francisco.

The east now brightened quickly, and wonderful blue mountains in the direction of Cuenca reared above the lower layers of cloud. Man-o'-war birds, blue-footed gannets, pelicans, herons, and laughing gulls dotted the sky, and black skimmers plowed along the tidal rips. *El arador*, the plowman, they call this bird in Ecuador, with an imagery better than our own. It seemed to us in the early light that extraordinary numbers of humming birds were likewise darting about above the river, but they soon resolved themselves into powerfully flying crickets of a kind all too well known at certain seasons in Guayaquil (Murphy, 1925, 441).

The Gulf of Guayaquil is the relic of an ancient, larger estuary, now bordered with long islands of silt consolidated by mangroves and penetrated by innumerable creeks through which the current of the river does not flow. The large island of Puná is not, however, a delta formation but is a recently detached portion of the sandstone plateau of Santa Elena. Inland around the shores of the gulf are successive zones comprising 1, the "manglares" (mangrove swamps) where the flooding tide covers the roots; 2, the savannahs, which are above the high-tide line but are inundated by rainwater during the invierno (January to May); and 3, the agricultural land.

During July, 1922, Dr. Chapman and his field associates made a reconnaissance of the Gulf of Guayaquil, cruising into many little-frequented waterways of Puná and also along the southern or Jambelí coast as far as the Peruvian border. Some of the specimens obtained are reported upon in Part II of this book. Among the discoveries of the expedition was the fact that large numbers of northern non-breeding shore birds (Limicolae) are to be found upon the mud flats of the gulf during the midsummer period of the northern hemisphere. The species collected include Black-bellied Plovers, Hudsonian Curlews, and Dowitchers, all in winter plumage and, as previously noted, with their sex organs in a dormant condition.

To southwestward of Puná Island, in the middle of the broad expanse of the Gulf of Guayaquil, lies the small island of Santa Clara, Amortajada, or El Muerto, the latter two of its names referring to its extraordinary resemblance to a shrouded corpse. It has this macabre appearance from many bearings of the compass, a circumstance which was evidently as true three or four centuries ago, when the island first received its names, as it is today. El Muerto, which is the mark for all shipping entering or leaving the Guayas, is steep-walled and of an altitude of about 68 meters. It lies far enough to seaward to be west of the rain-line described below, and hence is prevailingly arid, with no more than a crowning thicket of xerophilous vegetation. The island is noteworthy as the southernmost nesting station on the west coast of South America of two or more species of sea birds belonging to pan-tropical surface waters. Incidentally, its summit is perhaps the most remote spot on the coast from which the snow-capped peak of Chimborazo can be seen in clear weather.

As the guest of Mr. E. Hope Norton, of Guayaquil, I had the pleasure of visiting El Muerto on February 25 and 26, 1925. The first surprise, noted even from a distance, was that the island is not the "rock" of the pilot books, but that all of it now above the surface of the gulf is composed of an alluvial silt which is as fine-grained as loess; mingled with this are remains of tiny shells. The material is stratified and slightly tilted, and it rises in straight or overhanging cliffs which, during the often-mentioned season of exceptional rains, were undergoing terrific erosion. The brinks and faces of the cliffs were dissolving, so to speak, under the nightly deluges, the slides being so sudden and extensive that many hundreds of roosting sea birds were caught and carried down by them. It almost surpassed the strength of human will to walk near the edge of the cliffs on the plateau of the island, because a succession of parallel seams showed where the next slight impulse, as of a footfall, might set in motion a landslide.

The fact that this island, which has been known as the "Dead Man" since the earliest days of discovery, still resembles a corpse is proof enough that years of heavy rainfall have affected it only at long intervals. A very few seasons such as those of 1891 and 1925 would utterly change its appearance or even wash it completely into the gulf.

I found that no sea fowl could breed at El Muerto during the early months of 1925, perhaps merely because the rains sluiced away their eggs each night, or perhaps because the precipitation had a more fundamental effect upon the metabolism and reproductive processes of the birds. Boobies and pelicans sat about with an air of hopeless lassitude on the green mould that had grown all over the bare parts of the island. The boobies were the worst sufferers from landslides and their bodies peppered the surface of the piled-up silt below the cliffs. The man-o'-war birds, while somewhat more active, had apparently undertaken no nest-building.

The vertebrate fauna of El Muerto, at the time of my visit, comprised lizards of two or more species, the Vermilion Flycatcher, a tanager and one or two other small land birds, Turkey Buzzards, Duck Hawks, and the three or four sea fowl that doubtless nest at the island during normal years. These are: tropical Brown Pelican, Blue-footed Booby, Bigüá Cormorant, and Man-o'-war Bird. In addition, I observed in the vicinity of El Muerto the following stray species from the cooler, southerly waters: Piquero, 1; Guanay, 2; Kelp Gull, 5. Finally three species which might be classed as migrants from the north were noted, these being the Laughing Gull, Royal Tern, and Spotted Sandpiper. The last, by rhe way, were constantly to be seen upon the rafts of water hyacinths which drifted up and down the Guayas with the changing tides.

Westward over the Andes from rain forests of the Oriente, the territory of southern Ecuador first shares two alternating seasons, wet and dry, which in the extreme west give way to a climate only slightly less arid than that of the not distant Peruvian desert. The peninsula of Santa Elena, and the coast which stretches straight northward, lie partly in the zone of long droughts; farther south, the boundary of this zone bends eastward into the funnel-shaped Gulf of Guayaquil to strike the Peruvian shores near Tumbez. From some undetermined point at the northern end of the Amotape range we can draw a line across country to the delta of the Tumbez River, thence by a water loop between the islands of Puná and Sanra Clara (which are but eleven miles apart), and, finally, across the base of Santa Elena and northward close to the ocean toward Cape San Lorenzo. East of this line there is an annual rainy season; west of it rain falls in appreciable quantity only at intervals of years.

The meteorological frontier is very exact, however imperfectly its course has yet been traced, for on the coast between Santa Elena and San Lorenzo are communities, separated only a mile or two, in which the respective climatic distinctions hold. Moreover, the animal life reflects the differences, and the plants still more . . .

Regarding the interval of the rainfall cycle on the semi-arid portions of the mainland, and the outlying islands, opinion differs. It is commonly spoken of in the country as a seven-year period, but it may sometimes be a little shorter or a little longer. In any event, we came to Santa Elena on February 11 and found the rains in progress. . . .

The peninsula was green for the first time since 1919. A month before the whole country had been burnt up with drought, and burros, cows, and goats, reduced to hide and bones, had

> gathered daily about the cable station to fill their bellies with bushels of discarded paper tape. Then came the first showers, and many cattle died in the new mire because they lacked strength to extricate themselves. Now the survivors were living in what was beginning to be a green land of plenty. During a month on the coast we experienced but one entirely rainless day (February 21) and one rainless night (February 24–25). The middle land of the peninsula became a great morass; grass and shrubs sprang up everywhere from what had been bare ground; verdant lines worked down the seams of cliffs facing the sea. The captain of a steamer, which came close in shore while rounding Santa Elena on the route to Guayaquil, remarked that but for confidence in his own navigation, supported by his recognition of the wooden lighthouse, he would have believed himself in another part of the world. "The lighthouse is the same," he said, "but the country is new." . . .
>
> And now, following the soaking of the soil and the sprouting of vegetation, came the plague of insects—not mosquitoes or other biting pests, but merely flies and bugs, beetles and moths, which obscured the bright electric bulbs and peppered the walls and tablecloths with moving specks of various sizes and modes of progression. Water beetles plumped into the soup plates; large, metallic bombadier beetles, or carabids, which prey upon caterpillars, dashed about the lighted rooms in the evenings, filling the air with their squirts of iodine. And the caterpillar-producers, too, flocked to the lights—numberless brown sphinx moths belonging to a cosmopolitan species (*Celerio lineata*) which is distributed in America all the way from Canada to the southern tropics. At Santa Elena, it is probable that the pupae had slept for seven long years in the ground, biding the millenium (Murphy, 1925, 445).

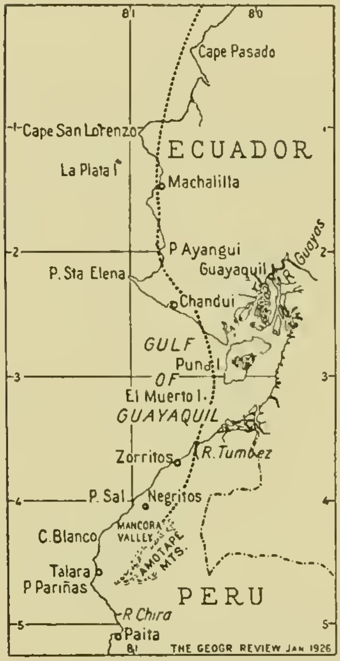


FIG. 45. Coasts of northern Peru and southern Ecuador. The dotted line divides regions having annual rains (to the east) from those having rains only at intervals of years (to the west).

From Murphy (1926).

Sheppard (1933, 211) describes in further detail the effects of the subsequent wet season of 1932 in southwestern Ecuador:

> One of the most striking features of a heavy wet season in this part of the world is the rapid change that takes place from a lifeless, semiarid landscape to a verdant and attractive-looking countryside, enriched by flowers in great variety and enlivened by bird and insect life in astonishing profusion.
>
> After only a few weeks the grass attains a height of two to three feet. Trees and shrubs also that for years have been practically dormant suddenly burgeon forth and assume the appearance that one associates with tropical vegetation. On the other hand, the true xerophytes, such as members of the Cactaceae, do not flourish during a wet season. They are quickly overgrown by parasitical plants and, losing their rich green color, present an unhealthy and dejected appearance.

To northward of latitude 2° S., in the Bay of Santa Elena, is the last tiny spot of land reminiscent of the thoroughgoing desert. This is the little islet of Pelado which, with its bald whitewashed top, looks exactly like a Peruvian guano island, a fact all the more remarkable because a short strip of mainland coast just abreast of it is extraordinarily green. Even a seventh-year rainy visitation would be sufficient to debilitate the fertilizer that accumulates upon Pelado, yet I was informed that at least one vessel had loaded there with guano.

Pelado is steep-walled and about twenty meters high. When I visited it on February 14, 1925, its surface had been deeply channeled by rainfall. A rising wind from the north caused tall combers, with the light of the sky showing through them, to surge around both sides of the island, so that it was impossible to make a landing from the Ecuadorian bongo, or dugout, which I had towed thither by launch. However, there would have been little to learn, for Man-o'-war Birds, Brown Pelicans, and Blue-footed Boobies had exclusive possession, except for one Wandering Tattler (*Heteroscelus incanus*) illuminated by the light from the foam in a dark cave at sea level. The boobies were the most numerous of the sea birds, but none of the three species, an example of each of which I collected, was nesting. At this islet I saw for the first time man-o'-war birds actually upon the ground, for many were resting around the verge of the cliffs.

Farther northward, in latitude 1° 25′ S., and close against the mainland, is the well-wooded island of Salango, as well as various lesser islets concerning which I have no information relating to resident oceanic birds. We are here at the threshold of a district which, toward western Colombia and the Pacific side of eastern Panama, is extraordinarily little known either to naturalists or to the world of commercial affairs. The lands along the ocean have been investigated even less than the cordillera behind them, a fact due to the progressive increase northward alongshore in the length of the rainy season and the concomitant difficulties with reference to human transportation and existence. In western Ecuador the wet and green coast begins in patches, which quickly win out over the last vestiges of the desert. Along the mainland of Manabí, for example, brief stretches of well-watered ocean front alternate for some distance with brown sections that lie under the arid spell of a "rain shadow" caused by some feature of the local topography. In the vicinity of the little seaport of Machalilla and elsewhere, there are hanging valleys suggesting that the coast is here undergoing a tectonic uplift, which is proceeding at a faster rate than the ability of the rivulets to wear down their channels. Going still farther northward one meets with an acceleration in the beginning of the annual rainy season, and the wet invierno markedly increases in length at the expense of the verano. To northward of the picturesque and forested region of Cape San Francisco, beyond which the coast turns northeastward toward the Colombian Chocó, there is a rapid trend toward more and more constant precipitation. To this prevailingly rainy zone, in fact, the basins of the Ríos Esmeraldas and Santiago belong.

About 27 kilometers off the Ecuadorian coast, in latitude 1° 16′ S., or well south of the great salient at Cape San Lorenzo, is the large island of La Plata, which is inhabited only by a lighthouse keeper and his family. It is west of the rain-line and therefore covered with perennial arid-zone vegetation which is supplemented, however, by a luxuriant carpet and drapery of grasses, herbs, tubers, vines, etc., at the times of cyclical precipitation. It is, moreover, a famous haunt of ocean fowl, and is probably the southernmost breeding station of the Red-billed Tropic-bird on the west coast of South America.

Fig. 46. Southwestern Ecuador and northwestern Peru.
From the American Museum map of Ecuador and contiguous regions.

La Plata has an area of approximately 14 square kilometers and is about 5.5 kilometers in north-south length by 2 kilometers in greatest breadth. Lying upon a base of volcanic rock resembling basalt are successive Quarternary marine beach levels, or tablazos, standing at elevations of 30, 152, and 226 meters above the sea and resembling those of Santa Elena and northern Peru. The highest level of the island is therefore flat-topped. It rises steeply on the eastern and northern sides and slopes away westward, the cut-banks toward the open Pacific, which are, in part at least, the friable conglomerate of the lowest tablazo, rising sheer about 30 meters above the waves. A gorge 150 meters in depth has been eroded through the hard volcanic rock of the thickest part of the island; demonstrating, according to Sheppard (1927, 480), that La Plata is a residuum of continental mainland dissected by a fragment of an ancient river valley.

During the rainy season of 1925, Mr. Van Campen Heilner and I visited La Plata by launch from Point Santa Elena, as recorded in an earlier note on our field work. As we approached the southern end of the island, early in the morning of February 17, characteristic features of the adjacent tropical waters were noted in the guise of the yellow and black sea snakes (*Pelamis platurus*); giant rays which leaped clear of the ocean or glided past us with their upcurved "wing-tips" in the air; schools of flying fish with albacores and rooster fishes (*Nematistius*) in pursuit; yellow clusters of algae resembling Sargasso weed; and numbers of Masked Boobies (*Sula dactylatra*) which mingled with the familiar Blue-footed species.

At the only anchorage of La Plata, off a short sandy beach on the eastern coast, the surface water had the very high temperature of 27.7° C. We lost no time in getting ashore, and devoted two days to a reconnaissance under the guidance of the lightkeeper and his stalwart son.

The hills of La Plata were covered with a forest of tree-cactus, palo santo, acacias, a lantana-like plant, wild cotton, and shrubbery, together with a wealth of ground vegetation brought into life by the rains; most of the trees and tall cacti were bearded with Spanish moss. Conspicuous among the fresh greenery on the long western slope beyond the divide were clumps of a golden yellow composite, a large, white, yellow-hearted spider lily or "amancae" (*Hymenocallis*), and a plant resembling lily-of-the-valley but not yet in flower. The bestarred fields that stretched toward the cliffs, and the cylindrical islets carved from the lowest tablazo at either end of a wide cove, made a vista of extraordinary beauty. Eight cows and calves, a bull, and half a dozen burros were in clover after the lean years. The goats, of which there were apparently hundreds, had doubtless contrived to keep themselves sleek even during the long drought. The usual weekly toll of two well-grown kids was made by the lightkeeper's son, with an old army musket, during our first morning's walk. The wonderful adaptability of these ungulates to island life was impressed upon me as I stood on a projecting point of the cliff near the southern end of La Plata, watching the swirling surf below, the schools of fish that ruffled the surface offshore, and the view across the blue water toward Montecriste. Beneath me the sheer drop to the waves seemed to offer no foothold even for a bird, but before my eyes a file of goats came trotting around a bend on the very face of the precipice, about halfway down toward the water. Startled at the sight of me, each beast performed a pirouette out over the abyss and, with scarcely a break in action, the whole troop scampered back out of sight. It was difficùlt to recognize the mere trace of a ledge that the goats had been using as a foot-path.

La Plata rang with bird songs, the caroling of the "chirote" or Mockingbiid rising above those of all the others. During our wanderings we noted two tyrannids, including the Vermilion Flycatcher, a form of which even reaches the distant Galápagos, a wren, the Military Blackbird, two species of doves and two of hawks, the Turkey Vulture, Wandering Tattler, Spotted Sandpiper, and Cocoi Heron—all exclusive of the oceanic species. Seventeen kinds of land birds have been found at La Plata during March, only the Mockingbird being of a race distinct from representatives on the opposite mainland (Chapman, 1926, 577). Except for birds, the only native land vertebrates I found were lizards and a non-venomous snake.

Most notable among the sea fowl were the gorgeous Masked Boobies which had just reached the stage of egg-laying along the seaward cliff of La Plata. This constituted the first breeding record of the species at any point nearer to the west coast of South America than the Galápagos and San Felix. The pampa of the Blue-footed Boobies, on the highest tablazo, was unoccupied, though the white rings of many of their old nests were still visible. The lightkeeper stated that the "Rabo de Gallo," or Tropic-bird, an example of which I saw in flight, bred on the beetling cliffs at the north end of La Plata, and that during the preceding October the nests of Man-o'-war Birds had covered the shrubbery of the southeast point. The total list of observed waterfowl is a scanty one, as follows:

ALBATROSSES

Diomedea irrorata. The skin of a Galápagos Albatross, shot during November, 1924, was hanging in the lightkeeper's dwelling.

TROPIC-BIRDS

Phaëthon aethereus.

PELICANS

Pelecanus occidentalis (*carolinensis* ?).

BOOBIES

Sula nebouxii. Common about the island.
Sula dactylatra. Nesting.

MAN-O'-WAR BIRDS

Fregata magnificens.

GULLS

Larus dominicanus. One example of the Kelp Gull feeding in a tide-rip a short distance south of La Plata, February 17; a far northern record for this species.

Larus atricilla. Not uncommon over the surrounding ocean.

The remainder of our voyage of circumnavigation must be brief for the reason that we are now to skirt one of the least-known coastal regions in the New World. As Eder (1913, 5) remarks, the stretch between the Colombian Chocó and Darien is an almost virgin field for scientific work, while to southward, toward northwestern Ecuador, exploration has not passed the pioneering stage Along much of this coast rain falls on practically every day in the year, and the temperature rises every day to the neighborhood of 35° C.

The native sea birds of the district include several of the tropical species with which we have already become familiar, as well as at least one new and peculiar form, namely, the well-marked Colombian race of the Brown Booby known as *Sula leucogaster etesiaca*. This booby is so closely confined as a breeding bird to areas and seasons of excessive wetness that high humidity as a genetic requirement for the hatching of its eggs or the development of its young is by no means beyond the bounds of likelihood. I encountered an example of this booby at sea, on a floating tree trunk, about 30 kilometers to westward of Tumaco, on March 13, 1925. It has not been recorded farther southward even during years marked by extraordinary expansion of the rainy area, but it breeds, as we shall see, at humid islands to northward and at Cocos far offshore.

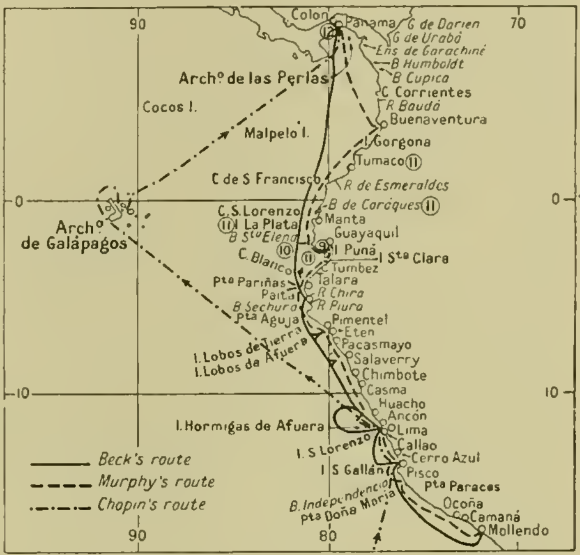


FIG. 47. Northern Pacific coast of South America and the associated islands. For more detailed maps see figures 42 (Peruvian coast and guano islands), 45 and 46 (Gulf of Guayaquil and adjacent regions), 44 (Galápagos Islands), 48 (Cocos Island), 49 (Malpelo Island), 50 (Pearl Islands). In addition to the courses of voyages and coastal excursions by Beck, Murphy, and Chapin, local American Museum field work is indicated by figures in circles: 9, Chapman and Cherrie, at Puná and Santa Clara Islands and elsewhere in the Gulf of Guayaquil; 10, Cherrie and Gill, on the Peninsula of Santa Elena; 11, Richardson, at Puná and La Plata Islands, Tumaco Island, and along adjacent parts of the coasts of Ecuador and Colombia; 12, Hallinan, in the Bay of Panama.

Noddies and fairy terns, which also nest at the tropical islands on the high sea in these latitudes, apparently avoid the continental littoral. Transient or wandering sea fowl presumably pass through the coastal waters in great numbers at certain seasons, but our knowledge of them is based almost altogether upon casual records. My own field identifications between the Gulf of Panama and the coast of Ecuador include only the following birds, all observed during the months of February, March, September, or November: Galápagos Albatross, Galápagos Petrel (*Pterodroma phaeopygia*), Sooty Shearwater, Black Petrel

(*Loomelania melania*), Blue-footed Booby, Masked Booby, Colombian Booby, Red-billed Tropic-bird, Man-o'-war Bird, and a number of undetermined gulls and Limicolae.

That the climatic differences between the arid coasts of Peru and southwestern Ecuador and the forested shores of Colombia are homologous with those between the parched lowlands of the Galápagos and rain-soaked Cocos Island has already been noted. Near the continental coast, winds of monsoon type blow from a westerly quarter in July, for example, and from the northeast in January. Variations of this schedule hold throughout the year. The sea is close at hand in both these directions; the surface of the Pacific and of the Caribbean are alike warm; evaporation is rapid, and the moist air is adiabatically cooled to its dew point upon ascending the slopes of the Serranía del Baudó and other coastal mountains. Not only are temperatures high at all seasons, but there is little amplitude. Such uniformity of control is responsible for the fact that widespread storms are rare even though local thundersqualls may be frequent.

The Pacific coast of Colombia is, naturally, one of the least populated parts of the country, and the forest which covers it is practically unbroken from the crests down to the shores of the Pacific. To northward of latitude 4° N., the cordillera is separated from the ocean by a coastal chain that reaches an elevation of 1800 meters at the source of the Río Baudó, and then drops away to northward. Southward, in the zone known as the Chocó, the western cordillera dominates the Pacific and the mountain streams have constructed a sort of continuous delta along the coast, behind which they join with one another in a maze of channels or esteros navigable for small craft. Mangroves cover the alluvium, and north of the multiple mouths of the Río Patia, near Tumaco, this swampy fringe, which is the home of continental marsh birds, attains a width of fully 50 kilometers. The Patia is the only river that cuts through the Andes to reach the coastlands and the Pacific. Tumaco itself, which stands on three flat islands off an inlet of this low and complicated coast, is at the edge of the rains, so to speak, and is just southward of a region which Richardson describes as having perpetually a "climate like a Turkish bath." His further notes, published by Chapman (1917, 49), are as follows:

> The island of Tumaco is dry, sunny, and sandy with only stunted vegetation; and, on one side, mangroves. There are only a few common birds there. On reaching the mainland at Sala Honda, at the mouth of the Patia, everything changes and the next one hundred miles is through a dense swamp of flooded forests. It is inhabited only by negroes who live on the river banks and cultivate patches of rice and plantains and cut wood for the steamer. Their huts are built of bamboo on poles five to eleven feet above the ground, and they last only a few years. When abandoned their thatched roofs are soon converted by nature into veritable 'roof' gardens; a mass of vines and parasites, ferns, mosses, and even corn and bananas growing on top of them until they cave in.

De la Rüe (1934, 17) graphically describes a recent reconnaissance by launch and canoe through the shallow channels between the mangrove islands of Fray Juan and Concepción, southwest of Buenaventura, and then inland across the lowlands by way of the Ríos Yuramangui and Naya. The whole region he found to consist of inundated and all but uninhabited forest, the stretches back from the rivers being still totally unexplored. Huts of negroes at placer gold workings, or at small plots of tillage along the Naya, are built upon piles to afford partial escape from noxious insects and from the sudden and enormous floods caused by rainfall which, de la Rüe states, exceeds 10 meters per annum on the slopes of the cordillera.

Lying 40 kilometers off the coast about halfway between Tumaco and Buenaventura, and centering at latitude 2° 58′ N., longitude 78° 5′ W., is Gorgona, the only Colombian island corresponding in size and position with La Plata in Ecuador, and Lobos de Tierra in Peru. These three islands, incidentally, are placed along a north-south line measuring less than ten degrees of latitude, yet Lobos and Gorgona represent, respectively, the utmost extremes of aridity and wetness, while La Plata is, as nearly as possible, exactly intermediate.

Gorgona is 9 kilometers in length by nearly 3 in greatest width, triple-hilled, the central peak rising to 395 meters above sea level. The island therefore has a very different appearance from the neighboring swampy mainland coast. There is no dry season; rain falls throughout the year, and heavy thunderstorms are daily phenomena. The island is covered with dense tropical forest made up of both tall trees and undergrowth, and broken only by numerous streams. Progress inland involves constant use of the machete. The beach presents an open path at low tide, but the flood, which rises fully 3 meters, brings the sea to the very edge of the forest. Fish and whales are abundant in the ocean round about Gorgona, and current circulation is said to be extremely active, although the flow may be in large measure tidal.

Because of its isolation, vegetal luxuriance, and lack of human inhabitants, Gorgona might be expected to support a rich and varied vertebrate fauna but, as a matter of fact, the island is characterized rather by a marked paucity of birds and other higher animals. W. W. Brown, Jr., who has investigated it, found that to encounter from six to ten individual land birds during an entire day's tramp was an average experience (Thayer and Bangs, 1905, 87). Of the 16 known species of birds, four are peculiar to the island. There are likewise a number of endemic forms among the other vertebrates, which comprise a spiny rat, an agouti, two bats, a cebus monkey, six lizards, four snakes, and two frogs, all related to not distant continental animals. The whole island swarms with land crabs.

Resident sea fowl are restricted, so far as known, to the Man-o'-war Bird and the Blue-footed and Colombian Boobies. Of the last (*Sula leucogaster etesiaca*), Gorgona is the type locality. If the tropical Brown Pelican does not reach the island to nest, the fact illustrates once more how closely this species hugs the continent except for its distribution along the island arcs of the Antilles and its accidental attainment of the Galápagos.

The sea birds all occupy Gorgonilla, a peninsuloid extension from the southeastern end of Gorgona, separated at high water. Brown found that the breeding season for the three marine species had passed by mid-June, which would indicate a synchronized reproductive rhythm, unlike the condition prevailing among many sea bird populations in drier parts of the maritime tropics, as at the Galápagos. Probably the peak of egg-laying for the boobies and frigate-birds of Gorgonilla coincides with the yearly decrease in precipitation which begins in November and reaches its lowest point in March. In an area of sustained rainfall, it is difficult to understand, however, why such slight variations can show so pronounced a physiological correlation.

Buenaventura I visited on March 14, 1925, when, strangely enough, no rain fell, although most of the day was heavily overcast. The captain of the S. S. 'Ucayali' was making his twenty-ninth call within fourteen months at this port, and on the preceding twenty-eight it had rained throughout his stay!

The coast north of the mouth of the Río Dagua, by way of which one passes upstream to Buenaventura, was of alluring appearance in the lucid, late afternoon light, consisting of low sandstone bluffs, overhung with festoons of rank vegetation, and stretching away toward the Isla de las Palmas. A file of twenty Brown Pelicans crossed the steamer's bow, Royal Terns were balancing daintily on the flotsam, and a few Man-o'-war Birds were idling high in air. The brief scene, while a red sun sank, gave me my only glimpse of the coastal bird life in the heart of the humid tropics.

The shore from here toward Panama, according to Eder (1913, 194), is no better known commercially than scientifically. A few miserable fishing or foresters' hamlets brave the continual rains and the ravaging heat. Several well-sheltered bays afford anchorage, but there are no roads across the Baudó range. The strip between the mangrove swamps and the mountains is at best very narrow, and most of the few visitors to the region have returned with more malaria than enthusiasm.

Nevertheless, along the much-indented shores to northward and southward of Cupica Bay (latitude 6° 40′ N.), are many coastal islets, some of which are evidently higher than mangrove-bars because the word "roca" is applied to them upon the old Spanish maps. A reconnaissance in a small craft, equipped for both oceanographic and zoölogical studies, would no doubt be eminently profitable. Little has been undertaken since the surveys for a proposed Pacific-Atrato-Darien canal, carried out during the middle part of the last century. Certain of the geographic names along this coast, such as Cape Corrientes, are highly suggestive of interesting problems to one who has seen the effect of currents upon the distribution of life in the ocean.

Insensibly the Colombian coast runs into that of the Isthmus of Darien. The rains, particularly those of the first third of the calendar year, begin to drop off in volume, and within the Gulf of Panama the total annual precipitation falls to about half that of the opposite Caribbean coast. At Humboldt Bay, in latitude 7° N., we are just over the mountains from the starting point of our circumnavigation in the Gulf of Urabá. The incomparable mangrove growth of one of the several estuaries opening into Humboldt Bay is thus described by Schott (in Michler, 1861, 150):

> In entering and ascending this river, a mangrove region, most magnificently developed, receives the traveler. Its width, from its borders on the bay to where the tidal marks become obliterated, may be set at one mile and a half.

Nowhere on the Atlantic or Pacific coast have we met with a rhizophorous tree vegetation of such magnitude. The truly gorgeous net work of roots for miles and miles, all around, appears like an arched foundation upon which the mighty colonnades of the straight growing mangrove timber are reposing. Here we notice single trunks, of from two to three feet in diameter, bearing graceful crowns of a light green foliage, at a height of about 100 feet or more.

The aspect of this almost unbounded labyrinth of roots, grasping upon a bottomless layer of soft brackish mud, bears some analogy to zoöphytic life, with the difference only, that corals are built from the bottom upwards, whilst the roots of these trees, in an opposite direction, ramify downwards through the bottom. Both, however, are employed by nature to conquer the waters. The height of the mangrove roots above low water mark may be considered as a tide gauge, which here shows about eight or nine feet between the two tidal extremities.

14. Islands of the Tropical Pacific Bight

The meteorology and oceanography of this exclusively tropical section of the eastern Pacific have been discussed earlier (p. 102). The islands within the area include representatives of both oceanic and continental types, which have certain faunistic bonds with one another and with the climatically distinct Galápagos. Swarth (1934, 222) writes:

Cocos Island (north-east of the Galapagos and about midway toward Costa Rica) and Malpelo Island (a barren rock about midway between the Galapagos and Panama) both have their parts in a study of the source of the Galapagos fauna. The tiny Cocos Island possesses only four species of land birds, but these four are of striking character. They are the Cuckoo (*Coccyzus ferrugineus*), Flycatcher (*Nesotriccus ridgwayi*), Mangrove Warbler (*Dendroica petechia aureola*) and "Finch" (*Pinaroloxias inornata*). The Cuckoo and Flycatcher, both peculiar to Cocos, are too sharply differentiated to permit recognition of their immediate affinities. The Finch, also restricted to Cocos, is recognisable as a member of the Geospizidae, the only species known to occur elsewhere than in the Galapagos. The Mangrove Warbler in the sub-species *aureola* occurs on Cocos and the Galapagos, nowhere else. On Malpelo Island there is apparently a small colony of the Swallow-tailed Gull, otherwise restricted closely to the Galapagos.

a. Cocos Island.

Cocos, which is about 1000 kilometers from Panama, and equally far from the Galápagos, extends 6.4 kilometers in its longest diameter which is east and west, and is about 21 kilometers in circumference. The central hills rise to an altitude of 518 meters, which is much less than is commonly credited to them, and the shores present wave-cut cliffs with steep slopes and canyons above. The western side of the island is extremely precipitous and is visible from a hundred kilometers at sea; most of the indentations and negotiable landing-places are on the northerly shores. At Chatham Bay, for instance, a large gorge descends quite to the beach, through which a stream has cut its way to the ocean. A similar rivulet in Wafer Bay is reported to come from a lake in the interior. Other brooks flow down all sides of the island, pouring in many places over the cliffs with undiminished volume throughout the year.

As a spot of romantic beauty, even aside from its "treasure island" associations with pirates and freebooters, Cocos is almost if not quite the equal of some of the Polynesian isles with which, in appearance and even in bird life, it has much in common. The rock is volcanic, and the still unexplored peaks may be cones, but the surface does not appear to be laid down as laminated lava.

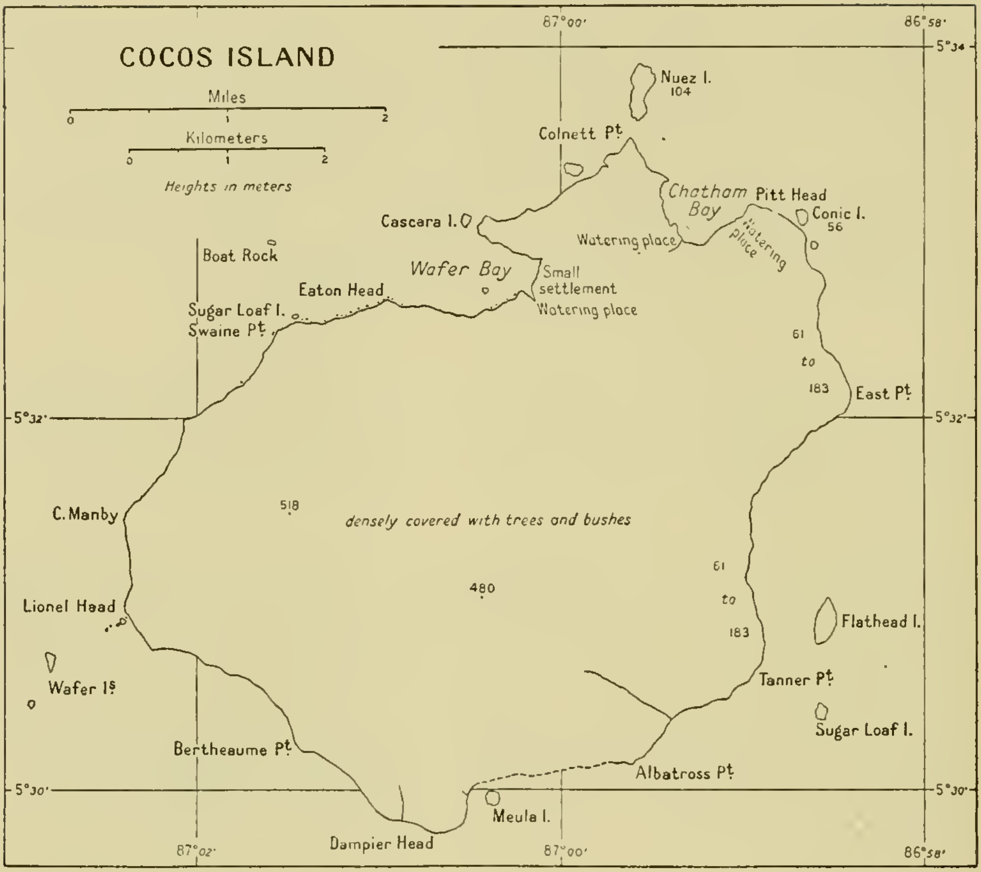


Fig. 48.

It is covered everywhere by a shallow but rich soil. The climate is extremely humid, for the island lies fairly in the path of the Equatorial Countercurrent. The oceanic circulation is therefore chiefly from Cocos toward the continental mainland, militating against the transfer of life by natural agencies from South America to the island. In this connection it is interesting that neither the Brown Pelican nor the Oyster-catcher has reached Cocos, though the Colombian Booby has. Furthermore, the Fairy Tern of the island is distinctly of Polynesian rather than of Atlantic subspecific affinities. Tropic-birds seem to be wanting, possibly because the surface waters in this rainy region are insufficiently saline.

The flora of Cocos is relatively small in number of species but is extraordinarily luxuriant. Tall hardwood trees and dense undergrowth cover the slopes and ridges; there are groves of tree ferns in the ravines and palms at middle altitudes, making the island far more green and lush than any other in the eastern Pacific Ocean. The disappearance at sea level of the coconut palm, for which the island was named, has been due to ruthless felling of the groves by buccaneers and the crews of whaling vessels.

With the exception of the birds, a lizard and a snake are the only native vertebrates; rats and hogs, however, have been introduced, the latter by Colnett in 1793. Even insects are stated to be relatively scarce, the most conspicuous being a very minute and abundant ant which visitors find it impossible to keep off their persons; its bite is excessively annoying and its presence makes travelling on Cocos Island somewhat disagreeable (Snodgrass and Heller, 1902, 504).

The known sea birds of Cocos comprise only the following, though it is hard to believe that no species of petrel breeds at the island.

BOOBIES
Sula sula
Sula leucogaster etesiaca

MAN-O'-WAR BIRDS
Fregata (magnificens ?)

TERNS
Anoüs stolidus ridgwayi
Anoüs minutus diamesus
Gygis alba (candida ?)

b. Malpelo Island.

Malpelo looms like a black iceberg, with clusters of rocks to northward and southward, and with very deep soundings only a short distance off its sheer cliffs. It is 523 kilometers west by south of Point Chirambirá, Colombia, and slightly nearer the Peninsula de Azuero of Panama. It is less than 2 kilometers in length, rising to an elevation of 258 meters, practically inaccessible, and without vegetation other than small patches of shrubs on its heights.

Malpelo was perhaps the first Pacific island discovered by seamen sailing from a port on the American continent. It is shown upon a map of "Peru" published in 1530. Landings have seldom been made, though the Spanish commodore Malaspina reports that in 1790 a ship in distress obtained rainwater from a pool some thirty steps above the sea on a shelf at the northern end of the islet.

Vallaux (1933, 198), who quotes from various early voyagers, states that Malpelo lies in a center of peculiarly active oceanic circulation, the violent currents around it sometimes causing bands of surface water to swell into crests which resemble

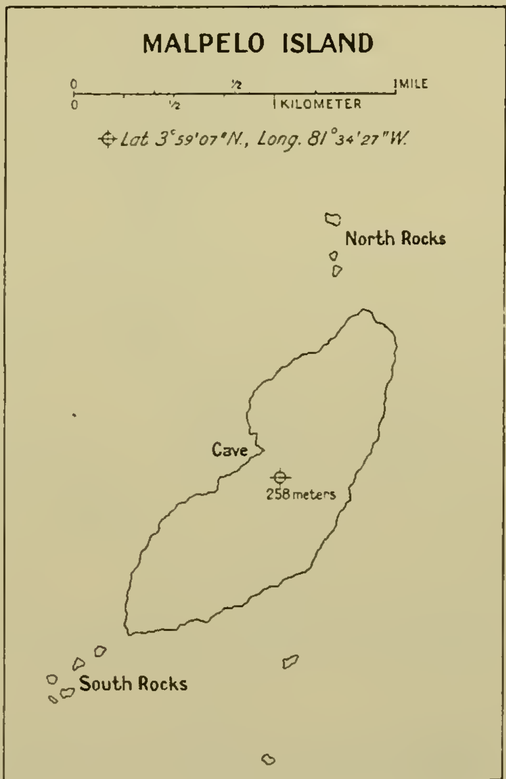


FIG. 49.

reefs. Townsend (1895, 125) visited Malpelo on March 5, 1891, and collected a species of lizard and the first examples of the Swallow-tailed Gull (*Creagrus furcatus*) known from the locality. He reports that sea birds of several kinds swarm about the unattainable summit of the island. The identity of these has never been determined, but noddies and perhaps fairy terns would be probable members of the avifauna.

c. Pearl Islands.

The Islas de las Perlas form an archipelago of sixteen larger islands, and more than fifty holms and rocks, on the eastern side of the Gulf of Panama. Their total area is about 1165 square kilometers, and their nearest point to the main-

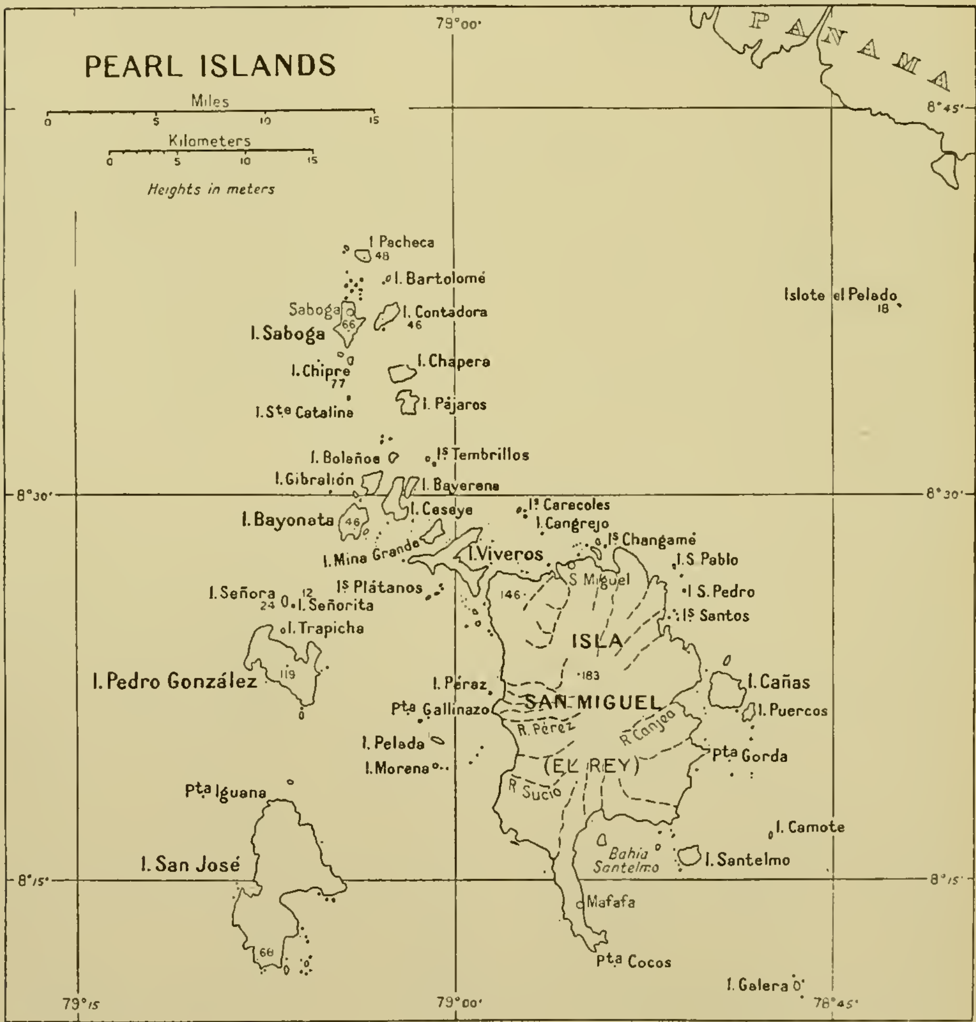


FIG. 50.

land is distant 35 kilometers. The islands are volcanic and, according to Rendahl (1920, 1), they have apparently had no continental connection since the elevation above the sea of the Isthmus of Panama. Many members are heavily wooded, and the numerous coconut groves and bright sandy beaches, interrupted by low, rocky bluffs crowned with trees, give them a charming appearance. The rainfall régime is that of the adjacent Pacific side of the isthmus, and is, of course, sufficient to support numbers of permanent streams, some of which end at the sea in waterfalls. After the torrential rains of the northern-hemisphere summer period, the surface salinity in the gulf around the islands becomes very low, a fact which may have some relation to the absence of certain sea birds, such as noddies, from the Pearl Islands. There is evidence, moreover, that the peak of the breeding season for the resident water birds comes after the abrupt drop in monthly precipitation that takes place in December and January, to continue until April. The surface temperature of the water about the Pearl Islands remains high (27° C., or thereabouts) during much of the year.

San Miguel, or Isla del Rey, with a length of 24 kilometers, a breadth of 11, and a greatest elevation of 183 meters, is the largest island, and has the richest avifauna. San José, Pedro Gonzáles, Casaya, Saboga, and Pacheca are of secondary importance. The islands supporting tropical forests are

Saboga	Bayoneta	San José
Chapera	Viveros	San Miguel
Pájaros	Pedro Gonzáles	Santelmo (partly)
Casaya	Trapiche	Galera

The islands and islets which are mainly rocky and with scanty vegetation, and which furnish the principal headquarters of the resident sea birds, are

Pacheca	Santelmo (partly)
Señora	Cangrejo
Señorita	

The sea birds feed along the shores of many islands at which they do not nest, sometimes congregating by thousands, for example, in a cove on the southern shore of Bayoneta.

According to Rendahl's study, the Pearl Islands have 63 species of resident birds, including possibly 10 endemic forms. Members of 26 families represented on the opposite mainland are completely wanting at the islands. The affinities of even the sea birds are mainly continental, as will be evident from the concluding list. No nesting petrels or tropic-birds are known, nor even such oceanic boobies as *Sula dactylatra* and *S. sula*. Sturgis (1928, 111) states, however, that some form of the latter species (*i. e.* Red-footed Booby) is not uncommon in waters about the Pearl Islands at certain seasons. In the following list of resident oceanic birds the few dates relating to the breeding period are based chiefly upon the observations and compilations of Rendahl and of Sturgis.

Pelicans

Pelecanus occidentalis (*carolinensis* ?). Nesting at Señora, Santelmo, Pedro Gonzáles, and Pacheca. At the last-named island the Pelicans occupy the outermost trees on the plateau, the central part of this forested area being occupied by Bigüá Cormorants. Well-grown young Pelicans have been observed in the nests during March.

Boobies

Sula nebouxii. Breeds at Pacheca and Galera.

Sula leucogaster etesiaca. Breeds at San Miguel, Saboga, Galera, and abundantly in the northern part of Pacheca.

Cormorants

Phalacrocorax olivaceus olivaceus. Breeds at San Miguel, Saboga, Pacheca and Santelmo. Nest-building has been observed at Pacheca during March, and eggs during the middle of April.

Man-o'-war Birds

Fregata magnificens. Breeds at Pacheca, Galera and Cangrejo. Eggs have been observed during February and March.

Oyster-catchers

Haematopus ostralegus palliatus. A Pearl Island specimen examined proves to belong to the Atlantic race which, as noted elsewhere, ranges for some distance from the Isthmus of Panama northward and southward along the Pacific coast.

PART II

THE OCEANIC BIRDS

SCOPE AND METHOD OF TREATMENT

South America, as previously pointed out, is the longest mass of land lying in the relatively open oceans of the southern hemisphere. Parts of its seacoast fall within every zone from the north-equatorial practically to the antarctic. Furthermore, the environments on both the east and west coasts are modified in a simple, almost diagrammatic manner by such great geophysical phenomena as the systems of regular winds and ocean currents. It is natural, therefore, that nearly all the genera, and a large proportion of the species, of southern-hemisphere pelagic birds should occur within the limits of the field. Since the scope of this book also includes the American quadrant of Antarctica—the region in which the geographic and biotic connection between the southern continents and the south polar regions is closest—it is also natural to find that every one of the truly antarctic species of birds likewise falls within our list.

Among the littoral, as opposed to the typically pelagic, birds, we find, as might be expected, a higher proportion of forms peculiar to our region. Even in this group, however, many of the South American species, such as the Kelp Gull (*Larus dominicanus*), are circumpolar. Others, including certain sub-antarctic or pan-antarctic cormorants, for example *Phalacrocorax atriceps* and *P. albiventer*, are at least members of a Formenkreis distributed around the world in high southerly latitudes, but the specific and subspecific relationships of these birds are not yet fully understood. Still other littoral forms, such as the several races of the White-breasted Oyster-catcher (*Haematopus ostralegus*), are representatives of a practically cosmopolitan species which encircles the globe between the cold oceans that lie toward both the north and the south. As might be inferred, some of the most remarkable of the endemic coastal birds are known only from the southerly or westerly shores of South America. A few of these, including a cormorant (*Phalacrocorax gaimardi*) and a gull (*Leucophaeus scoresbii*), perhaps have recognizable relatives in the New Zealand region; others, such as the Kelp Goose (*Chloëphaga*), the steamer ducks (*Tachyeres*), a gull (*Larus belcheri*), the Inca Tern (*Larosterna*), and two species of oyster-catcher (*Haematopus ater* and *H. leucopodus*), are very distinctively South American. In several of these latter instances the genera are not known elsewhere, and in the case of the Inca Tern it would be difficult even to pick its closest relative in another part of the world.

A number of more or less widely distributed sea birds and beach birds belonging to the cooler parts of the southern hemisphere have probably had their primary centers of dispersal in the South American region. This seems to be true, for example, of the Ringed Penguin (*Pygoscelis antarctica*), the penguins of the genus *Spheniscus*, and perhaps also of the crested penguins (*Eudyptes*): it is also probably true of the diving petrels (Pelecanoididae), as well as of the sheath-bills (Chionididae), of which the Indian Ocean representative is sometimes regarded as a different genus from that occurring in the American sector Data in support of these assumptions will be given in due course.

Our ultimate understanding of the distribution and systematic status of South American oceanic birds, particularly of those which are allied through close or distant kinship with other forms in the circumpolar area, is bound up, as I have pointed out elsewhere (Murphy, 1928, 374), with far more extensive collecting than has yet been undertaken; with broad taxonomic work such as only satisfactory collections can make possible; and with the bringing to bear of an oceanographic point of view in considering the reactions of the living birds. The terrestrial life of many of these creatures, as is sometimes forgotten, is reduced to a minimum; their ranges appear to be circumscribed, in the main, by the same set of factors which control other marine organisms, and detailed study of their ecological relationships promises fruitful outcome.

As regards collecting, it is certain that no adequate series of antarctic or sub-antarctic specimens, representing forms from the entire breeding range of a single genus, have yet been brought together. To those biologists who affect to believe that taxonomy is a finished or fruitless field for research, I must state my opinion thar it is, on the contrary, the still uncompleted foundation for whatever we may eventually hope to learn in ornithology. Systematic studies, especially those pertaining to species and races of the sub-antarctic islands, have thus far been made at random, a fact which we realize today far more than was realized a few decades ago, when the famous "Catalogue of Birds of the British Museum" and subsequent monographs were published. From year to year since that time new material has seeped in, little by little, to museums in a score of countries, and piecemeal systematic studies have revealed intricate diversity among the species or lesser units of certain groups while, curiously, the forms of others seem to spread throughout very large areas without exhibiting geographic variation—contrasting states which impress us with the nonconformity of nature. A final classification of all the birds found between the "Roaring Forties" and the south polar continent is still a long way in the future. The mere fact that so much recent ornithological writing has degenerated into a game of juggling localities and subspecific names should not, however, obscure the truth that taxonomy must be worked out to its practical limit before we can interpret the subtler points of distribution. Up to the present, no single museum in the world possesses an even moderately good representation of birds from the antarctic and sub-antarctic islands as a whole. If all existing collections were combined, they would still be insufficient, especially since scarcely any specimens are known from the South Sandwich archipelago, Bouvet Island, and other isolated and important stations.

No one who has become familiar as I have with the literature dealing with birds of the southern oceans, as published during the present century, can fail to be aware of the confusing and disgraceful results of building intricate systematic structures, with wholesale manufacture of generic and subspecific names, in advance of sound fundamental work. The method of classifying birds by seemingly rational geographic arrangement and the free application of names, either disinterred or created, is doubtless easy and amusing to certain types of minds. Moreover, it is to be expected that time, and the labor of other ornithologists, will confirm a certain proportion of conclusions drawn from even slap-dash methods. But the least that can be said against standards of the sort is that they condone half-finished work and that their results, however correct some of them may chance to be, are not admissible as the data of science until they have been tested by the very study and painstaking comparison which certain recent writers have so cheerfully evaded. In the domain of true science there is no place for the autocrat who states his deductions but withholds the evidence. Such procedure is not only unfair, but is ever open to the suspicion that the evidence, if there be any, might not be able to withstand critical examination. It is a matter of serious culpability that in scores of recent ornithological papers unnecessary work has been heaped up for future investigators, work which the authors themselves might in many cases have completed for all time. By hasty, hit-or-miss, often unintelligible diagnoses of species and subspecies; by ignoring the obligatory custom of fixing types and of supplying detailed descriptions and measurements; by publishing irresponsible affirmations on grounds known to themselves alone, such writers have assured a vast increase in the already overwhelming columns of synonyms, and have set an example which, if followed extensively, would bring systematic ornithology into utter disrepute.

Fortunately, in a current systematic book, namely Peters's "Check-List of Birds of the World," of which only the first two volumes have yet appeared (1931 and 1934), we have an admirable standard. Following conservative principles so long exemplified by Dr. Ernst Hartert, Peters has adopted a modern and simple arrangement of families and genera, at the same time retaining as subgenera many names which might prove of genuine structural or evolutionary connotation to a specialist working in a particular group. While Peters has endeavored to give subspecies a critical consideration, it has obviously been impossible for him adequately to review this enormous field in the absence of material representing many oceanic groups. In such instances, as, for example, with the whale-birds of the genus *Pachyptila* (1931, 48), and the terns of the *Sterna fuscata* assemblage (1934, 338), he has merely sought—by listing all of the described forms with an explanation that he is not in a position to sponsor them—to smooth the path of the first worker in possession of sufficient specimens. This is an honest method, for it indicates that the names are used tentatively, pending a satisfactory revision. Of the whale-bird group just referred to, no fewer than nineteen subspecies of the four known species are recorded, not counting several additional names which Peters has felt obliged to reduce to synonymy. There is no reason to suppose that these whale-birds do not, indeed, break up into a number of geographic races, but from a study of a very large number of specimens representing the four species, taken in widely separated parts of their respective ranges, and all examined with reference to the original descriptions of the subspecies, I am prepared to maintain that most of the alleged subspecies have been described with a hopeless lack of precision and upon a basis of utterly negligible material. In other words, the races themselves would be negligible but for the fact that the names have found their way into the inexorable system of zoölogical literature, so that the task remains for some fellow-worker to complete the original describer's job by indicating his synonyms and properly crediting him with the subspecific names concerning which his poorly supported guesses may prove to be correct.

In this book I take pleasure in following the nomenclature of Peters's "Check-List," except in a few instances in which subsequent revision has made a change seem desirable. This means also that I follow him in the use of comprehensive genera, believing not only that an indication of relationship is as a rule more illuminating than one of divergence but, furthermore, as I shall attempt to show, that many of the criteria upon which generic differentiation has been based are spurious or indefinable. To those taxonomists who may be disappointed in finding an unsatisfactory discrimination of geographic races in the following pages, I can only say what I have inferred above, namely that the time has not yet arrived for such detailed zoögeographic classification within certain groups. It should be remembered that all of my systematic studies had to be completed before the great Rothschild collection, acquired by the American Museum in 1932, had become available for reference. Future use of this collection, in conjunction with the Brewster-Sanford collection, the Whitney South Sea collection, and other splendid series of sea birds in the American Museum, should enable exact systematic work to be carried much further; for the present I must be content to indicate only the facts of relationship for which there are abundant data, and to attempt to point out the place in nature of the birds coming within the scope of this book.

The selection of species and forms for consideration in the following biographical section has been based upon geographical criteria rather than blood relationship. I have sought to include only birds which have close associations with salt water. In the case of penguins, petrels, man-o'-war birds, etc., this has, of course, meant the inclusion of all forms occurring within the area. Among the geese, ducks, terns, and shore birds, however, I have not hesitated to choose boldly, even among aggregations of as close kinship as the geese of the genus *Chloëphaga*. Many inland birds which reach the seacoast, and which are of much geographic interest for my purposes, have been sufficiently discussed in Part I, and find no place among the life histories that follow.

From an ecological point of view, the birds of which I write fall into four groups corresponding with the classifications of Hagerup (1926, 139) and Wynne-Edwards (1935, 240). They comprise:

1. Littoral birds, characteristic of the beaches or rocky foreshores, such as the oyster-catchers, kelp goose, and sheath-bill.

2. Inshore birds, confined mostly to waters within sight of the land and, in some instances, more or less habitual in fresh water, such as one species of cormorant, the skimmers, and many gulls and terns.

3. Offshore birds, ranging as far as the edge of the continental shelf, such as pelicans, several cormorants, and two or more of the diving petrels. (This

group is much more fully represented in the northern hemisphere, by the Alcidae, for example, than it is in South America.)

4. Pelagic birds, belonging to the high seas. Many such hardly come within sight of land except at the reproductive season. The tropic-birds, a host of Procellariiformes, and the migratory penguins are examples.

The reader will doubtless find the biographies, and the introductory essays preceding each group of them, somewhat inconsistent, not to say arbitrary. For the irregularity in length and style of the biographies I have no apology; it is sufficient to say that I have not tried to tell about any species more than the sometimes meager facts warrant. As to the introductory matter, I have found it most convenient to make this relate either to an order, a family, or a lesser group of genera or species, the special needs of each instance being regarded as more important than consistency of plan. A total of 183 species and subspecies, representing the following five orders and sixteen families, are more or less formally considered. The species which migrate to South America from the northern hemisphere receive only summary treatment.

Order Sphenisciformes
- Family Spheniscidae: Penguins

Order Procellariiformes
- Family Diomedeidae: Albatrosses
- Procellariidae: Petrels, Storm Petrels, Shearwaters, etc.
- Pelecanoididae: Diving Petrels

Order Pelecaniformes
- Family Phaëthontidae: Tropic-birds
- Pelecanidae: Pelicans
- Sulidae: Boobies
- Phalacrocoracidae: Cormorants
- Fregatidae: Frigate-birds

Order Anseriformes
- Family Anatidae: Geese and Ducks

Order Charadriiformes
- Family Haematopodidae: Oyster-catchers
- Phalaropodidae: Phalaropes
- Chionididae: Sheath-bills
- Stercorariidae: Skuas and Jaegers
- Laridae: Gulls and Terns
- Rynchopidae: Skimmers

As to the structure of the biographies, I have already indicated that our knowledge of the life histories of practically all oceanic birds is no more than fragmentary, a fact that makes it very difficult to follow a uniform plan in the preparation of the numerous texts. Since, in the present work, the accounts represent a combination of original studies with information from a wide range of literature, and since they make frequent use of quoted text which it is often undesirable to break up, the difficulties are increased. I have, therefore, bound myself to no ironclad scheme, but have endeavored merely to develop each life history in accordance with the data at hand. The result is in many instances heavily one-sided, but the deficiencies can be remedied only through future research. In the main, I have endeavored to stress two aspects of the bird's existence, namely, (1) the distributional, concerned with its geographical responses, and (2) the behavioristic, concerned with its psychobiologic responses. The two are perhaps one, for distribution, as determined by tolerances and other metabolic reactions, is in last analysis a matter of behavior. The general outline followed, with many necessary elisions and many changes of order and emphasis, is shown below:

Head Matter

Scientific name and original citation.
Vernacular name: English, South American Spanish or Portuguese, aboriginal; also the principal synonyms of the specific name.
Characters: Diagnostic and descriptive; size, proportions, weight, anatomical notes; dimensions.
Eggs: Description, number, and measurements.
Distribution: World and South American regions.

Biographical Text

Word picture or outstanding impression of the bird in life.
Historical and economic status.
American Museum specimens; field experience during Museum expeditions.
Systematic relationships of the form; variations, individual and geographic.
Place in the South American region.
Migrations.
Preferred habitats, sea and land; geographic and ecologic correlations.
Breeding season: Time, length, geographic or other variation in the dates.
Habits and behavior: Courtship, territory, mating, nesting, incubation, reactions to other animals, including man.
The young: Growth, care, methods of feeding, reactions, mortality.
Moult of young and adults.
Voice.
Food and feeding.
Enemies and diseases.

Subheadings in the biographies of the birds have been dispensed with partly for economy of space and, more particularly, because it is felt that the index of the work will serve every purpose in bringing together references to kindred subjects scattered throughout the text.

FORMS DESCRIBED AS NEW IN THIS BOOK

Oceanites oceanicus chilensis . . . . .p. 754
Phalacrocorax olivaceus hornensis . . .p. 915

THE SPHENISCIFORMES

THE PENGUINS
FAMILY SPHENISCIDAE

Malgré la diversité apparente des amusements qui semblent m'attirer, ma vie n'a qu'un objet. Elle est tendue tout entière vers l'accomplissement d'un grand dessein. J'écris l'histoire des Pingouins. —Anatole France

In a French encyclopedic work on natural history published in 1868, I find the following statement: "Thanks to the many descriptive documents furnished by ancient as well as modern navigators, the natural history of penguins may be considered complete."

Since that date four species of penguins, then unknown, have been described; the breeding places of many others have, for the first time, been found; and the fossil record has yielded certain fragments of great importance. Now, with a third of the twentieth century behind us, we are perhaps justified in feeling that we have at least scratched the surface with reference to the natural history of penguins, and are possibly at the threshold of further discoveries regarding their ancestry and adaptations. For recent detailed knowledge of the appearance and behavior of penguins we have to thank not only the publications of naturalists who have painstakingly observed, but also those new adjutants of exploration, the camera-men. A well-made motion picture has certain advantages beyond even what the eye can perceive. It is objective and permanent; it may be viewed over and over again at adjustable speeds. In giving credit to our sources of information regarding many species of penguins, the superb accomplishments of such pictorial recorders as Ponting, Hurley, Kearton, and Kohl-Larsen must never be forgotten. Moreover, a great field still awaits exploitation by the camera.

The penguins, which comprise one of the most well-marked major groups of birds, have been given a highly varied systematic ranking by different zoölogists. Gadow has stressed their fundamental resemblances to the Procellariiformes and certain related orders of Neognathae, while other anatomists, such as Gill, Stejneger, Menzbier, and Lowe have tended to emphasize their distinctness, and even to grant them a position equivalent to that of all the rest of modern birds. Wetmore (1934, 1) has also seen fit to segregate the penguins in an exclusive superorder, Impennes, in accordance with the recent conclusions of Lowe (1933, 483).

However much the superficial and adaptive features of their structure may set the penguins off from other avian groups, I think it is not difficult to show that Lowe has gone too far in interpreting them as primitive, primarily aquatic birds, which have not descended from flying ancestors, but have become differentiated directly from a reptilian or pro-avian stock. A brief review of the subject may be of interest, especially since ten of the seventeen known species of modern penguins occur within the field of this book. The latest authority on the fossil penguins, Lambrecht (1933, 224), gives so exhaustive a bibliography that it will not be necessary for me to cite the references in full.

Ancestry

Lambrecht lists thirty-five species of fossil penguins, assigned to twenty-two genera. Of these, two genera and three species have been described from Miocene formations of New Zealand. Of the remainder, twenty-six species are credited to the Miocene or Upper Oligocene of Patagonia, five to the Miocene of Seymour Island, on the western side of Weddell Sea, beyond latitude 64° S., and one to both Patagonia and Seymour Island. Lambrecht's list is complete rather than critical, and the discrimination ot thirty-two species in America may ultimately prove excessive. Nevertheless, the presence of a score of fossil genera, of which all but one or two certainly represent penguins, is sufficient indication that these birds flourished exceedingly in the American quadrant of Antarctica, and neighboring regions, during early Tertiary time.

The Seymour Island fossils, associated with the bones of zeuglodonts or primitive whales, were discovered by the Swedish Antarctic Expedition of 1901–1903. Wiman (1905, 1) regarded the remains as much older than those of the Patagonian penguins, but this opinion has not been substantiated. He described six genera, compared the foot and leg bones of the largest with the corresponding parts of the modern Emperor Penguin, and deduced from the rule of proportion that the giant of the ancient forms must have had a standing height of between 100 and 175 centimeters. The higher figure would be the equivalent of about 5½ feet. Wiman also compared the leg bones of the Tertiary penguins with those of extinct bipedal reptiles and concluded on good grounds and correctly, in my opinion, that the marked resemblances are due to homoplasy.

So far, so good. But Wiman further compared his fossils with somewhat inadequate skeletal elements of modern penguins, and thus reached deductions which Lowe has now thoroughly upset. What Wiman attempted to demonstrate, in brief, is that although the Tertiary penguins from American Antarctica bear substantial structural resemblance to modern penguins, the tarsometatarsi of the former are of a more fused or ambulatory type, and that in this respect the fossil species stand nearer the stem of carinate or flying birds.

Lowe, in his recent elaborate study of what he calls the primitive character of the penguins, shows conclusively that Wiman had compared the fossil foot bones of *adult* penguins with the corresponding bones of an *immature* modern penguin, thereby invalidating the key point of his reasoning. Lowe has no difficulty in proving that the tarsometatarsus of the Tertiary penguins was in fact no more "carinate" than that of existing species, and that Miocene and even earlier penguins were already typical members of the modern group, with wings and feet differing only in minor respects from extant forms.

Upon this basis, Lowe develops a thesis which by no means follows, namely that the ancestors of penguins have never been flying birds. He considers, in all, six classes of evidence—palaeontological, embryological, pterylographic, osteological, myological, and geographic—and from each of them attempts to show that penguins have no linear relationship with birds possessing normal wings. With all of his data, it is obviously impossible to deal here, but it is important to state a few of the more trenchant objections to Lowe's hypothesis, as recently advanced by Gregory and Murphy (1935, 1).

Among the osteological peculiarities of penguins stressed by Lowe is the supposed resemblance of their very short, almost separate metapodials to the corresponding elements in the feet of a running dinosaur (*Ceratosaurus*). But the enormous differences between penguins and carnivorous dinosaurs in the construction of skull and trunk skeleton, together with the vast gap in time between the Upper Jurassic and the early Tertiary, indicates that any foot likenesses are either fortuitous or convergent. If, however, we actually compare the feet of these diverse creatures, we find that despite the spreading character of the metatarsals in penguins, the three elements still retain evidence of derivation from the fused bones of normal birds.

Lowe exhibits some beautiful preparations of the wings of penguin embryos and, by showing that they are indubitable penguin wings, he concludes that they were never anything else. According to Parsons (1932, 141), embryology does not supply a final answer as to whether penguins are of very primitive stock or whether they represent modern types of birds, highly specialized for their peculiar life. This author, however, does go so far as to say that the extraordinarily early and full development of the forelimb in penguin embryonic life is "reminiscent" of Mesozoic aquatic reptiles. To those who accept the present-day point of view that many embryonic conditions are merely preparatory to adult conditions, this remote analogy will not weigh heavily. The fact that adult penguin wings retain certain conditions found only in the embryos of carinate birds may be but an added item of evidence that penguins are to some extent larvalized carinates. Jacobi (1911, 216) has called attention to the fact that the penguin's skeleton retains many embryonic features during early life and, in some respects, in the adult stage. He holds that penguin embryos are in the main much like those of flying birds, and that the bulk of ontogenetic evidence is in favor of the carinate origin of penguins, although their branching off must have taken place as early as the Cretaceous. He says, furthermore, that the proximal bone of the wing in Tertiary penguins was proportionately longer than in modern species, and hence closer to the carinate condition. Hutton (1902, 1) reports that several of the flight muscles of the wings of ordinary birds appear to be represented by non-contractile tendinous bands in the penguins.

It seems strange that Lowe does not recognize the construction of the penguin wing as a paddle-like modification of a flying wing. The member shows the fusion of the digits and other general characters of the wings of aërial birds, whereas in the pectoral appendages of even the most bird-like of dinosaurs the digits remained separate, as they did also in the primitive winged bird *Archaeopteryx*. In the entire pectoral girdle, indeed, the penguins retain convincing testimony of their derivation from carinate birds. All of the bones here have such an outstandingly avian, "flying" stamp that the penguins may be said merely to fly under water instead of in the air.

It is true, as Lowe states, that the dorsal sutures separating the spine from the ilia remain open in penguins. This, however, is the usual condition in aquatic vertebrates, and prompts the question as to why Lowe never mentions the obvious analogies between penguins and cetaceans. There is weighty and extensive evidence that whales have been derived from normal hairy land mammals with well-developed legs; that degeneration and specialization have played havoc with both their embryonic and adult anatomy, so that whales can no more walk on land than penguins can fly in the air.

Furthermore, in the architecture of the penguins' skull there is special indication of descent from post-reptilian ancestors. The palate, as in many carinates, is of the schizognathous type. At the other end of the spine, the penguins possess a true pygostyle, a relic of their descent from ancestors with a normal bird-like tail. The penguins' long and flexibly arranged tail vertebrae, of the ordinary bird-like type, were noted a century ago by Swainson (1836, 1, 261). The number of their major tail coverts, too, equals the number of rectrices, as it does in the majority of flying birds.

It is among characters of feathering that Lowe believes he finds some of the most cogent reasons for his belief that penguins have no flying antecedents. Instead of a pattern of feathered and bare spaces on the body, the penguins, like the ostrich and its allies, have a uniform feather-coat. Lowe notes that this same pterylographic arrangement is also common to the Crested Screamer (*Palamedea*) and holds that the latter, alone among the birds he would regard as carinate, shows in this respect the same "primitive" plan as do those he calls the "primarily aquatic" penguins and the "primarily terrestrial" ostrich-like birds. He goes on to say that he sees through his study of the penguin feather the outcome not of a process of degeneration, but one of failure to develop. The barbules at the distal ends of the barbs of penguin contour feathers are, he holds, specialized pennal-down barbules. The arrangement of the wing feathers in the penguins may be said to be larval in character, with specialties superimposed.

With the last conclusion I would agree, except as to the interpretation. Many penguin characters, including those of feathers, are doubtless to a certain extent larval, but this by no means precludes the likelihood that in earlier stages this same feather structure may have been succeeded by others which have since dropped away. I cannot agree that penguin feathers are evidence that the birds have specialized directly from a primitive, non-flying, generalized ancestor.

Lowe has given us many interesting details regarding the peculiarities of penguin pterylosis. He finds for example that there are 300 feathers in a 25 millimeter square on the back of *Pygoscelis papua*. There are 100 or more putative remiges on the border of the Emperor Penguin's wing; no other bird has more than 42. There are no less than 38 successive rows of scale-like feathers between the pre- and post-axial borders of the Emperor Penguin's wing, which means something like 3800 feathers on the dorsal surface of the forearm alone in this species. But Lowe speaks of all these numbers as the "primitive quantum," for which I believe we have not the slightest iota of evidence, while all the correlated probabilities are against it.

Lowe has discovered an extraordinarily interesting fact in the relationships of certain feathers on the upper and under surface of the penguin's wing, and one in which there is an important discrepancy between penguins and all typical flying birds. This relates to the positions of the hitherto unrecognized coverts and "quills" of penguins. It was pointed out long ago by Sundevall that the major and median under wing coverts in normal flying birds have their concave surfaces facing downwards, instead of upwards, or against the quills, as do the rows of coverts anterior to them. Wray subsequently explained this anomaly by demonstrating that in embryonic development the first two rows of under coverts arise on the outer side of the wing, and later, with the hypertrophied growth of the remiges, become shifted around to the inner or ventral side.

Now Lowe shows that the early embryonic condition persists in the adult penguin. In *Aptenodytes*, for example, there are four rows of marginal white feathers. Two of these rows are implanted above the actual edge of the wing and face downward; the two immediately below the edge of the wing face upward. The homologies permit him to point out the first row of blue feathers on the dorsal surface as the hitherto unrecognized remiges. The feather arrangement along the hind edge of the penguin's wing is therefore persistently embryonic, but it does not follow that it is phylogenetically primitive. On the contrary, the condition is the one that would almost necessarily be restored with the reduction of large flight quills to the size of undifferentiated coverts.

I am ready to hold with Lowe that the described feather relationship is larval or embryonic, and even that it may simulate the ultimate ancestral condition. Rather than representing a truly primitive stage, however, I should say that the position of the penguin's coverts merely indicates that a phylogenetically later stage once existed, and has since dropped out. If one knew penguins only by their wings, such a conclusion might not be justifiable, but it appears to be the only logical inference when taken in conjunction with the mass of other evidence.

It is, of course, entirely possible that the ancestors of penguins may have more or less lost the art of flight long before they took to pelagic life. Their center of dispersal was probably in an area corresponding with what we now call the Antarctic Continent, and this region has apparently been the most isolated portion of the earth's surface during a very great period of geologic time. It is likely, indeed, that it has been so long and so widely separated from the northern continents by water that it was never reached by terrestrial animals of any sort. Flying birds, however, could not be barred out. We may note, furthermore, that among birds reaching remote and safe insular areas, loss of flight is apt to occur. Therefore, without being far-fetched, we may picture the ancestral penguin as a bird that had given up the air and had taken to the ground or to littoral waters, acquiring during this phase something of the pedestrian and graviportal ability that still characterizes the group. It is worth noting here that Ameghino called the fossil *Cladornis* a "dry-land penguin." Now with the approach of periods of glaciation, such as have marked many different geological epochs and which, indeed, grip contemporary Antarctica, some of these flightless birds would have been forced to the sea for survival, producing the ancestors of the penguin order as we know it today. The beginnings of this trend may have come before the end of the Mesozoic. We can readily accept the morphological conclusions which Lowe points out with great thoroughness, correcting Wiman's error and proving that the fossil Miocene penguins were extremely closely related to the genera still in the world.

To conclude, I see in the penguin not a bird one stage removed from reptilian ancestry, and aquatic from the beginning of things, but rather, as advertised in its feathers and in all other parts of its make-up, a bird carrying the stigmata of three successive ancestral stages—first the flying, second the flightless, and third the supremely aquatic.

Morphological and Physiological Interrelationships

Pycraft (1898, 981) concludes from a study of penguin skeletons that the Australasian genus, *Eudyptula*, appears to represent the least specialized member of the family and is probably nearest the ancestral stock. Mathews and Iredale (1921, 8) likewise refer to *Eudyptula* as "the living representative of the immature state of *Eudyptes*." In Pycraft's radial diagram, the genus *Aptenodytes* is placed next to *Eudyptula* on one side, while on the other are the genera *Spheniscus*, *Eudyptes*, *Megadyptes*, and *Pygoscelis*. Of the six genera and seventeen species of penguins recognized by Peters (1931, 29), four genera and ten species occur within our New World region.

Wilson (1907, 36) has called attention to the excellent clue that more or less incipient or suppressed color characters of penguins sometimes give regarding the probable relationship between the genera. He has found, for example, that the well-known green gloss on the head of the King Penguin, but absent from the feathers of the Emperor, has a considerable range in extent and intensity. It is due, he says, to "the intermingling of minute dots of vivid orange pigment with the black." In respect to this character, the King Penguin forms an intermediate link between the Emperor on the one hand and the genus *Megadyptes* on the other. The golden band on the head of the latter points, in turn, toward the well-developed plumes worn by the species of *Eudyptes*.

Wilson, in the same brilliant monograph, has made the astute and easily verifiable observation that in the color and pattern of penguin plumage nine-tenths of the distinguishing characters appear on the head and neck. He remarks that, with the heads removed, it would be very difficult to distinguish between any of a dozen different species of penguins. Because of the low floating position of the birds in the water, when they come to the surface at all, the heads supply the recognition area, the only part, indeed, which is exposed to view. This is no doubt the explanation why strong differences in bill color, in the pattern of markings on head and throat, and in the development of bright superciliary plumes, ear-patches and similar ornamentation, have been evolved through

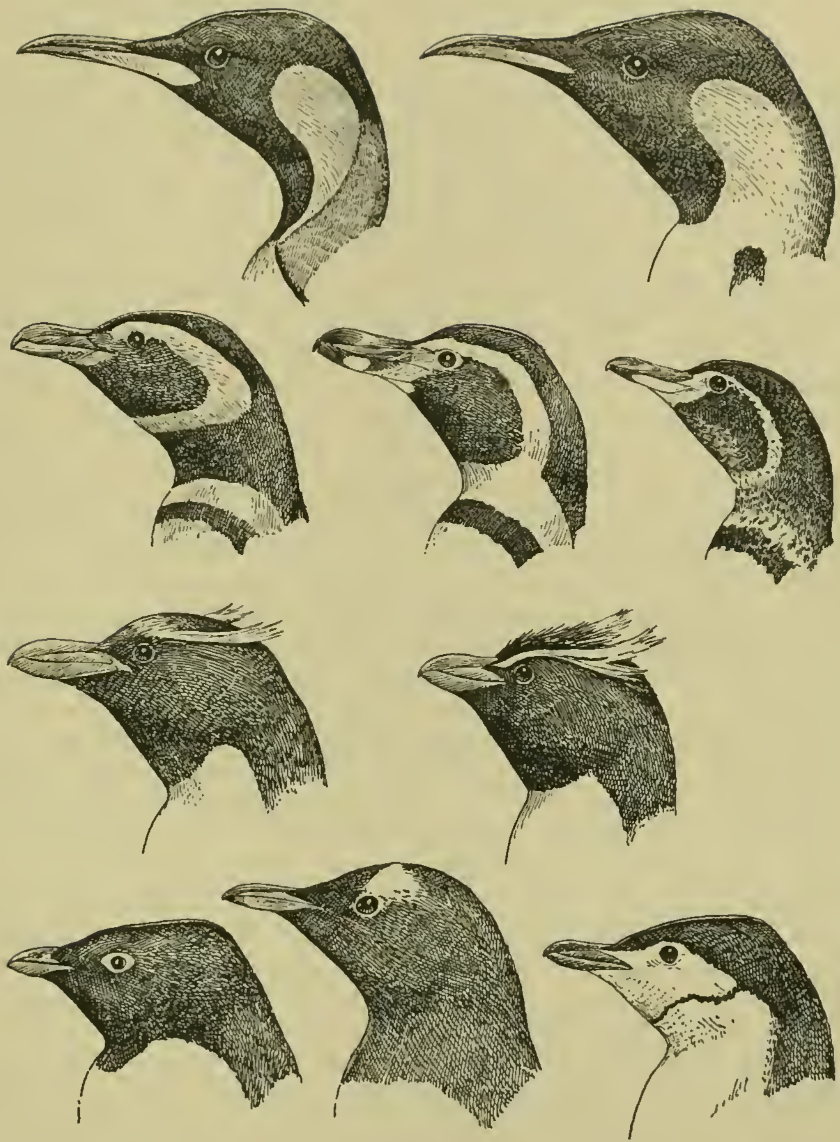


Fig. 51. American Penguins

Illustrating generic and specific characters revealed in the head. Reading from left to right: top row, King and Emperor (*Aptenodytes patagonicus* and *A. forsteri*); second row, Magellanic, Peruvian, and Galápagos (*Spheniscus magellanicus*, *S. humboldti*, and *S. mendiculus*); third row, Macaroni and Rockhopper (*Eudyptes chrysolophus* and *E. crestatus*); bottom row, Adélie, Gentoo, and Ringed (*Pygoscelis adeliae*, *P. papua*, and *P. antarctica*).

some sort of selection within the group. The remainder of the penguin's body, even to the dark soles of its feet, which are turned upward while it is swimming, appear to be colored and countershaded chiefly according to the canons of low visibility under water. Generic distinctions, no less than those of a specific grade, have been developed chiefly in the head.

Many special characteristics of the different species of penguins may be regarded as adaptive features, if the term is used in a properly guarded sense. For example, among the three representatives of the genus *Pygoscelis*, we find the nares feathered in a manner that would keep snow particles out of the respiratory tract in the one strictly antarctic member of the group, *P. adeliae*. The Ringed Penguin, *P. antarctica*, which is somewhat more northerly in its distribution, has this character less well marked, while in the still more northerly *P. papua* it is wanting. The penguins of the genus *Spheniscus*, which nowhere inhabit a snowy region, have entirely exposed nostrils. Furthermore, as I shall point out later, certain species of the last genus appear to have definite preferences regarding a moderate environmental temperature. The Emperor Penguin, at the other extreme, goes through its breeding period at a time when the thermometer never even approaches a degree of warmth equal to Centigrade zero, and plunges into the ocean through cracks in the sea-ice during antarctic midwinter. Such traits are not only physiological, but are also germinal and heritable, no less so, in fact, than morphological features. They fit in well with the hypothesis that structure precedes function, and must certainly have had an important selective value as regards environment and present distribution.

Kendeigh (1934, 396) refers to this principle when he uses the term "limits of tolerance" in relation to various environmental factors explaining the distribution and migratory movements of birds. In a state of nature birds do not normally reach any such actual limit but respond rather to antecedent zones of physiological discomfort or grades of preference. We may think in such terms of the mutually exclusive breeding ranges of the Magellanic and Peruvian Penguins. In this instance, a preference regarding water temperature might stand as one limit of tolerance, and interspecific competition as another.

The ability of the Emperor Penguin to endure a temperature corresponding to the greatest terrestrial degree of cold, and to undergo the most exhausting of its life functions during this period, is one of the most remarkable physiological feats known among warm-blooded animals. The following quotation from Bigelow (1931, 149) will serve to emphasize this point:

> The discovery of warm blood has never been made among sea animals. All that live there are descended from warm-blooded terrestrial ancestors. Animals of truly marine heritage have not found it necessary to provide the protection against variations in the thermal environment. The warm-blooded oceanic animals are under a handicap because the capacity for heat of the medium in which they live makes the maintenance of their own body temperatures a much more difficult task than it is in the atmosphere. A penguin, for example, requires the bulk of its blubber as a protection against the outside cold, but the mere presence of this makes the bird require more food as well as more energy for propelling its body through the water. A fish, on the other hand, needs no fat at all for the purpose of insulation, but only as a storehouse for energy. This, moreover, is capable of being drawn upon even to the point of total exhaustion.

Another physiological item of great interest, and worthy of the investigation it has never received, involves not only penguins but many other sea birds as well. This has to do with the seasonal and abrupt change from the ingestion of sea water to that of fresh water, and *vice versa*. The Adélie Penguin, for example, comes ashore in antarctic spring from its pelagic migration, and for the ensuing month of the courtship period eats absolutely nothing but snow, which in that part of the world is practically pure, mineral-free H_2O. After the eggs appear, this species resumes the drinking of sea water. The Humboldt or Peruvian Penguin, on the other hand, inhabits a tropical desert coast and throughout its life has no source of free fluid other than rather highly saline ocean water. The copious swallowing of fresh water is apparently enough to cause the death of at least a chick of this species, perhaps because of the resulting change in the hydration of its tissues.

It would seem that animals which can live without liquid other than sea water must be able to excrete a highly concentrated urine. The human organism can seldom excrete urine containing more than two per cent sodium chloride. Animals restricted to sea water can dilute it in the body only with H_2O produced by the burning of food. Part of the water thus produced leaves the body as vapor in the air expired from the lungs, and, in some animals, part leaves in the form of sweat. Birds, of course, have no sweat glands, but the antarctic penguins must lose important amounts of moisture through respiration because the cold air they inspire contains little moisture, while the warm air they breathe out carries a good deal. It is quite possible that they lose by respiration more water than they produce by combustion of food. In the latter case, if they drink only sea water the salt concentration in the urine would be greater than in sea water. It would be highly interesting to find out whether this is true.

Some physiologists appear to believe that sea birds do not drink ocean water, but that, like marine turtles, they make use of only the water content of their food together with metabolic water, conserving practically all except what is lost with the expired air by reabsorption in the urinary tubules and in the cloaca. This is undoubtedly true of many birds during the nestling stage, but there is abundant evidence from direct observation that the adults actually swallow sea water. We need, however, exact information regarding the quantity ingested before it can be learned how closely metabolic watei alone can come to maintaining rheir water equilibrium.

The bird's kidney differs from that of the lower vertebrates in that about one out of every five tubules is of mammalian character, the other four being reptilian. Birds and reptiles agree in that they excrete a large proportion of their metabolized nitrogen in the form of uric acid, a physiological habit which in two ways subserves water economy. In the first place, there is a limit to the osmotic concentration of urine, and the structure of uric acid is such that each molecule (that is, each osmotically active moiety) carries four nitrogens into the urine, rather than two as is the case with urea. Secondly, uric acid is a chemically peculiar substance in that it is capable of colloidal suspension up to about 20 per cent, even though its actual solubility is extremely small. The colloidal solution is highly unstable, and at the slightest provocation solid uric acid is precipitated.

Birds undoubtedly excrete such a supersaturated or colloidal solution of uric acid into the ureters. When this fluid passes to the cloaca, the uric acid is thrown out and the water in which it was suspended is reabsorbed, leaving only a semi-solid residue to be expelled from the body. Consequently, the animal loses a minimum of water through the ordinary excretory routes. It seems likely that the origin of such a uric acid habitus is connected with the necessity of the birds to conserve water.

The ability to change from drinking seawater to drinking fresh water, and back again, might be expected among animals the kidneys of which have developed a high degree of regulatory power with respect to the excretion of water and salts. When the sodium chloride concentration in the blood plasma of vertebrates in general sinks below a certain level, urinary excretion of chloride stops, so that very little is lost from the body. Consequently, the creatures can go for a long time without salt. With respect to the penguins, two problems are presented: first, that a young example of the Peruvian Penguin should die apparently from drinking fresh water (as related in the subsequent biography), and second, that the Adélie and other penguins should survive when drinking seawater exclusively. The latter appears to be of the greater physiological significance, because many animals can be killed merely by pushing the rate of fresh water ingestion beyond the normal.

All penguins appear to be myopic in a medium of atmosphere. Their resulting behavior is one of the reasons why so much description has been tinged with anthropomorphism. Despite their nearsightedness, however, their eyes are extremely sensitive to light. When a penguin stands with one side of its head in shadow, the pupil on that side will often be widely dilated even when the other is contracted to a tiny speck.

Regarding the extensive oceanic travels of many kinds of penguins, Bigelow writes (1931, 149):

> The ordinary problems of bird migration are considerably more complicated if we consider the seasonal journeys of penguins which travel for many hundreds of miles through a medium in which temperature and chemical composition are so nearly uniform over long distances that the most delicate tests are needed to reveal any differences at points many miles apart.

Levick (1914) goes so far as to say that the migrations of the penguins at sea, together with their direct journeys across ice-fields when their horizon cannot be more than one or two kilometers distant even in the clearest weather, is an "unanswerable reply" to naturalists who maintain that such birds do not possess a "special sense of direction."

Psychobiologic Reactions

Penguins, like other birds, are creatures of highly instinctive behavior which expresses itself in what may prove to be relatively simple patterns. Nothing could be farther from the truth, of course, than the popular conception regarding their "intelligence." I judge, indeed, that they become conditioned to new stimuli much less readily than the majority of higher birds, although the evidence for this can hardly be called final. Certainly in their contacts with human observers, penguins exhibit the folly of instinct no less often than its perfection. Unfamiliar situations, however palpable from our point of view, present problems which they solve slowly if at all, and they show a more than Chinese tenacity in clinging to the ways of their ancestors. Particularly in following tracks over difficult ground or ice, penguins are prone to trudge in the wake of a pioneer of their own kind long after such an original route remains practical, and even though better and safer paths lie directly under their eyes. Many examples of this apparent and often laughable obtuseness will be found in the biographies that succeed this section.

Possibly such lack of awareness works for the welfare of the various species in the long run, as do certain other reactions which might ordinarily be called antisocial. Bennett (1927, 259) writes, for instance, that the period of the year during which the antarctic penguins are on the nesting ground can be summed up as one of feeding, fighting, courting, thieving, and philandering. The thieving consists of robbing each other of nesting material and eggs. The egg-stealing habit is probably beneficial, first because it tends to prevent eggs from becoming chilled, and second because it covers them before ever-present enemies can pounce upon them. Furthermore, it means that one or more eggs of a set may still hatch, even when one or both parents have been sacrificed to a sea-leopard.

The opportunities offered by penguin communities for studies of social organization have hardly begun to be realized. Probably most published observations are insufficiently objective, although there is also a considerable mass of literature worthy of study in the light of conclusions derived from tested and more closely controlled sources. The excellent records of Levick, for example, include many precise descriptions of penguin behavior which seem as though they were fully comparable with recent laboratory discoveries regarding other birds. There comes to mind immediately Levick's account of the rogue or "hooligan" Adélie Penguins, the vicious behavior of which makes them a scourge to normal breeding penguins in the antarctic colonies. If such rogue penguins are assumed to be unmated birds in a great flock composed mainly of couples with reduced outside contacts, their behavior can be interpreted as that of individuals which have not been able to sublimate their pugnacious and dominating urge, which is at one stage a necessary element in the courting and mating pattern.

The work of Masure and Allee (1934, 306) on social order, "pecking rights," etc., among chickens and pigeons suggests, in fact, a number of explanations for penguin behavior which had formerly seemed unaccountable. These authors, repeating in part the investigations of Schjelderup-Ebbe and other biologists whom they cite, find that a definite social order exists in all sex-segregated flocks, the outstanding indication of caste or privilege being the ability to peck other birds without suffering retaliatory pecking. A mixing of the sexes, with subsequent pairing off of the birds, serves to change the picture. In a flock of mostly mated pigeons the greater part of the pecking was done by two unmated females, and it is the latter to which I would compare Levick's "hooligan" penguins.

Masure and Allee find that birds standing high in the social system have more contacts than those lower in the scale. Among chickens, one hen may peck without being pecked back, and a second may hold the pecking right over others of lower social status. The hen at the bottom of the scale might be seriously hampered in gathering food, even to an extent which would rapidly lead to its death. It seems to be fully established that strength is only one factor in this social stratification.

There is evidence, some of which is detailed hereafter, that penguins have what might be called an "Ugly Duckling complex," that is, that they express strong negative reactions toward abnormal members of their own society. During the mating season, however, the tables may be turned, and a hitherto marked and scorned female, such as an albino, may change its social status and become the object of particular solicitation by amorous males.

In the problems connected with the recognition of sex among birds, a penguin colony would offer an ideal field laboratory. Levick's notes at least suggest that the Adélie Penguins can mate only through initiating the first phase of courtship behavior with reference to random other penguins, the next step being determined by the response of the individual addressed. Thus he describes male birds bowing and making the gesture of placing a pebble (real or imaginary) at the feet of a neighbor. If the latter pays no attention to the approach, it is at best an unreceptive female; if it fights, it is probably a male. In either case the progressive courtship pattern is for the time sidetracked. If, however, the second bird responds appropriately, it is a female nearing the oestrus condition, and the affair may proceed.

In Gillespie's book on captive King Penguins at Edinburgh (1932), there are also numerous suggestions that sex recognition is only one of the results of the individual struggle toward intimidation and social dominance, although the testimony is inconclusive. However, under date of December 5, 1932, Mr. Gillespie has written me as follows:

> It does seem that the king penguins fail to recognize each other as to sex. Both sexes were represented among our birds, even when there were only three of them. What I saw (subsequently checked by proof of the sex of each bird) was, (1) a female pursuing a male and assuming masculine behavior; (2) one male endeavoring to mate with another, even though a female was present and apparently receptive; (3) two females attempting to mate, although an unmated male was with them.
>
> The first case may be explained by the fact that the female was sexually mature, while the male probably was not, and a parallel set of circumstances may account for the third case. The second, however, indicates that sex-awareness was wanting except through trial and error.

All of this is suggestive rather than conclusive, but it agrees with the recent findings of Allen (1934, 180) regarding the Ruffed Grouse, and perhaps other birds as well. His studies indicate that certain birds which lack pronounced differences in the secondary sexual characters do not immediately recognize or discriminate between the sexes in their own species. Rather, such discrimination is arrived at by trial; behavior patterns of domination and subservience then become important in the control of the mating cycle.

Recent experimental research on fowls, pigeons, and mammals by Riddle (1935, 730; 1935, 352), Bates (1935, 361), and others serve, furthermore, to give us a physiological framework for the remarkable brooding habits of the Emperor Penguin, which have been so well described but so little understood. We know that four or more distinct hormones are sent into the blood stream by the anterior lobe of the pituitary gland, of which two—the follicle-stimulating hormone and prolactin—are mutually counteractive. The former acts upon gonadal tissue and, by regulating the estrin output of the ovary, increases uterine or oviducal size. Prolactin in turn puts a check upon such processes, and also induces broodiness, which among birds is now identified as the phyletic equivalent of both the maternal instinct and lactation among mammals. Injection of prolactin, for example, causes virgin rats to cuddle new-born members of their own kind; likewise it arouses the incubating response in hens that have not laid eggs. In nature, broody behavior is, of course, essential to the propagation of birds, but the objective of incubation would be defeated by an ovary that continued to produce eggs. It is therefore essential that broodiness be synchronized with either an inactive or an involuting gonad, and the secretion of prolactin brings about both the reaction and the necessary synchronization.

It seems clear that by means of a third physiological agency—connected possibly with exceptionally delayed attainment of sexual maturity—a partial suppression of the secretion of follicle-stimulating hormone among most members of a so-called "breeding" Emperor Penguin population is counterbalanced by an abundance or excess of prolactin secretion. Thus is produced a much higher percentage of brooding than of reproducing adults. Few lay eggs but all are conditioned to hatch them, with the result that plenty of "parental" care is assured for chicks which must live through more desperately severe environmental conditions than those experienced by any other young birds.

Finally, it seems to me that a thorough study of the motivation and pattern of penguin behavior might offer valuable data regarding the systematic relationships of the group. Very many of the normal reactions of penguins closely resemble those of certain Procellariiformes and Pelecaniformes. Their posturing known as the "ecstatic attitude," with the neck and the flippers at right angles to the body; their swaying of the head while gaggling; their inversion of the head and neck over the back; their use of pebbles, feathers, and other objects in the courtship performance; their inability to recognize their normal food when it is out of the water, unless they are artificially conditioned to do so—these and other items of penguin behavior are exceedingly like those of albatrosses, cormorants, or boobies. It remains only to learn whether such reactions are broadly avian or whether, as I suspect, they are more or less peculiar to rhe three orders of birds referred to, and probably indicative of blood relationship between them.

Distribution

However little doubt there may be about the austral origin of the penguins, the group is not now by any means antarctic. Only two of the seventeen species reach the shores of the polar continent or even cross the antarctic circle. Five more nest in regions varying between ice-covered and ice-free; six species belong definitely to south-temperate latitudes; and four are tropical or sub-tropical. Some penguins are more or less circumpolar in distribution, which makes it possible for seven species to center around the Cape Horn-Antarctic section, four around the Kerguelen-Heard region in the southern Indian Ocean, and eight around the New Zealand region. In more excentric circles, which cut the southern continents, we find two species in African waters, three in America, and three in the Australia-Tasmania district.

No birds illustrate more thoroughly than penguins the effect of oceanic circulation upon distribution. Few species, asserts Boubier (1919, 131), have been able to endure the increasing rigors of their supposed ancestral home. All directions away from the antarctic are, however, northward, and the birds have found that an intermediate climatic zone offers optimum conditions for their needs. In what manner have they extended northward, asks Boubier, and why to such unequal distances from the antarctic circle? Compare the latitudes attained by four different species:

Galápagos Islands: Equator.
Brazil: 24° to 30° S.
Angola: 16° S.
West Australia: About 22° S.

Boubier discusses the cool, northward-flowing ocean currents, and gives data on the relative temperature of the water at various points inhabited by penguins. Just north of the tropic of Capricorn, he says, at Swakopmund in southwest Africa, the mean annual temperature of the surface water is 14.3° C., as against 23° at the same latitude on the coast of Brazil. In August the temperature at Swakopmund is but 9.3°, whereas at no point along the eastern coast of Africa does it ever become as cool as that. Finally, at Swakopmund the water has a mean annual temperature of about 1° C. lower than that of the atmosphere. As regards conditions in America, we are already acquainted with the effect of the Falkland and Humboldt Currents. The coast of Patagonia, furthermore, is bathed by cool bottom waters brought up by convection; between latitudes 36° and 40° S. the surface temperature of the water averages only 10° or 11° C.

Boubier gives an excellent description of the contrast between the plankton of the Benguela and of the Mozambique or Agulhas Currents, on opposite coasts of Africa, and of the rich coastal waters of Atlantic Patagonia. He states, moreover, that the isotherm of 20° C. for the mean annual temperature of the air coincides with the northern limit of penguins. This isotherm passes from the coast of northern Peru southeastward across South America toward Rio Grande do Sul, later turns northeastward across the Atlantic to the west African coast, which it redescends toward the Cape of Good Hope, and then inclines slightly to the northward across the Indian Ocean, reaching the Australian coast not far from the tropic of Capricorn.

It remains to say, concludes Boubier, that with one or two exceptions the penguins diminish in size as their ranges extend away from the high-latitude center of dispersal. The largest species is the Emperor of Antarctica; the smallest are the penguins of Australia and the Galápagos.

In the subsequent biographies I shall have more or less to say about the apparent distribution of penguins by means of iceberg-riding, or through other influences of the west-wind drift, from the American section of the Antarctic toward the eastern South Atlantic, Africa, and the Indian Ocean.

KING PENGUIN

*Aptenodytes patagonicus**

Aptenodytes patagonica J. F. Miller, 1778, Var. Subj. Nat. Hist., pt. 4, pl. 23. (Locality uncertain, but probably South Georgia, from where the first specimens may have been brought to Europe.)

Names: In South America, "Pingüín Real," "Pingüín Rey." These are Spanish "book names," translations of the English designation, which is a true folk name. The principal specific names under which this penguin has been listed are the synonyms *patachonicus*, *pennanti*, and *longirostris*.

Characters: Nearly a meter in length, and second in size among existing penguins. Resembling only the Emperor Penguin, from which it differs in being smaller, of brighter coloration in the yellow areas, and in having the base of the lower mandible and the tarsus unfeathered.

Adults (sexes alike): Bill long, slender, pointed, and slightly decurved, the maxilla and tip black, the broad plates of the mandibular rami basally orange, fading distally; dorsal plumage bluish gray; ventral surface, caudad from the breast, white; rectrices and vestigial wing quills mostly blackish; head and throat black with a greenish gloss; spatulate auricular patches of cadmium yellow, extending caudad as narrowing bands and joining the orange breast-plate, which blends through golden and paler yellow with the white of the lower breast; narrow lateral black lines extend along the throat and sides of breast, demarcating the dark dorsal and light ventral plumage, these lines broadening toward the front of the shoulder, and ending below the axilla; feet black.

The color of the reticulated iris is raw umber. The pupil is *square* when contracted; when dilated it assumes a succession of polygonal shapes, like an "iris diaphragm." This character has been reported by Eaton (Sharpe, 1879, 152) and many successors. Werth (1925, 600) notes that at night the pupils are very large, whereas in daylight they are reduced to a minute dot. In life the prominent nictitating membrane is frequently passed across the cornea.

The sides of the mandible in living birds are yellow, deepening into orange and then into coral-red toward the central part of the mandibular shield. Reported sexual difference in the color of the shield is not borne out by my observations. At the front of the neck, where the branches of the cadmium auricular patches are confluent, the color becomes orange. The posterior edge of the patch, where it joins the bluish tone of the hind neck, is distinctly green, the blending of the yellow and blue producing a solid color on the individual feathers. The concealed portions of the yellow feathers of the ear-patches are white; those of the feathers on back and breast, grayish.

The length of one adult in the flesh, from tip of bill to tip of tail, was 97 cm.; to tip of longest toe, with legs outstretched, 114 cm. The sexes are alike in size. Dimensions of 15 adults are as follows: bill from gape, 122–136 (127); bill from nasal feathers, 69–78 (74); wing from axilla, 320–341 (328); tail, 45–78 (63); foot, heel to tip of middle claw, 157–180 (172) mm.

*Although in the foregoing text I have followed the precedent of Peters and others in giving this specific name a feminine ending, the genus (ἀπτήν, wingless + δύτης, a diver) is clearly a masculine term.

Reid (1835, 132) gives a full description of the King Penguin's anatomy, together with comparative tables of certain structures in this and other species. He notes that a male from the Falklands had a small intestine 6.85 meters in length, the combined length of the remainder of the alimentary tract being less than 60 centimeters. Such a proportion is fairly characteristic of fish-eaters in general. Le Souëf (1902, 26) has called attention to the long spines on the King Penguin's tongue, and upon the sides and roof of the mouth.

The mesoptyle down of chicks is dusky or smoky drab, that of younger birds apparently still undescribed (see notes in the biography).

The large egg is subpyriform, and of a pale olive-green color. An egg taken from the oviduct of a dead bird is pure white. Soon after being deposited the eggs become so plastered with mud that the original color of the shell is indistinguishable Measurements of six from South Georgia are: 108 x 77, 98 x 74, 96 x 75, 108 x 76, 101 x 76, 107 x 75 mm. The eggs have pale yellow yolks, and are without strong smell or flavor.

Distribution: The range of the species, including subspecies of slight distinctness or doubtful validity, is circumpolar in the zone of the westerly winds. The King Penguin is typically "low antarctic," being replaced on polar coasts by the Emperor. It even touches the temperate border of the sub-antarctic belt, as a breeding bird, at the Falkland Islands. However, the latter can be called temperate solely because of continental influences upon the climate; the Falklands lie, in reality, well south of the latitude of Kerguelen Island.

Breeding colonies of this penguin, outside the American region, are known at the Prince Edward and Crozet Islands, Kerguelen, Heard Island, and Macquarie Island. Stragglers have been reported from New Zealand and the islands just to southward, and from Tasmania.

In the South American pan-antarctic the King Penguin breeds at South Georgia, the northerly islands of the South Sandwich group, and at Staten Island, where it was formerly abundant. The Falklands, too, once harbored populous colonies, but are now visited only by wandering birds. The greater part of the eastern Magellanic region was doubtless once within the breeding area, for the King Penguin has been recorded as resident in the Strait of Magellan and other Fuegian channels. Specimens have been taken as far west as Magallanes during February, the height of the normal breeding season (Burmeister, 1888, 321; Salvadori, 1900, 633; Reichenow, 1908, 546; Dabbene, 1920, 7). In western Tierra del Fuego, or elsewhere on the windward coast of southern South America, the species seems to be known only from Molina's account (1810, 201, "*Aptenodytes maxima*"), which states that it sometimes visits the region between Chiloé and the Strait of Magellan.

There are no records of the King Penguin at the South Orkney Islands, and no recent records for islands of the archipelago of West Antarctica, south of Cape Horn. James Eights (1838, 211), however, published an excellent account of the bird and its breeding habits as observed at the South Shetland Islands where, he states, the King Penguins were to be "seen in great numbers, covering the shores for some considerable distance." If this be correct, the species has crossed the 60th parallel of south latitude, and approached relatively near the antarctic circle, only in the American sector of its range.

With its large size, graceful lines, and golden ornamentation, the King Penguin is one of the handsomest members of its family. Although less impressive in stature and bulk than the Emperor, its dignity of behavior suffers nothing by comparison, while in color pattern it is an even more striking creature.

Time was when the King Penguin was familiar to travellers along the coast or through the narrow waterways of southernmost South America. Its actual breeding places were assuredly always upon islets rather than continental beaches for, even at the Falklands, Fitz Roy (1839, 252) noted that the now extinct wild dogs or "foxes" preyed upon the King Penguins when they landed at any of the main islands. Nevertheless, the Magellanic strands, like those of true sanctuary-islands from Staten Land eastward around the world in the zone of pan-antarctic environment, were in all probability once lined at certain seasons with ranks of this gorgeous bird.

Part of the early history of the species can never be reconstructed; for the rest we must delve into the scattered journals of old-time voyagers. Of this we may be certain—that man is wholly and directly responsible for wanton destruction of the King Penguin throughout its former range. Nowhere has the bird come into actual competition with him, his domestic animals or plants, or his fisheries; nowhere has it occupied territory that human beings wanted for another purpose. But working against the existence of the King Penguin, since the late eighteenth century, have been its tempting, gold-bedecked skin, its oleaginous coat of fat, its sedentary habits, and its disregard of man. This last, being a congenital character of penguins, is not to be eliminated from the species through the mere experience of individual birds. Furthermore, the edibility of penguin eggs, and the fact that the King Penguin neither hides in a burrow nor nests in high places of difficult access, have also worked toward its selective extinction.

At all breeding grounds regularly visited by men, the reduction of the King Penguin has run a progressive course, at least until the partial legal protection of recent years. Increase of numbers is now notable at South Georgia, and perhaps at Macquarie Island, south of New Zealand. At the latter locality, however, single colonies covering 30 to 40 acres, as reported in 1834 and later, and characterized by hordes of as many as 60,000 birds simultaneously entering or leaving the sea at any hour of the day or night (Bennett, 1834, 34), had been so decimated by the early part of the present century that the whole island was estimated to possess only 6000 to 7000 of these penguins (Ainsworth, 1915, 167).

At the Falkland Islands, where King Penguins were not scarce up to 1870, they now occur so rarely that the sight of one example is worthy of record. Rumor has it that all the residents of the last rookery in West Falkland were boiled down by a shepherd who used their oil to waterproof the roof of his house (Vallentin, 1924, 288). At Staten Island and South Georgia, where the King Penguins have likewise been much persecuted for their oil, a great diminution in their numbers has been noted for half a century or more (Klutschak, 1881, 522; Fauvety, 1888, 322). If the species ever inhabited the South Shetlands, as seems strongly probable, it disappeared long decades ago.

Turning now to one of the few regions upon which the crushing hand of man has fallen lightly, it seems happily true that the King Penguin may be as abundant as ever at certain islands of the icy and remote South Sandwich group, southeast of South Georgia. Here vast numbers of penguins were observed by the Russian circumnavigator, Bellingshausen, in 1819. A century later the German south-polar explorer, Filchner (1922, 121), likewise reported hundreds of thousands of breeding penguins, representing three or more species, at Zavodovski, Candlemas, and other of the South Sandwich Islands visited by Bellingshausen. Neither the Russian nor the German identified his penguins, but Sir Hubert Wilkins (1923, 491) has since clinched the matter by his specific record of King Penguins as one of the kinds observed abundantly upon Zavodovski and in the waters round about.

During the course of the Brewster-Sanford Expedition the King Penguin was not encountered, but in the southern summer of 1912–1913 I found it common, though nowhere very numerous, at South Georgia (Murphy, 1915, 103). In the following pages my previously published notes on the species are transcribed, with the free interpolation of data from other literature.

Captain James Cook, the discoverer, refers to the large numbers of King Penguins observed on the occasions of his several landings at South Georgia in January, 1775, and James Weddell, who visited the island in 1823, has left us an entertaining and substantially accurate account of the bird. For more than a century there was no check upon those who sought its oil. Klutschak saw the wreck of a French penguin-hunting ship in 1877, and reports that the pairs of small iron try-pots, in which penguin blubber was rendered, could be seen at that date in many places along the northeastern coast of the island. When, however, South Georgia was made a political dependency of the Falkland Islands, a better era dawned, and recent motion pictures of the King Penguin colonies indicate that the population has multiplied even since the date of my experiences in 1913.

I visited three rookeries, all of which were in the neighborhood of nesting stations of a smaller penguin (*Pygoscelis papua*), but all on low ground. The last is characteristic of the King Penguin. Among scores of breeding places mentioned in the literature, I find a reference to but one on a knoll, "about a hundred and fifty feet above sea level," this being at Right Whale Bay, South Georgia (Matthews, 1929, 590). Bare, bleak moraines, well back from the water, with a snowbank and a glacial torrent close at hand, seem to be the preferred sites at South Georgia. The prevailing winds, chilled by the snow of the higher slopes from which they blow, sweep through the unsheltered penguin communities during a large proportion of the time.

In less actively glaciated regions the King Penguins select a similar terrain as regards lowness and freedom from vegetation. At Marion Island, of the Prince Edward group, the 'Challenger' party found a colony on a slimy flat, surrounding a tarn a kilometer from the sea (Campbell, 1877, 86; Moseley, 1879, 176). Of the Macquarie colony Wilson (1907, 34) writes that it lay in a stony quagmire between the strand and the foot of the hills.

> The Kings' rookery was filthy, neither more nor less, and the whole area smelt abominably . . .—hundreds . . . huddled together in close companies, living and breeding on an area of mud, stones, and water at the foot of the overhanging hills. The breeding birds avoid the tussock grass, amongst which one finds only bands of bachelors and unemployed. Generally, the sitting bird makes an effort to keep clean and dry by balancing itself on a stone, a little island as it were, in the muddy trickle that surrounds it.

Away from the immediate vicinity of the South Georgian colonies I observed only a single King Penguin ashore, but on the whaling banks, thirty or more kilometers to northward of the island, instantaneous glimpses of foraging birds were sometimes to be had from the whaling steamers, when the King Penguins leaped above the surface for air. They were never so common on these banks as *Pygoscelis papua*, partly because the latter is a far more abundant bird and partly, perhaps, because King Penguins are mainly squid-eaters rather than crustacean-eaters. It is probable that they find the bulk of their food close to shore, in the great fringes of kelp. This is correlated, furthermore, with the fact that the King Penguin is a sedentary species, not migrating from its breeding grounds at the end of the antarctic summer as so many of the smaller penguins do

The hordes of King Penguins in coastal waters close to large breeding stations are well described by Hamilton (1895, 559), who saw many thousands in Lusitania Bay, Macquarie Island, in March. They were sporting around an anchored vessel, chasing each other in strings, like porpoises, or dashing about at great speed in small compact bands. For the most part, of course, they remained beneath the surface, but they often sprang into the air during their play. Sometimes they rolled, or lay comically upon their backs. Many pecked at the water line of the ship or even attempted to scramble aboard. They were all incredibly quick in their movements, and easily avoided anything thrown at them.

The life histories of birds of the far south are generally made up of successive phases which, at least in any one locality, fit all members of a given species. Thus the eggs will normally be laid at about the same date, the chicks will grow up together, and the end of the reproductive season for the entire group will come at the same period within limits of a very few days. This represents a natural dovetailing with a severe and rigid meteorological cycle, and is what we should expect. The pattern applies to all pan-antarctic species that have a relatively short breeding season, as well as to some of those with a long breeding season.

But the King Penguin appears to be an exception. Reports from many widely separated breeding stations indicate that, while the peak of egg-laying comes in November or December, eggs in every stage of incubation may be found at any locality throughout half the year. At Kerguelen, Rallier du Baty saw eggs in October (Loranchet, 1916, 154). Larsen, at South Georgia, found young birds in various stages, as well as fresh eggs, as late as March 10, and he believed that even this far into the antarctic autumn some of the adults were still to lay (Lönnberg, 1906, 88). The state of affairs might be attributed to egging by marauding sealers or whalemen, necessitating the production of second-brood eggs, were it not for the fact that the moulting régime of adult King Penguins shows a similar irregularity. Moulting birds have been noted during every month between November and April, and it is probable that the aggregate period of plumage replacement occupies an even greater proportion of the year.

The circumstances are not difficult to understand when we consider that the King Penguin has no pronounced migratory impulse, that the ocean about its permanently occupied shore-territory is never completely ice-choked, and that the low antarctic winter climate is, on the whole, only slightly more severe than the summer climate. Within limits imposed only by the individual periods of parental responsibility, a King Penguin might undergo at almost any time of year the lie-up and fast enforced by the moulting process.

When I entered my first King Penguin rookery, at the Bay of Isles, South Georgia, on December 16, 1912, a few young of the previous year, fully grown but with ragged patches of long down still attached to their contour feathers, were associating with adult birds. Many of the latter were incubating, and at the approach of human beings they stretched up to the greatest possible height, and clung tenaciously to their eggs. After the members of a sealing crew had piled many eggs at one spot, the robbed penguins approached the heap and appropriated eggs to replace the lost ones. But not only did they take one egg—the proper complement; several tried to tuck *two* between their legs. One bird even attempted to gather up an egg that had been thoroughly crushed.

Thus, in common with the Emperor Penguin, the King develops insatiable sitting propensities. Repeatedly I saw robbed birds mothering smooth stones, when eggs were not obtainable. Those that did not have recourse to such cold solace shuffled around on the full length of their feet for a while after being forcibly deprived of the egg, instead of rising at once to the ordinary digitigrade gait as they do after a normal exchange of the egg between mates. In other words, if the stimulus is unduly abrupt, it takes the birds an hour or longer to become conditioned to an empty egg repository.

The egg is carried in the space between belly, tail, and feet. There is nothing in the way of a "cavity" or "pouch"—two words so frequently used in this connection. The position of the sitting bird is squatty, with inturned toes, depressed tail, and a broad transverse fold of skin covering the front or smaller apex of the egg, which is raised above the ground and rests upon the feet.

It is curious that the method of incubation of the King Penguin was so slow to find acceptance, for it was correctly described a hundred years ago, or thereabouts, by Weddell, Bennett, and Eights. The last, who was a surgeon, says that at the South Shetland Islands a person not acquainted with the peculiar breeding habits of the King Penguin might pass through hundreds of the birds without suspecting the presence of eggs. This is precisely the case. More recent accounts, with careful scientific detail, are those of Moseley, Kidder (1875, 41), Hazard (1894, 280), and Hamilton.

Incubating King Penguins can shift about slowly in spite of the egg on their insteps. They drag themselves along, maintaining a hunched posture, and hitching the feet with short steps so that the egg may not roll out. If they chance to trip, or if they are bowled over, they fall as stiffly as a statue, with the egg still in place. Recovery is accomplished by first using the bill as a prop against the ground, and next bracing themselves with the flippers, the feet being all the while as immobile as it is possible to hold them, with no more than the tip of the egg showing at any time.

The sitting Kings are fond of crowding together, as if to facilitate quarreling though the latter reaction, accompanied by slaps of the long flippers, tends to keep a minimum distance of a little under half a meter between their upright bodies. The circle thus bounded is the true nesting territory. When one bird budges, trouble is in store. With the beginning of movement, the adjacent sitters may be seen to glare at each other with sinuous necks twisted and heads cocked, and then to deal resounding whacks with their flippers, or lunges with their sharp bills, unto all their neighbors. Whole groups may become engaged in an indiscriminate skirmish, as if with both rapiers and broadswords. The birds endeavor to maintain equilibrium while banging each other, and only occasionally is one knocked off its pins Even then the egg is usually unharmed. Bearing upon this is Wilson's interesting comment: ". . . so tightly were they held that although we lifted the birds bodily from the ground, yet the egg was very seldom dropped."

Such is the reach and flexibility of the King Penguin's extensible neck that each sitter may easily become the center of a large ring of trouble. One February forenoon, while I was watching an incubating cluster, most members of which seemed asleep, a typical squabble started. One sitter came to, and began to poke its bill into the back of another's neck. The latter bird, grunting vehemently, retaliated by delivering backhand blows with one wing, but without turning to face its opponent. Intrusion of the weapons of neighboring penguins diverted the attentions of the pugnacious couple, and the affair ended in a general mêlée in which nine birds took part, each for itself and against every other. Within ten minutes all of them seemed peacefully asleep again, every bird, with eyes shut, swaying ever so gently in rhythm with its breathing.

The sealers at South Georgia, one of whom had marked breeding birds, stated that the mated King Penguins relieve each other of the egg every twenty-four hours, the change usually taking place late in the morning. Hamilton reports that at Macquarie the sexes are said to relieve each other about every two days. This matter seems never to have been accurately determined in the field, but mated captives in the Zoölogical Park at Edinburgh varied in the period of alternate retention of the egg between half a day and a week or longer. During times of twice-daily changes, the male was observed to sit at night, the female throughout the day (Gillespie, 1919, 314). No such fixed schedule as this, however, obtains in nature, as shown by the sexes of incubating specimens examined in the flesh.

King Penguins which were believed to be the very individuals robbed of their eggs at South Georgia on December 22, had begun to lay a second time, if the assumption was correct, on January 8. Pairing continued in this colony until at least the end of that month. Courting couples were often seen strolling off alone, in a most human fashion, and making their way to the tops of hillocks or snowbanks, or even up the glaciers. The usual pattern of caresses is for the birds to cross necks and sway from side to side, while facing each other, and then for the cock to step aside and press on his mate's nape until her head is bent quite to the ground. In the pairing attitude the female is prone upon her belly, the male nearly upright.

Trumpeting enters into the courtship relations, but is by no means confined to them, nor to the time of year marked by sexual activity. Quarreling because of triangular complications seems to be invariable in the early stages. Buller

(1905, 78) says that in battles between amorous cocks the female concerned not only sides with the winner, which would be the expected response, but also that she usually joins in the fray when it has reached a certain pitch. Certainly groups of three, squawking and cutting, are a common sight among what Wilson calls the "unemployed" birds.

Gillespie's observations upon the Edinburgh King Penguins, referred to above, make up the most precise record we have of the behavior of mated pairs and their interrelations with neighbors. Certain of these captives on several occasions enacted the courtship rôle and produced an egg, but the struggles of unmated companions to gain possession of the egg resulted in disaster. How exactly this agrees with the now classic story of Emperor Penguins exhibiting their strange lust for anybody's egg or chick in the winter darkness of the antarctic shelf-ice!

On September 1, 1919, the latest of a number of eggs was laid in the Edinburgh Zoölogical Park, and on this occasion all birds except the mated pair were at once removed from the enclosure. Three days later, however, the calling of one of the excluded penguins so disturbed the espoused male that he began to spend all of his time answering, instead of relieving his own mate in the task of incubation. As soon as a third penguin was restored to the group, the male returned to his duty. While the female of this pair held the egg, she always remained in one spot, where she had scooped a depression in the sand, but when the male exchanged with her he carried the egg more or less all over the enclosure, even descending backwards from one ledge of rock to another without mishap to his burden.

On October 22 the egg was found to be chipped and the chick alive. Two days later it escaped from the shell, the period of incubation being thus seven weeks and two to four days. This agrees with reports from the field. The young chick was kept in the same retreat as the egg, and it began to feed at once from the gullet of its parents.

At the rookeries the young are retained in their protective cradle, and passed from parent to parent, as long as they fit. Aside from the need of warmth, there is no other safe place because of the presence of skua gulls, the instinctive enmity of other parent penguins, or the possible super-solicitude of adults without offspring of their own. There are plenty of the latter, for numerous observers have noted that old King Penguins outnumber the young by a ratio greater than two to one.

When the fat-bodied youngsters can no longer be tucked away out of sight, they can still hide their heads in the familiar retreat, and this sort of ostrich-snuggling is a characteristic attitude until the chicks are at least old enough to be safe from the skua. Unfortunately we know little about the process of growing up, which requires approximately nine months. No naturalist appears to have published a journal covering King Penguin activities throughout the term of southern winter.

After the chicks are large enough to be left alone, a control-mechanism common among colonial sea birds tends to keep them from going astray. This is the reaction which impels every brooding adult to jab and strike at any chick within reach except its own. A young bird carried by human hands to a strange part of a rookery is sure to be beset. When the chicks are older, their sociability binds them together in a restricted area. Within the limits of the colony the adults likewise retain a strong feeling for individual locus. Marked examples have been found by Hamilton to return from the ocean day after day to the same spot.

Newly hatched King Penguins seem never to have been carefully described. The youngest I have seen were taken in early June at South Georgia, and were presumably two or more months of age. The smallest specimen is 50 centimeters in length. Its bill, to which the egg-tooth still adheres, measures only 49 millimeters from the gape. As among most long-beaked birds, the differential spurt in the growth of the bill begins in later youth. The down in the June specimens is of a nearly uniform dusky or smoky drab color all over the body. In the youngest it is thin and short over a mask-like area on the face. Traces of light-colored natal down still cling to the tips of the juvenal down on the head. The mask, at least, is suggestive of the young Emperor Penguin.

The partly grown chicks of the King Penguin toddle about after their parents when the latter are on the move. They chirp and whistle, endeavor to nibble at the bills of the old birds and sometimes plead by swaying the head to and fro in the manner of a young cormorant. When the adult has been sufficiently stimulated, it regurgitates food into its gullet, lowers its head, and the chick dives in up to the shoulders.

The young ones are mutually congenial, curious, and entirely without fear of man. If you remain among a band of them, they are likely to crowd about and squeak as though they expected to be fed. Such groups reminded me of college students wearing raccoon-skin coats. Buller likened them to "retriever pups," but the aptest fanciful name ever applied was that of sealers at the Crozet Islands, who dubbed them "oakum-boys" (Layard, 1867, 460). They look exactly like large handfuls of oakum ready for calking the seams of a ship. The long woolly down affords an excellent non-conductive winter covering, but by springtime (November) it is liable to be uncomfortably warm during sunny hours. Chicks that have not begun to shed sometimes sit and pant with wide-open bills, as if in distress.

Yearling birds, such as I saw in December, may have body down 90 millimeters or more in length. It fades with age, turning a streaky golden brown or even yellowish. It always remains shortest on the head, becoming hair-like and matted elsewhere before the post-juvenal moult. The change of coat is well illustrated by a series of our specimens. The down on the flippers is the first to go; it is then lost from the belly, next from the back, and lastly from the upper breast, throat, and head. Fragments of it cling longest on the neck. For the most part the whole envelopment comes off in the form of tangled mats. For a few days the sprouting contour plumage fails thoroughly to cover the skin of the head and gular region, which is hidden only gradually by the succeeding growth of black feathers. The new plumage of the upper breast reveals a pale yellowish tinge. The auricular patches are yellow, slightly brighter than the breast but without a suggestion of orange. The subtle, greenish yellow gloss or bloom makes its appearance on the crown of the head soon after the down has entirely disappeared. The young King Penguin is then a less glorified replica of its parents, with a weaker, blackish bill. About the time that the juvenals take to sea, toward the end of their second summer, the black lateral plates of the mandibular rami are moulted, the newly exposed surfaces of the shields being white.

I observed adult King Penguins moulting throughout my stay at South Georgia (November to March). After complete renewal of the plumage, the horny mandibular shields flaked off. The best record of the entire process is based upon captives, chiefly at the London Zoölogical Garden. Under such conditions the moult may become irregular, or even be entirely suppressed for as long as five years. On the other hand, the moulting behavior of six or more captives was similar in detail, and therefore probably typical.

A prelude to the moult appears to be a period of unusually heavy feeding. One captive devoured fifteen herrings per day shortly before the beginning of its month of abstinence. The report does not state the relation of this quantity to its normal quota of food. At the incipience of the moult the birds begin to look seedy and puffy; the feathers lose their lustre, the orange hue fades from the mandible, the head becomes gray. The Penguin ceases to go near the water or to call. It mopes in one spot with half-closed eyes.

The tail quills are the first feathers to be shed, and, in general, those from the lower half of the body precede those of the back, upper breast, and head. A flexible sheath at the base of each feather shaft encloses the tip of the succeeding feather so that the faded and crinkled old plumage tends to cling until the new has acquired most of its growth. The regional order in the moult may therefore be largely determined by the assistance of the bird's bill, which rubs off the old coat in flaky masses, wherever it can reach. Certain patches on back and flippers may still be attached when the epidermis of the mandible peels off like parchment. After about a month the rejuvenation and refurbishing may be finished. The bird begins to trumpet, to seek food, and to take particular delight in the water of its pool, in which it plays and rolls, or lies in a spread-eagle attitude upon the surface (De Winton, 1898, 900; 1899, 980; Pycraft, 1907, 13; Seth-Smith, 1912, 60).

Moulting birds appear to be more or less segregated in the colonies. Indeed, if we may believe the reports from early days, when King Penguins were observed by hundreds of thousands, the territories of moulters, brooders, "bachelors," and fledglings, respectively, were definitely separated (Weddell, 1825, 55).

Interspecific aloofness, and what human observers might call vanity, are two marked traits of the King Penguin. They dwell within a stone's throw of *Pygoscelis* penguins, play in the same glacial streams and ponds, and land upon the same beaches, yet the society of the two species is all but inviolably distinct. The negative reaction, moreover, is entirely on the part of the King Penguin, for the smaller species will make advances toward almost any creature. It is interesting to discover, however, that the King Penguin's aloofness is only part of its grouping impulse. It likes company and is closely bound to others of its own kind. When it finds itself alone, which is rarely, it associates with the first available group of birds, of whatever kind. I saw one in a flock of *Pygoscelis papua*. Von den Steinen (1890, 229) reports the same phenomenon at South Georgia, and Brooks (1917, 136) found a lone bird in the midst of two hundred Magellanic Penguins, at Port Stephens, Falkland Islands.

King Penguins deport themselves in an amusingly "lofty" manner toward human beings, paying slight attention to a man's quiet intrusion. If they are annoyed, they march away slowly and with an air of indifference, until they have been actually frightened by abuse, when they fall upon their breasts and scurry on all fours. Sitting birds are remarkably stolid; their impulse to decamp is so thoroughly inhibited at that stage that it is almost impossible to stampede them even after their eggs have been taken.

In ordinary progression, the King Penguins use their wings less as aids to balance than the smaller penguins do habitually. In descending steep slopes, however, they hold them as far backward as possible, and thrust forward the head. I frequently saw the birds coasting on their bellies, otter-like, down a broad snowbank.

The actions of "bachelor troops," *i. e.* birds of both sexes which are neither moulting nor incubating, nor feeding young, always furnish entertainment to an observer. Such bands frequently come out of the sea during the warmer parts of the day to sun themselves upon the beaches. The birds sleep either prone or upright; if in the latter position they often turn the bill behind the wing, where the ancestors of penguins may once have had coverts. They preen themselves scrupulously and even perform the stunt of balancing on one foot while they scratch the head with the other. Their characteristics are almost "regimental"; they may stand at attention, mark time, and march in either single or double file. They frequently shake their wings rapidly while they walk or stand.

The voice of an adult King Penguin is a long-drawn bugle call, not unmusical, and almost worthy of being classed as a tune. I am not quite certain that the females trumpet in the same manner as the males, but, if they do not, there are mutual trumpeting performances between males during the period of courtship. When delivering the call, the bird stretches to its full height, points the bill skyward, and the volley rings forth from an expanded chest. At the close of the effort the head is tilted forward with a jerk and the bugler stands at attention—a rigid, constrained pose always held for several moments. The yearling penguin's call is a clear whistle of three notes, as soft and sweet as the whistle of a song bird.

Cephalopod beaks were the only substances found within the King Penguins' stomachs at South Georgia. Other observers report these as well as pebbles and fish. "Two to three pounds of sprats" were taken from one stomach at the Falklands (Snow, 1857, 1, 257). All the birds I have examined were fat, the layer under the skin being sometimes 2 centimeters thick. The average weight of four large adults was 20 kilograms (44 pounds), which is higher than most of the recorded figures. Will (1884, 133) gives an average of 17 kilograms for South Georgia birds.

As regards enemies, I judge that the King Penguin is troubled relatively little by the skua, the scourge of the *Pygoscelis* rookeries. Its enemy in the ocean is the sea-leopard (*Hydrurga leptonyx*). From the stomach of one of these seals killed at the Bay of Isles, South Georgia, early in the morning of January 14, 1913, I took the remains of four King Penguins, besides fish and other material.

The King Penguin being a relatively sedentary bird, there is every reason why it may have become differentiated into two or more geographic races in the several parts of its extensive range. The characters put forward for three described subspecies, however, prove not applicable to the many specimens I have examined. For this reason I hold to the binomial name.

EMPEROR PENGUIN

Aptenodytes forsteri

Aptenodytes forsteri G. R. Gray, 1844, Ann. and Mag. Nat. Hist., 13, p. 315 (Antarctica, latitude 64° 77′ S.).

Names: "Pinguín Emperador." The specific names *patagonica* and *patachonica* were applied to this species in some of the early literature, owing to confusion of the King and Emperor Penguins before the date of Gray's description; *imperator* is also a synonym.

Characters: Length, 105–115 cm., with a standing height nearly as great when in the digitigrade position; the largest, by far, of existing penguins. Generally resembling the King Penguin, from which it is at once distinguishable not only by its greater height and bulk but also by the absence of a concentrated area of orange on the throat and upper breast, the lack of a complete auricular patch, and the presence in place of the latter, of a large white and yellow or orange area on the side of the neck, sharply defining the black hood. The yellow part of this area forms what might be called an incipient auricular patch, which blends into the white on the side of the neck without any sharp border. The black stripe from the axilla, which separates the dorsal and ventral plumage along the sides of the breast, terminates in a conspicuous club-shaped expansion about 5 cm. from the black throat. The shorter and more pronouncedly decurved bill also constitutes a marked distinction from the King Penguin. Other distinguishing and diagnostic characters may be summed up as follows: mandible partly feathered, so that the horny plate is proximally attenuated to a point, instead of expanded into a broad shield; it is purplish or lilac along both upper and lower edges, and rose colored in the central and proximal parts; maxilla and tip of mandible black; solid black feathering of hood carried down the nape, which is therefore black instead of blue as in the King Penguin; on the throat the straight caudad border of the hood cuts squarely across the satiny plumage of the lower throat. The latter, as well as the breast, are in fresh plumage strongly tinged with a golden or tawny hue, like aged silk, so that observers in the field have usually noted the Emperor Penguin's breast as "yellow" rather than white. The effect is especially pronounced in a dim light, when the color can be seen to be diffused throughout the ventral surface. Inner side of wing-flippers entirely white, whereas in the King Penguin they are distally blue for a quarter of their length; leg feathered on outer side as far as basal joints of phalanges (in the King Penguin the feet are entirely without feathers).

The following dimensions of Emperor Penguins are based upon Byrd Antarctic Expedition specimens, without discrimination of the sexes, which are apparently alike in size:

7 adults: bill from gape, 106–122 (115); bill from nasal feathers, 47–54 (50); wing from axilla, 307–340 (326); tail, 73–103 (88); foot, heel to tip of middle claw, 162–170 (165) mm.

In general character the egg of the Emperor Penguin is similar to that of the King, having the same broadly pyriform shape. It is also of the same pale greenish color when fresh laid, but the surface is considerably rougher, most of the eggs being well covered with little nodules, or embossed lines of chalk. The size is extremely variable so that the smallest eggs are scarcely if any larger than some of those of the King Penguin, while others are almost half again as large. In a series of 18 recorded by Wilson, the lengths ranged between 107 and 131 mm., and the breadth between 75 and 86 mm. Eggs that had not lost water through freezing and evaporation weighed up to 448.5 g., or just short of one pound.

Distribution: Circumpolar in the ocean bordering the antarctic continent. Breeds only upon areas of fast ice at favorable localities along antarctic shores. Throughout the greater part of its range the wanderings of the species are confined to waters south of the antarctic circle, but in the American quadrant bands of Emperor Penguins move farther northward with apparent regularity during the summer, appearing along both coasts of the West Antarctic Archipelago ("Graham Land") and reaching the South Shetlands and, more rarely, the South Orkneys. The species is unknown at other sub-antarctic islands, except for one stray bird at Kerguelen, and is the most truly antarctic of all birds.

The most important single study of the Emperor Penguin was made during the British National Antarctic Expedition of 1901–1904. The chief account of these researches is that of Dr. Edward A. Wilson, surgeon and naturalist to the party, who, a decade later, lost his life with Scott on the return journey from the South Pole. Recording his impressions of the penguins on the ice of McMurdo Sound, during the earliest days of Antarctic springtime, Wilson (1907, 16) wrote:

> Here one might find them about the middle of September in small companies, and in the best of plumage and condition. They seemed then rather to prefer our company than otherwise; and a party of fifteen on one occasion followed us for some distance. Always full of curiosity, they would stand round in a group making comments to one another on our appearance. They had no objection to being photographed, but resented being stroked. Such a group formed an exceedingly beautiful picture; their lemon-yellow breasts shone like satin in the sun, and their bluish backs and jet-black heads set off the golden yellow patch on the side of the neck, and the rose or lilac streak on the lower bill. The back and breast, if the bird had just been in the water, would glitter with crystals of ice and salt. No doubt the brilliance of such a picture was much enhanced by the fact that we were just emerging from the darkness of a polar winter, during which we had seen no sun for seventeen weeks. But still, such is their size and colouring that they would form a striking feature anywhere.

The Emperor Penguin apparently came under the notice of antarctic seafarers during the first years of the nineteenth century. There is even good evidence that an egg of the species was obtained as early as 1838, although it was probably found upon floating sea-ice, far removed from the time and locality of its origin. But, in any event, the distinction between the Emperor and King Penguins was not at that date clearly recognized, and it was only after the opening of the present century that any detailed knowledge of the extraordinary life history of this only completely south-polar bird was acquired.

Of passing historical interest is the fact that the Emperor Penguin presaged, in a very practical manner, the discovery of continental land in the far south. One captured on January 23, 1840, in latitude 66° 52′ S., longitude 150° 25′ E., during the course of the United States Exploring Expedition, was found to have in its stomach a quantity of basaltic pebbles, which were rightly interpreted as an indication of unknown antarctic lands (Peale, 1848, 258).

Beginning with the discoveries in Ross Sea, or among the ice-pack to northward, the Emperor Penguin has been encountered by successive antarctic expeditions at whatever point the central land mass was approached. Subsequent to the finding of the breeding station at Cape Crozier, at the western end of the Ross Shelf Ice, others were located by the Australasian Antarctic Expedition on the Shackleton Shelf Ice in Queen Mary Land (Mawson, 1915, 2, 116), and by the German South Polar Expedition at Gaussberg (Vanhöffen, 1905, 505). We now know that the range of the bird is completely circumpolar, even though its actual breeding grounds in the American quadrant are still to be found.

The southern limits of the Emperor Penguin's range are probably those imposed by the varying front of the Ross Shelf Ice, in about 78° S. Northward extension seems to be determined by the limits of pack-ice, and in general the bird is rare outside the antarctic circle. South of Cape Horn, however, the chain of high islands projecting northward between the Weddell and Belgica Seas presents a pathway by which Emperor Penguins, in common with many other antarctic organisms and phenomena, find their way into relatively low latitudes. On one side or the other of this region, which is in effect a peninsula extending into the west-wind zone, the Belgian, French, Swedish, Scottish, German, and other antarctic expeditions of recent years have met Emperor Penguins as far north as the South Orkney Islands, in latitudes lower than 61° S. (Menegaux, 1907, 26; Andersson, 1908, 19; Reichenow, 1908, 546; Wilton, Pirie, and Brown, 1908; Clarke, 1913, 233; Gain, 1914, 181; Dabbene, 1920, 7; Filchner, 1922, 259). At the South Shetlands a few usually put in an appearance during the early part of spring (September and October). On the opposite, or eastern, coast of Graham Land, various members of the Swedish Expedition met large flocks migrating northward from Weddell Sea during January. It is probable that the majority of such far-wandering birds are young of the year (Bennett, 1920, 30; 1931, 186), left to themselves in the ice when their parents and foster parents return southward to shed their outworn plumage.

The strictly antarctic nature of the Emperor Penguin is evidenced by the fact that the South Orkneys mark the extreme limit of its range. It has never been recorded from South Georgia. Even though the latter island is ice-covered and is frequently surrounded by floes, its climate is much less polar than that of the South Orkneys, with minimum winter temperatures often 14° C. higher (Harmer, 1931, 129).

The Emperor Penguin has not been seen during any expedition of the American Museum of Natural History. The Museum possesses, however, specimens collected during the work of Filchner and of Bruce in Weddell Sea, and these have recently been compared with Ross Sea birds brought home frozen by the First and Second Byrd Antarctic Expeditions. No difference is apparent between the examples from opposite sides of the polar continent. This would be expected, for practically all circumpolar marine animals of Antarctica have proved to exhibit no geographic variation.

The frozen specimens have been particularly valuable, for they have enabled me to weigh a series, to examine the alimentary tracts, and to note the trim, streamlined body contours. The last feature shows unsatisfactorily in photographs of living birds, and yet it is perhaps more pronounced in this giant penguin than in any smaller member of the family. Worthy of special note are the perfectly fusiform torso, the high ridge formed by the sacral portion of the back, which narrows smoothly toward the pygostyle and ends in a pointed tail of triangular cross-section, and the knife-edged fringes of plumage extending between the thickly feathered tarsi and the base of the tail. Every detail of the bird is fitted for torpedo-like penetration of the water and an untroubled wake.

Comparison of Emperor and King Penguins reveals the interesting fact that the structural differences between these two birds may be reduced to terms of differential growth. The larger species exhibits a vast excess of bulk and stature without a proportionate increase in the length of its appendages. In fact, the Emperor has not only a shorter bill than the King; it also has relatively very much shorter wings and feet. Minimum, maximum, and average dimensions in millimeters, based upon adults of each species, will be illuminating.

	Bill from gape	Bill from nasal feathers	Wing from axilla	Tail	Foot
A. patagonicus					
15 specimens . .	122–136 (127)	69–78 (74)	320–341 (328)	45–78 (63)	157–180 (172)
A. forsteri					
7 specimens . .	106–122 (115)	47–54 (50)	307–340 (326)	73–103 (88)	162–170 (165)

As regards the bill of the Emperor Penguin, the relative reduction is confined to the distal portion, between nostril and tip. The beak is distinctly more curved than that of the King Penguin, although the degree of curvature shows wide individual variation. The feet are broader and fleshier than those of the King Penguin, though relatively shorter. In the wing the difference is extraordinary, for the King Penguin proves to have as large a swimming organ as a congener of twice its weight! Measurements of the pectoral limb bones of fully grown birds further illustrate the disproportion. All the bones of the Emperor's flipper are thicker and heavier than those of the King's, the respective weights of the total wing skeletons being 120 and 80 grams. But only in the humerus does any element of the Emperor's wing show a superior absolute length.

	Humerus	Radius	Manus proximal	Manus middle	Manus distal	Total wing
A. patagonicus	117	85	70	52.5	38	362.5
A. forsteri	132	83	67.5	48.5	39	370

As appears from these figures, the forearm and hand of the King Penguin are actually longer than those of the Emperor. One might assume that the bird with the larger organ of propulsion, in relation to displacement, would be a swifter, stronger swimmer, but there seem to be no empirical data bearing upon this question. However, a correlation between swimming power and the respective habits of the two species may well be pointed out. The Emperor Penguin spends its life in ice-filled waters, so that even during its pelagic season it may come to rest at any time by leaping upon a cake or floe. It is well known that by shooting up from a depth this heavy bird can alight feet-first upon ice standing at least 1½ meters (5 feet) above the surface. The King Penguin, on the other hand, hunts in waters that are mainly ice-free. It returns, at intervals of a few days or less, to the same fixed land station, and in the course of this routine it must often battle against the strong currents that prevail in the west-wind zone. Probably the very existence of the species depends, to a greater degree than in the case of the Emperor Penguin, upon strong powers of locomotion.

Looked at from another point of view, the Emperor and King Penguins offer an ideal example of Bergmann's (1847, 595) principle of thermal economy in relation to latitude and the size of closely related organisms. The King Penguin remains permanently in regions marked by air temperatures mainly above the freezing point and rarely if ever dropping below −18° C. The larger species *breeds* in temperatures which descend to −62° C. (−80° F.), and which probably never rise as high as −18° C. The mathematical ratio between volume and surface indicates for the Emperor Penguin a relatively high capacity for the production and storage of bodily heat and energy, coupled with a relatively small radiating surface. All of this works out as an adaptive advantage, which is enhanced by the fact that the bird's extremities, such as bill, wings, and feet, have remained proportionately small.

The recorded weights of Emperor Penguins range between 26 and 42.7 kilograms (57–94 pounds). The average of 33 birds weighed by Wilson in November was 70.5 pounds; that of four weighed by Mawson in August, 70 pounds. Weight is related to condition rather than to sex. Wilson's biggest bird, a 90-pounder, chanced to be a female. Penguins of similar stature sometimes show a surprising difference in weight, according to the season of their capture. They seem to be fattest, with blubber 2 or 3 centimeters thick, just before the annual moult in November, or about April when they begin to gather at the rookeries. A large but thin female among the Byrd Antarctic Expedirion specimens weighed less than 50 pounds when received frozen at the American Museum but loss of blood may have in part accounted for this. At the other extreme is a bird noted in the manuscript field records of Commander J. R. Stenhouse, who took part in several of the British antarctic expeditions. This example was captured in Ross Sea, during November, 1915, and tipped the scales at 42.7 kilograms, a record for the species. Its girth just below the shoulders was 132 centimeters (52 inches).

The great strength and vitality of a lusty Emperor Penguin can scarcely be credited. The 'Erebus' and 'Terror' parties, during Ross's voyage in 1841, were astonished at the difficulty with which these birds were killed. One that was shot through the body with a solid ball of large bore was for some time apparently unaffected, and led its pursuers a merry chase (Ross, 1847, 1, 234; McCormick, 1884, 250). Five men from the Dundee whaler 'Balaena' tried to overcome an Emperor Penguin without harming it, and to hold it down on the ice. They were quite unequal to the task and were bowled about like ninepins. Eventually they succeeded in strapping two leather belts around the bird's body and, standing back, they took a breath. So did the penguin, and burst the belts. The capable creature was finally secured with a rope, but when hoisted on board it knocked out the ship's dog with a blow of its flipper. This example weighed 33.6 kilograms (74 pounds) (Donald, 1894, 329).

Dr. Wilson, who worked out the greater part of the life history of this penguin was, all in all, the most gifted ornithologist ever to serve in south-polar exploration. The dramatic story of his investigations covers a long period, for the hard-won information of the first 'Discovery' expedition was supplemented by a midwinter journey from Cape Evans to Cape Crozier and back duiing the 'Terra Nova' expedition of 1910. On this occasion Wilson and two companions obtained eggs and young embryos.

The undertaking is recounted by Cherry-Garrard (1921, 230 *et seq.*), who was a participant, in one of the most terrible passages of all polar literature. The outward trip of the three comrades, in the darkness of late June and early July, occupied 19 days, during which the temperature rarely rose higher than −40° F., while at noon of July 5 it touched −77.5° F., more than 109 degrees of frost. The objective of such mad zeal was achieved, and the subsequent history of the scientific spoils was carried through by the author of 'The Worst Journey in the World' to a sardonic conclusion in the bird room of the British Museum (p. 299).

Upon the published records of Wilson and Cherry-Garrard the following summary is based, with the inclusion of facts from other sources as well.

The Emperor Penguin's method of progression on ice varies with the necessity for speed. When left to themselves the birds walk bolt upright with great dignity, but if alarmed they drop down to the breast and toboggan rapidly by alternating strokes of their powerful legs and wings. When pressed to travel as fast as possible they glide along on the ice at a rate of about 14 to 16 kilometers per hour. If overtaken, they at once rise to their feet and show fight, facing their antagonists and using bill and flippers simultaneously, and the stroke of a wing, if caught fairly on the hand or shin, leaves a bruise which will be felt for many weeks.

The courtship behavior of the Emperor Penguin is unknown, but the birds lay their single egg on sea-ice close to antarctic shores about the end of June, and incubate it on their feet in the same manner as the King Penguins. The season of midwinter darkness is at least correlated with the greatest thickness of the ice, which makes for the safety of creatures that choose so precarious a nursery. Since seawater is at the same time necessary as a source of food, the breeding stations also have a definite relation to permanent leads or other openings in the ice, and these are most likely to be maintained by tidal movement very close to coasts and glacier fronts.

Below the wall of Ross Shelf Ice, for example, there is commonly a wide crack in the sea-ice. Moreover, the prevailing southeasterly winds tend continually to broaden it by forcing the growing ice-fields northward into Ross Sea. On the anchored ice of a small bay, at the point where the barrier abuts against Ross Island, is the rookery of Emperor Penguins visited on various occasions by Wilson and his several associates. Here, it was believed, no bird would ever have to walk farther than a kilometer and a half or thereabouts without finding an opening through which it could enter the ocean in quest of food.

Just how the penguins search out their prey at this season is a problem which has, perhaps, never been raised. Day or night above them is a continuous Stygian gloom, and surely no visible ray from even a clear firmament of stars can penetrate the frozen roof of the cold black water in which they forage. Eyes would seem of little use. Do the penguins merely feel for fish and squids and crustaceans? Or have they a sense of smell like that of a ground shark?

From afar the metallic trumpeting of the brooding Emperors can be heard through the polar night. When approached, the birds with eggs attempt to shuffle out of the way, but, if they are hustled, they are likely to drop their burdens, and these are picked up, almost before they stop rolling, by eggless birds which act as though they had been waiting for no other opportunity.

In different seasons Wilson estimated that from one in five to one in twelve, among the total population of the Cape Crozier colony, had an egg. At best only a small fraction of the birds breed during any one winter, and yet the unmated or barren individuals respond as warmly to the progeny of the rookery as do the actual procreators. All adults of both sexes not only share the active instinct for brooding, but all are also characterized by a patch of bare skin on the lower abdomen. Thus many old birds, rather than merely two parents, take turns in nursing each chick and egg, a custom which allows ample time for all to find open water, even under difficulties, and to obtain the great quantity of food that they must require. So irresistible, however, is the desire for mothering something, that eggs formerly frozen and long addled, dead chicks in the last stages of being worn to pieces, and even lumps of ice of convenient size, are tucked on to the feet and covered with the feathery muffs of numerous would-be fathers and mothers.

So avid and blind, indeed, is the interest of parents and foster parents alike in eggs and chicks that the resulting struggles work entirely gratuitous hardship upon the offspring, many of which are literally killed by kindness. No sooner does a brooding bird indicate its readiness to give up its charge than a scrimmage takes place, with dozens of free adults competing savagely for the honor of the next turn. As a result, the young are very roughly handled, their skin is frequently torn, and sometimes they become lost altogether by dropping into a crevice, in which they freeze to death while the old birds are completing a pointless argument above them. So unwillingly do the chicks take to the treatment they apprehend to be in store for them, that they have been observed to scramble away from the squabbling elders, and to crawl under an overhanging slab of ice, a hiding place from which they never escape. When the sun and wind of returning summer have banished the ice-fields from the head of Ross Sea, and the waves have hollowed caverns under the still clinging ice-foot of the cliffs, then one may have light to see, sticking in frozen ceilings, relics of the previous winter's carnage in the form of dead Emperor chicks which have not yet been swallowed up by the obliterating ocean (Lowe and Kinnear, 1930, 105).

Wilson believed that in the Cape Crozier rookery the mortality of the young penguins amounted to about 77 per cent before the date when the whole population moved northward on the ice-floes. Such a terrific death-rate, moreover, is superimposed upon the fact that relatively few of the adult females lay eggs at all during any one year. In addition to the ordeals for which over-zealous parents are responsible, the penguins, both young and old, are in constant danger of falls of ice from the overhanging cliffs, for at this breeding ground the birds huddle by hundreds in places where no man in his senses would camp over a single night.

It is possible that the environmental disadvantages at Cape Crozier are more than ordinarily great. At any rate, the colony of Emperors found at Haswell Island by Mawson, during November, seemed more floutishing. At the time of discovery the number of young exceeded that of adults, and the whole population was estimated at 7500 birds. They covered several acres of ice about a mile from the island, and extended in rows up the lower slopes of a berg. Signs were not wanting that an even larger area had recently been occupied by the birds. Vanhöffen also reports great numbers of downy young in December, at Gaussberg.

The period of incubation of the Emperor Penguin seems to be between seven and eight weeks, which means that at Cape Crozier the chicks atrive about the end of August. Every egg had hatched before September 12, the date of Wilson's first visit during the breeding season. The eggshells are evidently eaten by the adults, for bits of them appear in the excreta, mixed with fish bones. During the first weeks of life the young penguins grow slowly, but after two months or so there is a spurt in their development, so that by the beginning of January they may weigh 12 to 13 kilograms and are nearly as tall as the adults.

The newly hatched chicks are retained in the hiding place of the egg, from which they thrust out the head to take food from the turned-down mouth of the brooding adult. As they grow older and larger, they come to sit "outside," still on the feet of the old bird, and backed up against its breast. This position is alternated with one in which the chick squats on the ice and sticks its head into the warming-chamber. The stimulus which leads the youngster to open its mouth and prepare to swallow regurgitated food is a touch upon the bill, as has been determined by experiment.

The alternation between periods of brooding and of feeding, in a species marked by such a curious exhibition of multiple parenthood, is doubtless determined by a balance between hunger and the satisfaction derived from possession of an egg or chick—dead or alive. When the adult is kinaesthetically at rest because of a full stomach, the instinct to brood is paramount. When the internal pressure subsides through a period of digestion and excretion, the brooding reaction is inhibited, and the offspring is turned out to the none too tender mercies of adults which are conditioned to receive it.

It is of interest to note here that the nature of the external rhythmical stimulus to the Emperor Penguin's glandular system, leading in turn to the incipience of reproductive activity, is as yet utterly unknown. Recent research by Professor T. H. Bissonette and others goes to show that increasing length of daylight is the factor which ultimately determines the dates of reproduction among many birds. But the Emperor Penguin breeds during the very depth of antarctic blackness, the peak of generative energy being attained close to midwinter day. The ordinary seasonal correlation is, so to speak, absolutely reversed. Among other species of penguins the principle of light-control over the gonadial hormones seems to find substantiation, except in the case of two or more south-temperate and tropical members of the genus *Spheniscus*. These species, resident in latitudes where length of daylight undergoes the least annual change, have broken the conventional ties and have acquired an all-year or seasonless breeding period. The matter will be discussed further in the biography of the Peruvian Penguin.

After considering the long juvenile life of the King Penguin, it is somewhat astonishing to learn that the young Emperor wears its down only four to five months, instead of twice that length of time. The climatic environment, however, and the break up of the sea-ice, would make a longer downy stage impossible. Unless the Emperor Penguins were so constituted, they would not exist under present conditions. Wilson has written at length about this marked difference in the life histories of such apparently closely related penguins, and has puzzled, furthermore, over the fact that the young of the two species are far more dissimilar in appearance than their respective parents. There is no great biological difficulty here, however, for the factors of evolution, and the influence of selection, may work their visible effects upon embryonic or immature organisms no less than upon the adult stage. The young of King and Emperor Penguins are unlike in color and pattern and in the tempo of their plumage sequences; the adults, on the contrary, bear a close superficial resemblance, but they still reveal the extent of their divergent evolution in the differences of proportion acquired during growth.

During October or early November the Emperor Penguins begin their northward migration from the breeding grounds. Unemployed adults are the first to leave, and the voyage is made upon ice-pans as the latter successively break away from their moorings. The departure of the birds may be foretold by a wind or storm from the north which jams the ice at the head of Ross Sea up against the shores, and closes the leads. Such conditions seem to be recognized by the penguins as though they were symptoms of what is to follow. They become unsettled and restless, and with the reappearance of the normal southeasterly winds, which start the floes moving, the free birds file out to the edges and projecting points, and wait for the rafts to break away. The naturalists of the 'Discovery' observed this phenomenon at Cape Crozier, as Mawson's party did in Queen Mary Land, and in every instance the penguins were crowded along the extreme outer edge of the ice.

As the summer progresses, the adults caring for chicks fall into line, so that presently all but a few scattered birds are travelling northward with the floating ice, upon which the youngsters complete their infancy. By midsummer (the first of February at the latest), they must have finished the moult of the down so as to be able to take to the water and to fend for themselves when the rafts of ice have cracked up to form the smaller cakes of the pelagic floes.

Here, too, the adults, after a period of gorging upon food which includes a large proportion of crustaceans, abandon the younger generation, and work their way southward toward the stable foundation of fixed ice for the period of fasting entailed by the annual moult. The latter is similar to that of the King Penguin, but apparently more rapid. In a captive bird the whole process occupied twenty days, and the loss of the old feathers was followed by the shedding of the mandibular plates and the epidermis of the feet. Wilson noted a vast concentration of moulters during January at the eastern end of the Ross Shelf Ice, in the angle made by the glacier and the coast of King Edward VII Land.

By no means all of the moulting birds remain securely on the fast ice, for some are perforce carried out to sea upon rafts, where they sit patiently and helplessly, as shown by the accumulations of feathers and stains around them (Bernacchi, 1901, 46). The ultimate survival of such birds depends entirely upon the adequacy of their float. If they are fortunate, they complete the moult, once again enter the water, and make their way southward toward the breeding grounds, where most of the adults congregate by May.

The free pack-ice remains the habitat of the young penguins for nearly a year and a half, after which they also seek the continental fast ice for the moult of their first contour plumage and the assumption of adult garb.

As in the case of the King Penguin, the Emperor is generally credited with an attitude of aloofness toward the Adélie Penguin or other birds, both on ice and in the water. Again, however, this trait seems to be chiefly an expression of preference for its own kind, for single Emperor Penguins have often been noted among groups of the lesser relatives.

As regards intelligence, my personal observation and interpretation of the literature lead to the conclusion that penguins in general have no more than the usual avian endowment, which is little. Siple (1931, 40) has published a note in which he attributes great cleverness to Emperor Penguins in making their escape from a man-made pit in the surface snow of the Ross Shelf Ice. This enclosure was some 10 meters square by more than 1 deep, with undercut sides. Captive penguins repeatedly chipped away one wall with their bills until they had formed a ramp by which they could escape. Siple's account, however, credits the birds with an anthropomorphic understanding and precision which are not convincing.

The popular reputation for intelligence possessed by penguins is, of course, due to their upright posture, sociability, curiosity, nearsightedness, and similar attributes which caricature those of the human species, rather than to the result of tests as to their adaptability. All exact observations indicate that they are no less "insect-brained" than other lower birds. Their reflexes, to be sure, are capable of moderately rapid conditioning, and they are able to make more complex changes in behavior as a result of unpleasant experience. For example, penguins gradually learn to flee into the water at the approach of a man or dog, instead of continuing to act upon the impulse which associates danger only with water. But in other respects their reactions seem as hidebound and predictable as that of other ancient types of sea birds. The corpus striatum, rather than the cerebrum, is the seat of their being, and the brain, for all its great expansion, is concerned far more with keen sensory susceptibilities and delicate muscular coördinations than with any processes that might properly be termed "mental." Why, after all, should a penguin need "brains" when its fundamental and inherited behavior pattern takes care of it through the seasonal cycle and the generations?

The average age of the Emperor Penguin has been computed, from statistics obtained in the Cape Crozier rookery, as 34⅓ years. A region of lesser mortality would, however, yield a lower figure for longevity. The body temperature was determined as 100.7° F. (38.17° C.) by Wilson, and 100.2° F. by the 'Scotia' naturalists.

The food of the species is mainly fish and squids in continental waters, very small fish and plankton crustaceans when the birds are among the pack. Fish 5 to 15 centimeters in length, schizopod and euphausiid crustacea, large cuttlefish, crabs, and fragments of seaweed are all reported in the literature (Donald, 1894, 329; Bernacchi, 1901, 46; Andersson, 1908, 19; Saunders, 1901, 225; McCormick, 1884, 250). The strongly acid stomachs of Byrd Antarctic Expedition specimens from the Bay of Whales contained mostly the remains of cephalopods, identifiable from the beaks as *Psychroteuthis glacialis* Thiele. There were twenty pairs of beaks and a mass of the flesh in one stomach. The bodies of these squids had probably been fully 35 to 40 centimeters in length, and the entire animals more than a meter. The same stomach contained 74 granitic pebbles, with a total weight of 71 grams.

Pebbles are practically always present in the stomachs of both adults and chicks. In the Byrd Antarctic Expedition specimens they were mostly angular bits of basaltic lava, tuff, gneiss, granite, or greenstone, and ranged from grains of coarse sand to pebbles 33 millimeters in longest dimension. Sclater (1888, 325) refers to masses of pebbles "two to ten pounds" in weight, but this must be exceptional. The function of the pebbles is commonly assumed to be that of assisting in the trituration of food, which seems hardly likely in the absence of a muscular gizzard. The idea prevalent among southern sealers and whalemen, namely, that penguins ingest pebbles as ballast, may not be entirely fanciful and will warrant further investigation. This matter is referred to again in the accounts of other species.

The newly hatched Emperor Penguin is covered with silvery white or gray down, with the darker area on the ventral surface. The back from nape to tail, including the flippers, is light, thus reversing the usual arrangement of countershaded pigmentation. The tail is jet-black, as is also the head except for the pure white mask-like area around the eyes, cheeks, and throat. As Wilson points out, such coloration can have nothing to do with protection or concealment. He advances the theory that the white feathers, in which the cellular tissue is occupied by air instead of pigment, may supply a more satisfactory nonconducting coat than dark feathers. The black head with its contrasting white areas may serve as a conspicuous beacon for the adult penguins to see in the winter darkness.

The second coat of down was noted by Mawson at a time when most of the chicks stood as high as the shoulders of the adults. It is gray, darker on the dorsal surface. The eyes are surrounded by a lighter gray ring, and this in turn by a black ring. The tail is darker than any of the down, and the bill is black and straight. The oldest of such chicks had begun to moult from down to plumage (Mawson, 1915, **2**, 116).

After the moult of the down the whole of the back becomes bluish gray, the chin gray and mottled, but the throat, instead of being black as in the adult, is whitish with some gray feathers intermixed. The plates of the lower bill begin to show a suggestion of the color which is so conspicuous in the adult birds. After a year's weathering this plumage becomes greatly faded so that the head and back are prevailingly brown, and the gray patch at the side of the neck has become white. All the juvenile birds are extremely brown and drab when, at the age of about a year and a half, they undergo the moult that leads to mature dress, not characterized, however, by quite the richness of hue acquired after subsequent moults.

For a full understanding of the plumage sequences in the Emperor Penguin, Wilson's text, together with his sketches and extraordinarily faithful water colors, as reproduced in the second volume of the reports on the "National Antarctic Expedition, 1901–1904," should be consulted. His concise descriptions hardly permit briefer summary, nor does space warrant their quotation here in full.

> The cry of the adult Emperor is far louder, more prolonged, and more musical than the harsh croak of the Adélie Penguin. It is like a defiant trumpet-call, and can be heard at a great distance over the icefloes. This is its rallying call note, and is emitted with the head erect, but it has also a clucking or chattering note to which it gives expression in a different way. Bending the head and neck down low on the breast in a powerful expiratory effort, it then, in raising it, gives vent to an interrupted musical cry as the lungs are filled with air. The supraclavicular hollows can be seen distinctly emptying as the head goes down, and filling out again as the head is raised. The cry of the chick . . . is a more definite utterance of four notes emitted in the same way, and bearing a faint resemblance, according to our worthy bluejackets, to the words, "Gimme some more, gimme some more," which is at any rate always implied, even if the resemblance was somewhat vague (Wilson, 1907, 18).

Levick (1914, 140) remarks that, from a distance, the calls of the Emperor Penguins sound like the "overtone" notes of a ship's steam horn.

The sea-leopard is probably the only predacious enemy that the Emperor Penguin has to fear during the part of the year that it spends close to continental shores. Remains of the birds have been found in the stomachs of these seals. No doubt the killer whale would pick up penguins whenever it had an opportunity, but nothing very specific is known about its relation to the Emperor. Antarctic Skuas, the scourge of the Adélie colonies, are all far to northward during the period of winter night in which the Emperor incubates its egg and rears its chick.

Specimens of Emperor Penguins brought from Antarctica in the refrigerator of the bark 'City of New York,' at the close of the Byrd Antarctic Expeditions, have enabled me, as noted above, to examine the species in the flesh. Most details of the gross anatomy agree closely with those of the King Penguin, as described by Reid (1835, 147). The following points are of interest:

In a female weighing 34.9 kilograms, the pectoral muscles alone weighed 9.07 kilograms. This is well over one-quarter of the total body weight, or exactly 35 per cent of the body weight without the pectorals. The complete dried skeleton of this specimen weighs 1536 grams.

Despite the general density and hardness of bone, the ribs, uncinate processes, and scapular are extraordinarily flexible, a condition perhaps correlated with a high degree of lung expansibility. The flexibility of the very broad and elongate scapular could hardly be appreciated through examination of a dried bone; when first dissected from the investing muscles, however, the blade can be bent almost double upon itself. Scapular, coracoid, and the other elements of the pectoral girdle, including even the extraordinarily free play of the humeral ball in its cartilaginous capsule, parallel to a remarkable extent the corresponding arrangement in a sea turtle. Such a comparison is, indeed, pertinent to an understanding of how thoroughly the "wing" of a penguin has become a "flipper." The reach and the full power of rotation in this organ are, in turn, correlated with the perhaps unique elongation of the penguin's enormous pectoral muscles.

The tongue, palate, and entire lining of the mouth are covered with stiff retrorse spines up to 8 millimeters in length. The esophagus is without spines, and is marked by longitudinal, contractile folds or ridges throughout its length.

The trachea is 40 centimeters in length from the epiglottis to the point of branching. It is a broad, appressed, double tube, the septum being wanting only near its upper end. It is extraordinarily soft, and has heavy dorsal and lateral longitudinal muscles.

There are no supra-orbital ridges in the skull, so that the eyes project beyond the plane of anything above them. The supra-orbital glands are long and thick, but very narrow, so that they do not extend outward beyond the mid-line of the eyeball. This structure relates itself with the field notes of Wilson (1907, 23), who wrote:

> The complete absence of any protrusion of the brow or superciliary prominence gives the bird a quizzical look which is always entertaining. The movements of the eye are quick, and the upper lid is raised to look upwards without much motion of the head. The outer coverings of the eye are almost flush with the outer contour of the face and head; there is no attempt to offer it protection by bony ridges, but every effort is made to produce an eye so placed as to catch the glint of a fish above, below, ahead or astern, while the bird is in its element under water in search of food.

And, again, speaking of an Emperor Penguin chick:

> The movements of the eyes and eyelids were most peculiar, the eyes being so set in the head of the chick that, without turning sideways, it could see everything above it. Owing to the absence of any eyebrows the cornea was almost flush with the convex outline of the head, which was covered by very short and velvety down (Wilson, 1907, 27).

The sclerotic ring, although narrower than in most large birds, is composed of extremely heavy plates of bone. Reid (1835, 147) reports that the sclerotic of the King Penguin is less osseous than in most birds.

The small intestine measures 7.25 meters in length (as against 6.86 meters in the King Penguin, according to Reid). The colon is little more than a cloacal enlargement, about 10 centimeters long. Throughout the greater part of its length the small intestine is rather less than 10 millimeters in diameter, but the proximal end, for a meter or more beyond the stomach, is somewhat larger. Paired caeca about 5 centimeters in length branch off from the intestine at a distance of 28 centimeters from the cloaca.

The stomach is pyriform or squash-shaped, 30 centimeters in length, with the anterior part definitely constricted off from the pylorus. The anterior part is thickly lined with papillate gland orifices, while the larger pyloric portion is smooth and mainly non-glandular.

The gall bladder is an elongate organ, 25 centimeters in length by three or more in diameter, being most enlarged distally.

GENTOO PENGUIN

Pygoscelis papua

Aptenodytes papua Forster, 1781, Comment. Soc. Reg. Sci. Gottingensis, 3, p. 140, pl. 3 (Falkland Islands).

Names: Johnny Penguin, "Pinguín de Pico Rojo," "Juanito." The last is a Spanish translation of the English-speaking sealers' name, which dates at least from the eighteenth century. The species does not occur on the coast of the South American mainland, or in other regions where Spanish is generally spoken. "Rockhopper" and "Jackass Penguin" have sometimes been used in the literature, but usually through confusion with other species of penguins. The only common synonym among the specific names is *taeniata*, though *wagleri* and *papuensis* have also been applied.

Characters: Largest member of the genus *Pygoscelis*, with a length of 75 cm., and a wing of 22–24 cm. The only penguin with conspicuous white markings on *top* of the head. Dorsal surface slaty-gray, varying from very "blue" in fresh plumage to nearly black in intermediate, and brown in worn plumage; head and neck similar to back, but duskier or browner, and darker on forehead and occiput than on cheeks and throat; a fillet of white across the crown from eye to eye, narrow in the middle, but expanding terminally to form large, irregularly triangular spots above and behind the eyes; scattered white feathers conspicuous in many parts of the head including, sometimes, the throat; external surface of flippers like back, but bordered with white, narrowly on the anterior and more broadly on the posterior edges; inner side of flippers white, with a terminal dusky spot; tail blackish, except for the outermost two quills which are often white on one or both vanes; ventral surface, caudad from the throat, glossy white; bill orange or red, the culminicorn black; feet orange (with seasonal variations noted below); claws dark.

Measurements in millimeters of the series of *Pygoscelis papua* that I have personally examined are as follows: wing, 223–242; tail, 109–158; bill from gape, 68–93; foot (heel to tip of middle claw), 126–143 mm.

Dimensions recorded by Gain and others range as follows: total length, 700–800; wing-spread, 575–600; tail, 169–200 mm. The very long tails of specimens taken by the French naturalists in West Antarctica are noteworthy.

The white fillet, which is the most characteristic mark of this penguin, varies in a similar manner among adults from the several localities represented by American Museum specimens. In some examples the band across the crown is very broad, while in others it is a mere thread, or even incomplete. A male from Deception Island, South Shetlands, shows partial albinism on the dorsal surface, flippers, tail, and claws.

Scott and Sharpe (1904, 93) state that the immature penguins of this species have 18 rectrices, the outermost, which is entirely white, not being replaced after the moult that leads to the fully adult plumage. The outer two or three rectrices in mature birds are sometimes mostly white, but have black shafts.

Valette found that the intestines of *Pygoscelis papua* measured 320 cm. in length, with a capacity of about 350 cc.

The Scottish Expedition naturalists weighed 80 adults at the South Orkney Islands, finding a range of from 3.9–6.25 kilograms (8.5–13.75 pounds). The heaviest female weighed 5.7 kilograms (12.5 pounds).

The eggs are rounded or subspherical, and greenish white in color. The inner shell is dark blue-green, a hue which shines through the white, chalky outer coating. Extreme measurements recorded for about 60 eggs from many localities give: length, 62–79; breadth, 53–62 mm. The following figures show the range among 18 eggs from South Georgia: 74 x 57 (longest); 62 x 54 (smallest); 65 x 57 (nearest to spherical); 73 x 59 (largest). In a typical set, the two eggs measure 72 x 60 and 70 x 59, the former probably being the first laid. Von den Steinen gives the average weight of a South Georgia series as 137 grams. Weights of 26 eggs taken in West Antarctica, as recorded by Gain, ranged between 108 and 145 grams, the average being 126.

Distribution: A pan-antarctic, insular penguin, which seems generally to avoid continental coasts; its breeding station closest to the South American mainland appears to be Staten Island (De Agostini, 1924, 234). Circumpolar in the west-wind zone; resident at the Falklands and at all the low antarctic islands except, apparently, Bouvet. In the West Antarctic Archipelago the species penetrates into an essentially south-polar environment; elsewhere its closest approach to such appears to be at Heard Island, in the southern Indian Ocean. At South Georgia, Prince Edward and Crozet Islands, Kerguelen, and Macquarie, it finds its most flourishing centers of abundance. It is, therefore, a dominant penguin in the same habitat as that of the King Penguin. Excluding the Falkland Islands and Staten Island, the species reaches or approaches the temperate zone (*e.g.* Tasmania) only as a rare straggler.

Most common and most timid of pan-antarctic penguins is the joint testimony of many visitors to the far south regarding *Pygoscelis papua*. Some have implied that it is also the least interesring, from the human visitor's point of view. The last is hardly a fair conclusion, however, for no species would more richly repay an exhaustive study of behavior, carried on throughout an entire breeding season, than this relatively unaggressive, seemingly "overgrown" member of its genus, the only unique or striking mark of which is the white fillet that wreathes its brow.

The "John Penguin" was one of four kinds found to be abundant at the Falklands by Captain Edmund Fanning (1924, reprint) in October, 1797. The vernacular name must even then have been widely used among sealers, who have always preferred the eggs of this species above those of other penguins. As "Johnny" it is still in force among both English-speaking and Norwegian seafarers in the southern hemisphere. I have been unable to trace the history of the name "Gentoo," which is current at the Falklands. The word means a Hindu or Telugu, and its origin may perhaps refer to some peculiarity of the bird's markings, or may be merely bound up with the inappropriate specific name, *papua*, which Forster applied to specimens from the Falkland Islands because Sonnerat had previously, but incorrectly, reported the species from New Guinea.

During the Brewster-Sanford Expedition the Johnny Penguin was observed and collected at the Falklands by Mr. Beck. Earlier, at South Georgia, I had lived close to colonies of the bird for several weeks, and the notes made during that experience form the basis of the present biography. In addition to specimens from the localities named, the American Museum possesses examples collected by Mr. A. G. Bennett at the South Shetland Islands in 1922, and others from Macquarie and Kerguelen Islands.

The Johnny Penguin is either a migratory or a sedentary species, according to locality. In the northerly parts of its breeding range, as at the Falklands, South Georgia, Kerguelen, and Macquarie, the population is resident throughout the year (Oliver, 1930, 67; Matthews, 1929, 586; Bennett, 1926, 5; Vallentin, 1924, 290). At the verge of the true antarctic, anywhere between the South Orkneys and Petermann Island, it is a migratory bird, although a few members of any colony are likely to remain throughout the winter as far south as open water can be found (Gain, 1914, 46; Clarke, 1913, 230; Valette, 1906, 50; Andersson, 1908, 34; Brown, Mossman, and Pirie, 1906, 135).

As regards the extent of the migration and the maritime life of these southernmost representatives, practically nothing is known. It is hardly likely, for example, that the hundred thousand Johnny Penguins nesting at Laurie Island, South Orkneys, nearly all of which depart for the north in late March or early April, add their numbers to the resident population of South Georgia or any other low antarctic island. More probably such birds spend four or five months at sea, after which they return to their ancestral home-sites, as indicated by the banding experiments of Dr. Charcot's associates in the West Antarctic Archipelago beyond latitude 65° S.

On November 15, 1912, in latitude 43° 18′ S., longitude 41° 10′ W., South Atlantic Ocean, I saw penguins of this species, readily identifiable from their white head markings. The position is more than a thousand kilometers to northward of South Georgia, and still farther from the east coast of South America. Westerly winds had raised a heavy swell on this date, and shortly before nightfall the penguins began to pass our vessel in small bands, all heading in a northerly direction. The birds remained under water most of the time, but their braying calls frequently attracted attention toward sleek heads and upright tails, the only parts visible at the surface. During subsequent days a few more were seen. At that time I associated these penguins with the South Georgian colonies, but it now seems more plausible that they were pelagic migrants from farther south. The sedentary, low antarctic or sub-antarctic members of the species apparently do not stray so far from home.

At Kerguelen Island, Hall (1900, 31) reports that the resident Johnnies are common as far as 80 kilometers offshore. On September 28, 1915, Beck noted a number at the surface of the ocean about 125 kilometers north of Staten Island. Northeast of South Georgia I repeatedly saw groups of the birds feeding on the whaling banks up to 75 kilometers from land.

As the migratory habits of the species vary with latitude and climatic environment, so also do the time of nesting and of other normal cyclic processes, such as the moult. The dates of appearance of the earliest eggs at various islands, for example, are recorded as follows: Kerguelen, before September 10 (Kidder, 1875, 41; Loranchet, 1915, 154); Macquarie, September 12 to 18 (Tulloch, 1916, 92; Ainsworth, 1915, 223); Falklands, October 7 (Abbott, 1860, 336); South Georgia, October 26 (von den Steinen, 1890, 221); South Orkneys, November 6

(Clarke, Valette); Petermann Island, off the Graham Land coast, November 18 (Gain). A direct correlation with climatic conditions is evident, at least in a broad way.

Although some authorities have recognized two geographic races of this penguin, one characteristic of the American quadrant of the Antarctic, the other of the eastern hemisphere, I can find nothing in the specimens to warrant such a division. Suggestions of variation that can be correlated with latitude have also been made. Bennett (1920, 30), who has had wide field experience, states that the bills of the Johnny Penguins at the South Shetland and South Orkney Islands are redder during the breeding season than those of Falkland Island birds. Beck's field notes on the labels of Falkland specimens also say "bill orange," but these were all taken during November, after the courtship season had passed. The same specimens have uniformly longer bills than those of the nesting adults I obtained at South Georgia. Such variations may, nevertheless, be individual. Until a taxonomic study has been based upon adequate series of specimens from all or most of the breeding stations, it is better that differences of this kind should not be recognized in nomenclature.

At South Georgia I found the situations chosen by the Johnny Penguins for their rookeries to be highly diverse. Some of them lay in wet, hummocky meadows, crossed by numerous rills; others on well-drained flat ground covered with a luxuriant growth of tussock grass (*Poa flabellata*); and still others on the bare and windy heights.

The largest rookery discovered by our party, comprising upwards of four thousand adult birds, was distributed over knolls and ridges behind a morainal beach at the Bay of Isles. The site is bounded by two glaciers so that it can be reached only from the bay. In 1912–1913 the penguin settlements, beginning on low ground well back from the shore, extended inland and up the hills to an altitude of about two hundred meters. As long as young penguins were on this nesting ground, processions of adults might at all times be seen coming and going between the high land and the sea. The birds met and passed each other without a visible sign of recognition, each trundling gravely along on its own business. A broad thoroughfare had been stamped across the moraine, worn down through generations by the pattering of leathery feet, and, higher up, sinuous grooves extended across the broad snowbanks to the topmost portions of the colony, which were two kilometers from the shore.

This type of rookery is common at South Georgia wherever high land is accessible. No matter how much territory may be available near the water, no matter how wearisome the scramble up the hillsides, a certain proportion of the members of each colony select the summits of the shelterless ridges for their home. Why should marine birds which lack altogether the power of flight and which are at best indifferent walkers, be impelled to make the period of reproduction difficult for themselves by retreating as far as possible from their only source of food? The question has already been raised by Levick (1914, 70) with reference to the great colony of *Pygoscelis adeliae* at Cape Adare, where many of the breeders climb to the crest of the cape and make their nests 300 meters above sea level. In the case of neither the Johnny Penguin at South Georgia nor the Adélie Penguin at Cape Adare does protection offer an explanation of the habit. Both species have only one terrestrial enemy, the skua, to the ravages of which they are as susceptible on the highlands as on the shore. Levick does not attempt to explain the habit, beyond saying that it is "the result of their love of climbing." Perhaps nothing more is warranted, and yet the instinct may have a connection with the recent climatic history of the far south.

South Georgia, which may stand as a type of many antarctic islands, was formerly buried under an ice cap. The interior, which rises to an altitude of 2000 meters or more, is no longer ice-clad but is covered with an everlasting névé of the Alpine type. This consolidates at the sources of all the valleys to form glaciers that extend into the sea. Since most of the fiords have been carved out by former extensions of the valley glaciers, the coast is almost beachless, and the few areas of low flat land are terminal moraines or the beds of shortened glaciers. The glaciers fluctuate seasonally at their fronts, but the southern glacial age is generally on the wane, and an appreciable decline has taken place at South Georgia even since the visit of James Cook in 1775. Certainly Captain Cook's detailed account of unmelting ice and the absence of fresh-water streams in midsummer does not accord with present conditions.

Now it may be assumed that during a long period following the last complete glaciation, very little territory suitable for breeding use by penguins was exposed. Whatever bare rock existed must have been confined to ridges separating the ice-filled valleys. During such a time, the *Pygoscelis* penguins or their ancestors may have developed the trait which still leads them to seek lofty places for their nests. The same period, it would be easy to believe, saw the beginning of the curious "marsupial" method of incubation of the Emperor and King Penguins.

The fact that most of the pan-antarctic islands were formerly the home of a more abundant fauna than at present makes the perpetuation of what we may call the "mountaineering" instinct understandable. Animals obtaining their sustenance only in the sea would tend to increase more rapidly than the proportionate area of beach, and through overflow of population many birds would be forced to content themselves with the less accessible ground, leaving the shores to the great herds of summering seals, and the adjacent nesting sites to powerful rivals such as the King Penguins. Indeed, in the southerly islands of the American section of the far south, where *Pygoscelis papua* and *Pygoscelis adeliae* meet as breeding birds, the interspecific competition works out contrariwise for the former species. At the South Orkneys, for example, the Adélie Penguin is the earlier migrant as well as the more aggressive bird. Having similar tastes as the Johnny, it appropriates all the higher nesting sites, so that eventually the Johnnies come to occupy a broken ring around the colonies of their smaller but more pugnacious cousins.

Where high land is not available, as at some of the islets of the Falklands, the Johnny Penguins content themselves by building their nests far back from the water or, rather, as far as possible from the beach at which they make their landings. Beck found that they sometimes walked all across an islet, only to establish homes close to the water on the far side. The journey back and forth was then made by the traditional route, never by the short cut. This type of conservatism, characteristic of all penguins, seems especially marked in the present species.

The faith that the Johnnies hold in the protectiveness of land, especially high land, is strangely shown by their habit of running *away* from the water whenever danger threatens. Their marine enemy, the sea-leopard, has done its part to fix an instinct which urges them to seek safety only on *terra firma.* Consequently their acts are not governed by their perceptions. Time and again I have seen a group of them standing at the water's edge when a fox terrier, brought ashore from my vessel at South Georgia, started toward them on the run. If the penguins showed any concern at the approach of the barking dog, they invariably responded not by taking to the water and safety, but by scrambling up the nearest bank or hillside. Even after the dog had seized a penguin by the tail, and had swung it round and round before leaving it to worry a second bird, the dazed victim would still persist in scampering away from the water. I myself found that the surest way to keep the penguins ashore was to try to drive them into the sea. Nevertheless, the adult birds eventually adapt themselves to the presence of men and dogs by inhibiting the normal reaction and learning to seek the water at first alarm. This can be observed in the neighborhood of the whaling stations at South Georgia, in contrast with the reactions of penguins in remote colonies. The same phenomenon has also been recorded elsewhere (Sharpe, 1879, 154).

The deep-seated nature of the hill-climbing predilection among the Johnny Penguins is attested at South Georgia by a strange and somewhat romantic fact, namely that many of the penguins go back to their heights to die. In a hollow at the summit of a range of coastal hills south of the Bay of Isles lies a clear lake on a bed of ice-cracked stones. This transparent pool, formed entirely of snow water, with a maximum depth of 3 to 4 meters, is a penguin graveyard. In January, 1913, I found its bottom thickly strewn with the bodies of penguins which had outlived the perils of the sea and had apparently accomplished the rare feat among wild animals of dying a natural death. They lay by scores all over the stony bed of the cold tarn, mostly on their backs with pinions outstretched, their breasts reflecting gleams of white from the deeper water. Safe from sea-leopards in the ocean and from skuas ashore, they took their last rest; for months, perhaps years, they would undergo no bodily change in their frigid grave.

Before the beginning of the breeding season the Johnny Penguins congregate on the beaches in huddled thousands every evening, and often sleep in similar bands upon the snowbanks behind the crest of the shore. At South Georgia such gatherings, indicative of a developing community feeling, take place during September and October. At the South Orkneys, where a very few individuals reside throughout the winter, migrants bent upon nesting continue to arrive until November. After reaching land, however, most of them appear to wander about aimlessly for a number of days, permitting other species of penguins, or even the native cormorants, to entrench themselves securely before the Johnnies begin the acquisition and defense of the family territory.

I did not reach the breeding grounds in time to observe the actions of the birds in the first stages of courtship, nor does their selective behavior at this time appear to be described in the literature, except for Valette's testimony that they toy with pebbles in the manner of the Adélie Penguins. The marital performance is briefly described by Matthews, who observed it at South Georgia. The paired birds sit upon or near the nest, which is often the trampled remains of a last year's structure, and bow to each other, making a simultaneous low hissing sound. When this has been several times repeated, they point their heads upward and trumpet loudly. After pairing has taken place the female stands upon the foundations of the nest, while her mate collects and brings up building material. This is deposited, and the birds bow to each other. The female then begins to arrange the contribution, while the male stands by and trumpets before going for more. This agrees with the behavior of the more fully studied Adélie Penguin. The sexes, which are exactly alike in appearance, are easily distinguished by the actions of the mated pair.

The nests at South Georgia are more or less bulky mounds of humus and wisps of tussock grass, green moss, and sometimes bits of seaweed, the whole usually built upon a platform of small stones. Sometimes the floor of the cavity is unlined, the eggs resting upon a mosaic of pebbles. The bowl averages about 28 centimeters in diameter by 13 in depth (Szielasko, 1924, 9). Nests on hilltops are smaller than most of those on low ground, doubtless because of scarcity of vegetation in the former situations. In crowded parts of the colonies I saw a few nests built on the tops of glacial boulders about a meter high. At every opportunity the birds steal material from each other's nests, which leads to noisy protests and to quarrels in which both the beak and the flippers are employed.

Southward beyond the zone of terrestrial vegetation, as at Dundee Island, off the tip of the Antarctic Archipelago, moulted feathers take the place of grass in nest construction (Donald, 1894, 335). At the South Orkneys also, the 'Scotia' naturalists and others have noted this, as well as the fondness of the nest-builders for using bleached bones of their dead fellows. The Johnny Penguins, moreover, build very much larger nests than the high-latitude penguins with which they are associated, such as the Adélie, the Ringed, and the Macaroni.

In the milder and more luxuriant environment of the Falklands, or of Kerguelen, the Johnny Penguins make use of twigs and stalks which they break or twist off from herbs and low bushes. Often they go to the trouble of removing the bark from the bits of wood before they work them into the nest. In such localities the broken shrubbery may define their paths, which can be seen winding across the moors like sheep-trails. Kidder notes that at Kerguelen the paths to the rookeries are marked by borders of exceptionally luxuriant vegetation.

At the Falklands the colonies are nearly always on northern exposures, so that the sun and the constant manuring combine to increase plant-growth. Here "this penguin is sometimes known as the best farmer in the country, so greatly does it improve the pasture in the vicinity of the rookeries" (Bennett, 1926, 5).

Both parents incubate, relieving each other at irregular intervals, which may extend to many days in regions where ice must be crossed during the search for open water. Three or four days in alternating periods are common at South Georgia. A bare brood-patch is present in both sexes of incubating birds. The relief of guard is made very quickly, after a period of preliminary palavering, so that the eggs are exposed only momentarily. When sitting birds are driven from their nests, however, they are likely to carry the hinder egg out between their legs and thus lose it. The period of incubation averages 33 days, 31 to 35 days being the usual range, though longer terms have been recorded, especially in the southerly parts of the range, where the sitters are frequently snowed under for days together. After the eggs have been cracked by the large egg-tooth of the chicks, it still appears to be a serious task for the latter to work their way out of the thick-shelled casing. Newly hatched penguins seem extraordinarily feeble, while their eggs are much tougher than those of other waterfowl in the same region.

Before the eggs have appeared, or during the early stage of incubation, the Johnny Penguins are generally timid, scampering off at the approach of a man. As compared with other species, writes Gain, "Ils reçoivent les visites humaines avec moins de protestations, mais plus d'inquiétude." "At times, a panic and consternation seems to possess them all," says Eaton of the species at Kerguelen (Sharpe, 1879, 154). While they flee, they look behind them and therefore stumble awkwardly or fall flat. Ordinarily, however, their fright is short-lived, and they rarely retreat more than a few paces if eggs are already in the nest. With advanced incubation and the hatching of young, the parent birds tend more and more to stand their ground and show fight, employing as weapons both bill and wings. With the latter they can shower forceful blows so rapidly that the human eye sees only a blur. On one occasion a bird that I had roused from sleep beat such a furious drumfire upon my leather leggings that its own flippers were soon bleeding.

When a brooding Johnny is forced away from young nestlings, it lingers near-by, trumpeting until the disturbance has passed; then it inspects its offspring minutely, stooping down nearsightedly and scrutinizing one and the other over and over again. When satisfied that all is well, it settles down contentedly, facing the wind. For the last reason incubating birds in one group usually point in the same direction, but they turn in the nests so as to direct their bills toward the natural enemies, the skuas, which walk about the rookeries with evil purpose, waiting for a chance to steal an egg. Eternal vigilance is the price of safety. The sitters hiss sharply whenever a skua draws near, and the unoccupied penguins make angry but vain rushes at the common foe, continuing to bristle with rage after the skua has leaped into the air.

Besides the hiss of courtship or of wrath, the Johnny Penguins have a variety of louder calls. As expressed by members of the French Antarctic Expedition, this species utters so many different sounds that the babel of voices sounds like a language (Menegaux, 1907, 5), while Szielasko likened the murmur of a colony to that of a crowded stock exchange. The ordinary trumpeting note is similar to that of a tin horn or the braying of an ass; the sound is double, being produced by both expiration and inspiration, and is accompanied by a swelling and falling of the lower throat, between the branches of the furculum. The sound can be reproduced by blowing and drawing through the trachea and syrinx of a dead penguin. The voice is of much lower pitch than that of the King Penguin. Usually the head is pointed upward during trumpeting. The mouth is held wide open, with the spiny tongue showing, and in cool weather the expelled breath condenses into puffs of vapor. The trumpetings are often repeated many times without interruption; under excitement the birds' whole energy seems to go into the call.

Another note is a short, single *caw* which the Johnnies are apt to utter as soon as they emerge from the sea. This sounds like a hail from one man to another, and the human suggestion is enhanced by the penguins' habit of waving their flippers, as if beckoning. Young Johnny Penguins begin to trumpet at an early age in the nest, but their voices are distinctive because of their weak and somewhat peevish quality. Nestlings also utter a soft peeping note, indicative of well-fed contentment.

By the date of my arrival at South Georgia (November), the nesting season had well begun, and the rookeries in the vicinity of Cumberland Bay had already been robbed of eggs by the resident Norwegian whalemen. The birds had, characteristically, laid second sets, and by December 3 most nests in these colonies contained at least one fresh egg. Two, the normal complement, were more common, but the effect of the excessive ovulation was shown by the presence of numerous undersized eggs. Observers in many parts of the range of this penguin report that from five to eight, or even ten, successive layings may result if the nests are robbed, the sets after the second comprising only one egg, which is very round, and the size and weight tending progressively to decrease, so that the last in the series may be only half as large as the first. Indeed, even in a first laying, the earlier egg is usually slightly larger than the second.

Three eggs have occasionally been found in one nest. Robbed Johnnies have been observed in the act of attempting to appropriate an egg from a neighbor's exposed nest. Experiments in placing the eggs of other species, such as the skua and the Giant Petrel, under incubating Johnny Penguins, have shown that they will be accepted, at least for a time. A skua egg, which is of totally different appearance from the white and roundish penguin egg, was in the only recorded instance apparently ejected after a few days (Lönnberg, 1906, 87).

The eggs are excellent eating, though being slightly insipid, they require more salt than a hen's egg. They seem to be generally preferred to the eggs of other penguins, the only dissenting opinion being that of Valerre, at the South Orkneys. The one objection to penguin eggs lies in their appearance, for the albumen does not thoroughly coagulate during boiling, and they therefore somewhat resemble jellyfish. The yolk of the Johnny Penguin egg is of a salmon-red color, whereas those of the other species with which it is commonly associated, such as the King, Macaroni, Rockhopper, and Magellanic Penguins, are yellow. Clayton (1776, 103) noted this distinction at the Falkland Islands in the year 1776; in fact, for this curious reason he called the species the "red" penguin.

It is apparent that this penguin is of considerable economic importance as an egg-producer, and that, in the more northerly and milder parts of the range, one or two layings may be collected without endangering the growth of the young. At the Falkland Islands, in October, 1915, Beck was conveyed from place to place by a cutter engaged in gathering Gentoo eggs. His notebook reports that five hundred or more were obtained at each of a number of small colonies. At South Georgia the birds appear to thrive even when the hatching of the chicks is delayed until early February. Over-collecting, however, may result in such a condition as that reported by Szielasko, who found at least fifteen hundred adult birds occupying a colony of not more than four hundred nests.

At South Georgia the first young penguins hatch during the last few days of November. They come out of the shell bright-eyed, but they react to sunlight by closing the lids tightly, which accounts for the tradition that they are at first "blind." At the Falklands to northward and the South Orkneys to southward, the times of hatching, as of other important events in the life of the species, are about two and a half weeks earlier and ten or twelve days later, respectively, than at South Georgia. At Kerguelen Island the annual reproductive cycle seems to begin earlier than anywhere else, young sometimes hatching during the first half of October.

The general observations in this account, except where otherwise noted, were made at South Georgia, in the sedentary and climatically milder part of the range. It will be of interest to compare a calendar of the Johnny Penguin's rhythmic functions at the extreme southerly limit of its breeding range. In the Petermann Island district, beyond 65° south latitude, a very few of the birds linger throughout the winter, their existence being dependent upon their ability to withstand not only the cold but also the fasting periods imposed whenever they are unable to locate open water. About the end of August the casual arrival of small groups of lively birds from the north indicates the approach of the migration, which does not get seriously under way, however, until the end of October. Pairing does not take place during migration, but only after the selection of nesting territory. The earliest date on which the mating act was noted was November 3. The first eggs were recorded on November 18, but chicks did not hatch out in numbers until the end of the first week in January. Before the first of March the chicks had begun their moult which was finished during that month, overlapping the moult of the adults. Immediately after the completion of the latter, in early April, the birds departed for the north, with the exception of the few that lingered later into the autumn. This summary of dates is based upon the records of the Second French Antarctic Expedition.

In the whole West Antarctic region, where the Johnny Penguin comes into contact with its polar cousin, *Pygoscelis adeliae*, it is interesting to note that it breeds considerably later than the latter, and likewise departs for the north about a month later. Curiously, however, the same stages in its life history are completed somewhat earlier than those of its other congener, *Pygoscelis antarctica*. It appears also that the maturing of the young of *papua* is slower than in either of the other species. At any rate, the young Johnnies appear to be fed considerably longer after completion of their moult, when one would assume that they were ready to swim well and to capture their own food. At South Georgia, which lies outside the migratory zone of the species, members of the German Transit of Venus Expedition believed that some of the young did not go into the water until September, when they must have been in the neighborhood of ten months old (Pagenstecher, 1885, 14).

At Christmas time, 1913, a large rookery at the Bay of Isles, South Georgia, which had not been disturbed that season by human beings, contained plenty of young penguins, the oldest of which were half-grown. Some of the nests held one egg and one chick, and among the further advanced families there was a great difference in the size of the two chicks due to the interval between their dates of laying, and in due course of hatching, which sometimes amounted to four days. Not infrequently the senior chick was fully twice as large as its nest-mate. Nests which contained nothing but one youngster were also very numerous; doubtless the skuas, which were ever eyeing the rookery from points of vantage, had accounted for the other. Considering the fact that the nest is constantly covered by one parent from the time the first egg is laid until the chicks are well grown, it is surprising that the raids of the skuas are so successful. They do succeed, however, in pulling out both eggs and young from under the very eyes, or rather the tails, of the brooding penguins. The most opportune moment for the deed seems to be when the mated adults are going through the routine expressive of affection, the moment before one relieves the other of the home-keeping duty.

The young Johnnies are fed from the gullets of the old birds and grow rapidly, early development showing especially in the abdominal part of the body. Within three or four days after hatching, the chicks become practically anchored to the nest by the weight of their corpulent bellies, which seem out of all proportion to the puny neck, wings, and legs. Within such distended stomachs I found disintegrated crustaceans, small cephalopod beaks, and pebbles. The only identifiable food that I personally found in the alimentary tracts of adults at South Georgia was examples of the pelagic opossum-shrimp known as *Antarctomysis maxima*. The birds are known to subsist largely upon the *Euphausia* group in South Georgian waters, the same organisms which supply subsistence to many of the whalebone-whales. Menegaux reports half a kilogram of euphausians in a single stomach. Typically, the Johnny Penguin is a crustacean-eater, though Bennett at the Falklands and Loranchet at Kerguelen note small fish in their stomachs, the latter author referring also to the constant presence of pebbles. Stomachs examined by the French naturalists in West Antarctica contained euphausiid, schizopod, and decapod crustaceans, as well as fish of the family Scopelidae. Moreover, the alimentary tracts of most examples teemed with cestode parasites and their cysts (Gain).

The Scopelidae are small deep-water fishes, mostly equipped with phosphorescent organs. They are known to approach the surface of the ocean at night, but since the *Pygoscelis* penguins pursue food only by day, we have here one of several indications that they penetrate to considerable depths. The subject will be referred to again in the accounts of other species.

Gain, of the French Expedition, reports that at Deception Island of the South Shetlands, King George Island, the De Gerlache Channel region, Hovgaard and Petermann Islands, and elsewhere in the American antarctic sector, the rookeries of *Pygoscelis papua* can be distinguished at a distance from those of other penguins because of the splashings of white excrement. This is certainly not in accord with conditions at South Georgia, where the ground of the breeding colonies quickly turns red from the triturated shells of crustaceans in the excreta. Possibly the observations of the French naturalists relate to the fasting period of courtship, when the droppings of the birds are in fact uncolored by recent food. Since this period is three weeks or so later than the similar stage in the life cycle of *Pygoscelis adeliae*, the latter would have eggs, and would have begun to feed again upon red plankton, while the Johnny Penguins were still going hungry. Apparently the season of courtship and mating, as well as that of the moult, are for all penguins times of abstinence from feeding.

Although every species of penguin obtains its food entirely in the water, devouring nothing other than moulted feathers and the shells of hatched eggs while ashore, Werth (1925, 594) found that captive Johnnies eventually learned to eat out of a bowl, and even to catch bits of fish tossed to them through the air.

At the end of December, among undisturbed colonies at South Georgia, I noted that many of the young penguins were half-grown, although a good proportion of the nests still contained eggs. By January 10, however, only one nest among thirty held them, and on January 24 no eggs remained except a few addled sets still covered by the patient parents.

By the middle of January the young were mostly two-thirds grown, and their incessant chattering could be heard a long way from the rookeries. The older youngsters walked about in an uncertain, wobbly fashion, tagging after their fathers and mothers and trumpeting nervously when left too far behind. When I walked among the nests, all but the youngest chicks left them and herded together. The brooding adults, too, rushed away, but a few squeaks from the abandoned little ones usually brought them back, scampering hither and thither and swinging their wings frantically. If the youngsters happened to be old enough to walk, the parents coaxed them along by giving small tastes of food, with promises of more, but in hysterical fashion they would soon forget to wait for their feeble babies, and would have to be called back repeatedly. The youngsters, even when very large, were fond of snuggling as closely as possible against their parents.

When caught in the hand, the fledglings struck with their harmless little wings and attempted to bite, at the same time protesting with high-pitched voices. After a few moments, however, they became absurdly tame and confident, and enjoyed having their plush-like backs stroked.

When undisturbed, the chicks are kept from roving by the fact that every adult on a nest will strike at any strange youngster wandering within range. The old birds seem especially to try to tweak the tongues of errant chicks. On the other hand, brooding adults will cover and guard any number of young penguins that are actually placed under them by human interference. Under such circumstances, indeed, they will extend their care even to young gulls or other birds.

By the end of January, at South Georgia, all but a very few of the young penguins, still clad in the softest of gray and white "fur," had permanently deserted the nests and had congregated by themselves, but always under the guard of adult nurses. The latter kept the chicks herded, and dashed at any skua that alighted near-by, while the other adults went communistic and transported bellyfuls of food which, presumably, was no longer intended for their own particular offspring. In fine weather such nursery groups might be seen sunning on the snowbanks, and at other times crouching from the wind in sheltered hollows. Some of the chicks were as large as the adults, but they were still dependent for their food, and they had not yet been to the seashore. I often saw them pleading to be fed when the old birds evidently did not wish to gratify them. Such begging youngsters ran about after the providers, following every dodge and turn, continually bumping into them and stepping on their tails until the harassed adults gave up in despair. The young ones would then press up closely, open their little bills expectantly, nibble at the throat of the old bird, and get the desired reaction of a regurgitated meal.

Young penguins do not go into the sea until they have lost completely their coat of down. In this respect they differ from other aquatic birds, and since the moult of the down is so important an event in the Johnny Penguin's economy the plumage sequence should be discussed in connection with growth.

Upon emerging from the egg the young Johnnies are clad in a covering of straight filaments, silvery gray on the dorsal surface, with the pileum, lores, and cheeks sooty or slaty, and a pale grayish supra-orbital stripe. The ventral surface is grayish white, tinged with buffy. This natal down is worn only a few days. Its filaments are attached to the tips of the second down, which is complex, long, dense, and curly. This second coat is deep neutral gray above, and white beneath, the upper surface of the wings being gray like the back, and both edges fringed with white. The last character is carried through to the adult plumage, as is also the extension of the dorsal coloration in front of the shoulders, a curious and almost universal mark among penguins. Traces of the Johnnies' frail natal down cling to the new coat for some time, but eventually wear off. The buff-colored egg-tooth adheres to the pink and black bill until the bird is nearly fully grown.

About the first of February at South Georgia most of the young begin moulting the second down, thus exposing the plumage which has grown out beneath.

The appearance of the white head-spots is the signal of the coming change. The down is shed in sheets and patches; the process superficially resembles the peeling of the velvet from a deer's horn. By the middle of February, or toward the close of the moulting period, clinging tufts, collars, or topknots of down give the otherwise smooth young penguins the appearance of clowns and pierrots. The last of the down to go is that on the hind head, neck, and shoulders. When the change has been completed the youngsters are distinguishable from their elders only by their sleeker appearance, short tails, pale feet, small light-colored bills, and voices which are unmistakably childish. At this age they still remain together in bands, and spend a good deal of the day in sleeping. They are, however, quite as inquisitive as the old birds. Until the end of February or later they are dependent for their food, and they are fed at least partially by regurgitation for a long while afterwards.

On March 12, at the rookery on the west shore of Possession Bay, I saw many fully grown young penguins following the old birds and demanding food. One youngster chased a sorry-looking adult to the water's edge where the latter turned and proceeded to pump up a meal. After a few moments, however, this persecuted parent, or foster parent, tore away, plunged under a breaking wave and was lost to view. The insatiable young penguin followed it into the surf but came out again discomfited within a few seconds.

The fact that the young Johnny Penguin moults directly into a plumage resembling that of its parents, whereas the Adélie has a distinct juvenal stage, has led Andersson to regard *Pygoscelis papua* as the more primitive member of its group. Such an inference, however, is hardly warranted. The King and Emperor Penguins exhibit an exactly parallel difference. Suppression or development of a juvenal plumage is a familiar phenomenon among birds, and is of the nature of changes that may result from germinal mutation at any stage in the phylogeny of a species.

The moult of the young Johnny Penguins is succeeded closely by the annual post-nuptial moult of the adults. Toward the end of February the feathers of the latter, already much faded and frayed, begin to drop out, further to litter up the ground of the rookeries, which have become evil-smelling and filthy from the surface mixture of mud, decaying tussock grass, excrement, down, and dead nestlings. The moulting season of the adults seems to endure all through the summer, the plumage coming off in patches. A period of several days intervenes between the loss of the contour feathers and of the long, stiff rectrices. On March 12 I observed that a few of the adults had not yet begun to doff their old coats, which were brown, rough, and threadbare. Many more, the majority of the birds in fact, were in the throes of the process and were exceedingly ragged, the new plumage showing in spots. Others had completed the shedding of the body feathers, but still retained their long tails, while the most advanced birds had dropped all their old feathers including the rectrices, a temporary loss which gave them a more dumpy outline than ever; for appearance's sake a Johnny can ill afford to be without its luxuriant tail. At the South Orkneys the 'Scotia' naturalists reported that the loss of the rectrices marked the beginning of the moult, but this does not agree with my observations at South Georgia unless, indeed, the long tails I observed were new and mushroom growths.

Certain changes in the colors of fleshy parts accompany the post-nuptial moult The inner surface of the wings, which is salmon-pink during the breeding season, now becomes white or nearly so. By the time the adults are in new plumage, their feet have turned orange. Later they grow pinkish again, except for the soles, which always remain black.

Since *Pygoscelis papua* has not the fearless temperament of its antarctic congeners, the most successful way to effect an intimate relationship is to approach them slowly, halting at a discreet distance and so inviting the penguins to take the initiative. They have a large bump of curiosity and will presently push the acquaintance, their familiarity increasing in direct proportion to the quietness and seeming indifference of the observer. A description taken from my notes of December 23, 1912, is characteristic. On the afternoon of this day I walked to a glacial pond on the far side of which stood a group of Johnny Penguins. As soon as they saw me, one of their number swam across under water and walked toward me. I remained motionless until it came up quite to my feet and stood there. When I moved quietly it followed, and when I stopped it did likewise. Then, one by one, it was joined by the other penguins from across the pond. It was whimsical to see this troop of mimicking small brothers with no other wish than to keep me company.

On March 12 I rowed ashore during a brisk snowstorm and found a whole army of penguins near the Possession Bay rookery. They were standing by hundreds in a long double row along the beach. These rows marched forward to meet and surround me, and their numbers were continually augmented by new arrivals which kept popping out of the surf and running up the shingle, as if much entertained to find me there.

The amusing, myopic curiosity of the Johnny Penguins is illustrated by the furtive way in which they inspect any striking or unfamiliar object. They pick up odd bits of kelp, bleached bones and other rubbish, carrying them for short distances, and I have seen a band of them walking around and around the fresh carcass of a seal, pecking at it with their bills.

The fact that the Johnny Penguins do not display toward human beings the attitude of combined indifference and combativeness which is so characteristic of the Adélie Penguins, and which is commonly called "bravery," has led many authors to describe them as "peaceful" as well as timid birds. The cocks do, however, fight lustily among themselves during the mating period. Perhaps the principal difference is that the social pugnacity of the Johnny is more short-lived than that of the Adélie. Possibly, too, the relative availability of nesting sites has something to do with the trait. In the low antarctic, as, for instance, at South Georgia, suitable territory is spacious and the nests are rarely crowded. Farther south the birds face heightened intra-specific pressure in their struggle for sites, besides which they endure a losing rivalry with other species.

At the South Orkneys the 'Scotia' naturalists describe them as fighting fiercely among themselves throughout the breeding season, but at South Georgia this would not be true after the appearance of the first eggs. As the latter approach the hatching point, and still more after the chicks have come out, the adults lose their terrorized reaction to the presence of unfamiliar interlopers, and will defend their homes literally to the death. Against the more or less playful attacks of a fox terrier I have seen groups of free birds on the beach huddle back to back, in a sort of Macedonian phalanx, striking out with quick wings at whatever point the dog charged. But the casual combats between two penguins were usually half-hearted affairs. For example, two barged out of the surf one day, within a few steps of me, and immediately began to slap and prod one another. They continued merrily for perhaps a minute, when they spied me and, instantly forgetting their altercation, came up the beach to have a look at the stranger. In several instances I captured adult penguins by running them down. Such birds naturally attempted to bite and strike, but only for a few moments; if their backs were stroked from neck to tail, their sudden docility would seem almost hypnotic.

The free penguins, *i. e.* those neither incubating nor brooding young, spend much time sleeping, particularly on sunny days. Vallentin once observed a group of fledglings asleep at 9.30 A.M., and noted that the same birds, in the same relative positions, were still sleeping at 4 P.M. They have two resting postures—one sitting bolt upright with the head turned behind the shoulder (usually the left) and the bill poked under the axilla; the other lying flat on the breast with the feet tucked forward among the feathers, the wings pressed against the sides, the head drawn snugly back, and the beak pointing slightly upward. The attitude reminded Eaton of a young thrush during repose. "Their eyes," he adds, "present a rather tearful appearance, and resemble bits of dull black glass set in their heads; perhaps the nictitating membrane may be kept drawn over them. At frequent intervals a kind of watery fluid is ejected from their mouth by a shake of the head" (Sharpe, 1879, 156). At South Georgia I found the upright position more commonly maintained during daytime dozes, but birds discovered along the strand after dark were always sleeping upon their bellies. A nap is followed by the toilet, the penguins preening themselves with much care, fluffing out the entire plumage until each feather lies as smoothly as a scale. While preening, they use their long stiff tails as a prop, thus justifying their generic name, *Pygoscelis* or "tail-legged."

The Johnnies walk in a deliberate manner, raising the feet high at each step, carrying their tails well above the ground, pointing their wings behind them as balancers, and thrusting the head forward into the accustomed half-blind attitude. Their nearsightedness is probably no less real than apparent, because of the specialization of their eyes for vision through a medium of water. The pupils of the eyes are contracted to a minute rhombic orifice during the day, but at night, and no doubt under considerable depths of water, they become very large.

In crossing the stony or hummocky beaches which separate various arms of the South Georgian bays, or which lead from the sea to the snow-water ponds in which the penguins delight to play, they follow regular, well-tramped avenues. When bent upon a definite journey across country, they trudge along very steadily and unconcernedly, and for the time seem to take no notice of their fellows. When in great haste, they fall upon the belly and run on all fours. By this well-known tobogganing mode of progression they can lead a man a very creditable chase. The total expanse of their wings is not more than 60 centimeters, but when they run on all fours at a fast pace each wing-tip strikes the snow about 70 centimeters ahead of the last imprint on the same side (Will, 1884, 134). In climbing steep banks the wings and bill are used as much as the feet. The most curious attitude of the Johnnies is assumed when they walk down an incline, such as a snowbank or steep beach. The head is then bent so far forward that the straight neck forms a right angle with the spine; the wings are held stiffly back as far as possible, and the round belly projects as the bird proceeds with gingerly steps. On rare occasions they hop instead of walk, springing with both feet from one beach pebble to another, in the manner of the Rockhopper or Jumping-jack Penguin (*Eudyptes crestatus*). Their fat bodies seem to be made to endure hard knocks, for not only do they tumble frequently wherever the going is rough on shore, but they also suffer fearful batterings on the shingle when they come out of the surf, sometimes being bowled over by four or five successive breakers before they can scramble out of the undertow. On the other hand, if the sea is smooth they pop out neatly and land upon their feet.

In the sub-antarctic parts of their range the Johnny Penguins clearly prefer to enter the sea from a shelving beach, rather than to plunge from a ledge of rock or ice. Indeed, if frightened they will usually run along shore to an easy take-off, instead of diving as far as their own height. When wading into the water, they invariably round the shoulders, bend down the head almost to their feet, and scoop beneath the surface as soon as there is depth enough to float them. Once under way, all their terrestrial awkwardness vanishes. They swim incredibly fast, remaining below the surface except when they leap out porpoise-like, giving an audible gasp for air—to be gone again within the twinkling of an eye. So quickly is this leap completed that penguins playing before the bows of a whaling steamer might readily be mistaken for jumping fish. Often while I was rowing a dory between my brig and the shore at South Georgia, shoals of Johnnies would swim around the boat, and after long submergence would skip out of water five or six times in rapid succession. During the porpoising, they hold the pinions straight out from the body, not close to the sides. The maximum length of the leap may be about two meters.

One evening I stood knee-deep in the water of the Bay of Isles, South Georgia, and watched at close quarters four Johnny Penguins swimming. The sea was fairly calm, the water clear and brilliant in the sunset light. The quartet of penguins darted hither and thither all about me, now and again almost brushing my legs. Frequently they rolled their backs above the surface, and more rarely they leaped out. I distinctly observed that the strokes of their flippers were sometimes made alternately and sometimes in unison. Probably they were feeding, although I could not see their prey. Whether for sport or a more serious purpose, they occasionally swam in the ridge of an advancing swell, going so far up the beach that they were left stranded for a moment. Presently three of them walked out of the sea, shook the water from their tails, and became so immensely interested in watching me that they pursued me for a while when I left the spot.

On another occasion I witnessed an extraordinary diversion of the penguins in the graveyard pool, mentioned above. This was bordered on three sides by perpendicular bands of hard snow, the remaining shore being a stony slope. One afternoon a few birds were swimming in it for enjoyment, I judge, for there was no food, no living thing, not even a visible alga, in the transparent snow water. How alert the penguins seemed in their own element! How unlike the inelegant creatures they sometimes are ashore! They dashed straight away under water the length of the pond and back again, with a velocity which I then had an opportunity to compute as about ten meters a second. They chased each other round and round, flashing into the air twice or thrice during their bursts of speed, every action plainly revealed through the clear quiet water, with the white corpses down below. When the swimmers now and again rested at the surface, only the spotted head and the up-pointed, ridged tail showed, as a rule, but sometimes they would float higher, like grebes. Several of them tried to leap onto a bank of frozen snow rising about a meter above the water. Strangely enough, they misjudged their distance repeatedly; they jumped prematurely, and were on the downward arc before they had cleared the edge. I saw one individual try a dozen times and fail; it always leaped a few lengths too soon and whacked its shiny breast against the wall.

A group of birds which had been sunning on a snowbank entered the water as if by mutual agreement. Some of them walked to the pebbly slope and waded, arching their necks and tucking their heads under water before making the plunge. Others flopped off the edge of the snow-ledge. I say flopped, because they did not make graceful standing dives; on the contrary, they entered with flagrant, splashing belly-bumpers. When first going into the water all of the birds executed the so-called washing reaction, although in this instance they were spotlessly clean to begin with. Immediately after the plunge they came to the surface and lay stiffly, first on one side of their bodies, then on the other, and beat with the uppermost wing and foot, kicking the latter back and forth, and rubbing the flipper across the feathers of the flanks, as if trying to wet themselves thoroughly.

From these observations, and all others made at South Georgia, one might judge that there was a great discrepancy in jumping and diving ability between *Pygoscelis papua* and *P. adeliae*. In part, such a conclusion is doubtless justified, for the prodigious, salmon-like leaps and graceful dives of the Adélie Penguin are perhaps nowhere equaled by the Johnny. And yet the difference may be essentially geographic rather than congenital. At the southerly outposts of its range, the Johnny Penguin is credited with being a very creditable jumper and diver. Menegaux even says that it can spring out of the sea with force enough to clear ice ledges 2.75 meters above, but this figure must surely be an exaggeration.

In any event, it seems that in sub-antarctic lands, where the coast is not continuously barred by an ice-foot, the resident Johnnies have lost the inclination, if not the ability, to gain the land by means of a catapultic leap. Farther south necessity has fostered the trick, as well as the predilection to dive head-first. Although I occasionally saw these penguins on the very brinks of South Georgian glaciers where they abutted on the bays, I believe that in all such instances the birds had climbed up over a sloping side, and that they invariably returned to the water by the same route.

While the Johnnies feed far from the coast, as noted above, they all apparently return to land for the night, at least throughout the breeding season. Their routine is very regular. In late afternoon at South Georgia, and nearly always at about the same hour, we would see long troops of them porpoising into the fiords from sea and heading toward their traditional landings. The habit is so dependable that sealers, overtaken in their boats by impenetrable fog, rely upon the homecoming Johnnies for the bearing of practicable beaches.

Considering that most natatorial birds swim as soon as they emerge from the shell, the tardiness of young penguins in taking to the water has been pointed out as a remarkable phenomenon. The explanation of this, no doubt, is that the speed and stamina required for capturing living prey, for escaping from the swift sea-leopard, and for passing through breaking surf, cannot be developed early in life by birds which use the wings, instead of the feet, as propelling organs. The entire sufficiency of the wings in the swimming evolutions of the Johnnies is illustrated by the experience of Lieutenant Eld, of the United States Exploring Expedition. Landing from the 'Flying Fish' at Macquarie Island, in 1840, he thought to secure living examples of these penguins by lashing their feet together. All but one, however, clambered out of the boat and swam off at unhampered speed (Peale, 1848, 264).

The pinions of nestling penguins seem extraordinarily underdeveloped. The little birds exercise by flapping them, weakly at first but vigorously later on, but they never enter the water of their own accord until they have completed the moult of the down. On many occasions I put nestling Johnnies of various ages, as well as full-grown moulting young, into fresh-water ponds, where they proved themselves almost as helpless as human beings unfamiliar with swimming. They instinctively put their heads under water and tried to plunge below the surface in the ancestral fashion, but it was a feat quite impossible for them. They beat the wings in unison and merely bobbed up and down without making much progress. Such a scene always attracted a band of skuas to the spot, as if these ogres appreciated the helplessness of a young penguin in the water. The skuas never struck while their prospective victim was swimming, but paced alongshore waiting to intercept its landing. Once a half-grown youngster with which I had been experimenting crawled out of the graveyard pool into the very jaws of seven skuas, which attacked it *en masse*. The little penguin struck with its feeble wings and cried out. Insignificant as it was, not one of the skuas dared seize it outright, but they made quick rushes from all sides, striking the penguin on the head with closed bills and then retreating. I rescued it and restored it to its nest, where I subsequently saw it resting with its head hidden between the legs of one of its parents.

In general, the Johnny Penguins may be said to show fondness for associating with other species. At South Georgia they are forever slipping in among the King Penguins, only to be snubbed. At Elephant Island Wilkins found them mixed more or less indiscriminately with *Eudyptes chrysolophus*. Andersson notes that in the Graham Land region their nests are almost invariably close to those of *Pygoscelis adeliae* and *antarctica*, while at Booth-Wandel Island they are mingled as well with those of the resident cormorants.

ADÉLIE PENGUIN

Pygoscelis adeliae

Catarrhactes adeliae Hombron and Jacquinot, 1841, Ann. Sci. Nat. Paris, (2) Zoöl., 16, p. 320 (Adélie Land, *circa* long. 140° E., Antarctica).

Names: Adelia Penguin, Black-throated Penguin, "Pingüín de Adelia." The last name has been adopted by Argentine authors who have published in Spanish upon the birds of the American quadrant of Antarctica. The species takes its name from Adélie Land, which had been so called by the French discoverer, Dumont d'Urville, in honor of his wife. Synonyms for the specific name of this penguin are *brevirostris*, *longicauda*, and *herculis*.

Characters: Total length and stature only slightly less than those of *Pygoscelis papua*, but bill, wings, and feet decidedly smaller. Average standing height about 73 cm.; wing-length 17–20 cm. Bill feathered on both mandibles for half its length. Head, normally without white markings except for the conspicuous white eyelids, the effect of which is enhanced in life by exposure of a large area of gleaming white cornea; a small proportion of breeding birds show irregular tufts of white feathers on the head, reminiscent of the scattered white cephalic flecking of *P. papua;* ventral part of the blackish hood cutting sharply across the fore neck from the cheeks, and forming a point in the mid-line. (In the immature plumage, worn for more than a year after the moult of the down, birds of this species have white throats and black eyelids.) Flippers differing from those of *P. papua* in that they are bordered with white on only the posterior edge, the color of the dark outer surface being carried just over the edge anteriorly. Plumage-pattern in other respects substantially resembling that of *papua*, as well as of the third member of the genus, *P. antarctica*. The dusky distal halves of the dorsal feathers, from bill to tail coverts, have jet-black shafts and are, in fresh plumage, tipped with sagittate sky-blue marks; the general color, whether prevailingly blue, black, or brown, depends mostly upon the state of wear and replacement. The upper parts of the head and neck look bluish black in breeding birds, the ventral surface of the body, caudad from the throat, being dazzling metallic white, everywhere separated by a sharp line from the dark areas. Tail, entirely black, reported to be composed of 14 rectrices, but two of the five adults in the American Museum Collection possess 16. Terminal dusky spot on white inner lining of flipper highly variable in extent. Iris, reddish brown; eyelids, white; bill, brick-red, the maxilla terminally black and the cutting edges of the mandible black; feet, pale flesh-pink, with black soles; claws, brown.

Measurements of the five American Museum specimens of *Pygoscelis adeliae* are as follows: wing, 180–195 (186); tail, 130–153; bill from gape, 51–62; exposed culmen, 35–44; foot 107 mm.

Dimensions of a large series recorded by Clarke are: total length, males, 712–800; females, 686–785; wing-length, males, 178–200; females, 177–189 mm. Dimensions given by Gain for 13 adults are: total length, 665–750; wing-spread, 480–535; wing, 176–200; tail, 165–199; exposed culmen, 33–46 mm. The maximum length of the tail quills is as great as in *Pygoscelis papua*. Their possibilities of growth become evident only in a long series of birds in good plumage.

Albinistic and isabelline examples of this species have been reported from many parts of its range.

Valette gives the following data on the viscera: length of whole alimentary tract, 384 cm.; of intestine, 324 cm.; total cubic capacity of alimentary canal, 250 cc.

The best data on the weight of Adélie Penguins are those of the 'Scotia' naturalists at the South Orkneys. The figures, as recorded by Clarke (1913, 230), show that male birds average somewhat heavier than females, and that a marked reduction in weight goes on during the breeding season, between the periods of mating and moult. The tables follow:

Males,	October,	5.2–6.4 kg.	(11.5–14.1 lbs.).
Males,	April,	3.3–4.5 kg.	(7.25–10 lbs.).
Females,	October,	3.9–5.9 kg.	(9–13 lbs.).
Females,	April,	2.7–3.6 kg.	(6–8 lbs.).

Body temperatures, given by numerous authorities, range mostly between 37.9° C. (100.2° F.) and 40.5° C. (104.9° F.) (Andersson, 1908, 21), but Clarke says that it sometimes proves as high as 41.1° C. (106° F.).

The eggs of the Adélie are typically subspherical, outwardly chalky but with a very green inner shell. They resemble those of *Pygoscelis papua*, and average quite as large. Measurements of 96 eggs recorded by Wilson range from 64–72 mm. in length and from 50–55 mm. in width. These had an average weight of 129 grams. About fifty eggs of the first laying collected by the French naturalists in West Antarctica measured from 61–77.5 mm. in length by 47–59.5 mm. in breadth, and weighed from 75–148 grams (Gain, 1914, 23).

Distribution: Antarctic and circumpolar; nesting on available exposures all round the shores of the polar continent, and migrating outward to the free pack-ice after the breeding season, but rarely passing north of latitude 60° S. Only in the American quadrant does the species reside in the sub-polar zone, its breeding grounds extending northward along both coasts of the Antarctic Archipelago to the South Shetland Islands and, beyond, to the South Orkney and South Sandwich groups, which are favorable because prevailingly icebound. Not known from other low antarctic islands, the published records for South Georgia, and probably for Bouvet, being unwarranted.

The Adélie is the most thoroughly investigated of penguins. Because of the widespread publicity its arresting appearance and manners have been given by means of pen, camera, cinematograph, and even the radio, it has become, moreover, easily the most familiar of penguins. Popularly speaking, it is the type and epitome of the penguin family, a prestige developed entirely during the period of active south-polar exploration that began after the opening of the present century.

With singular unanimity, explorers have likened the Adélie Penguin to a smart and fussy little man in evening clothes, with the tail of the black coat dragging on the ground, and who walks with the roll and swagger of an old salt just ashore from a long voyage. Levick writes:

> His carriage is confident as he approaches you over the snow, curiosity in his every movement. When within a yard or two of you, as you stand silently watching him, he halts, poking his head forward with little jerky movements, first to one side, then to the other, using his right and left eye alternately during his inspection. He seems to prefer using one eye at a time when viewing any near object, but when looking far ahead, or walking along, he looks straight ahead of him, using both eyes. He does this, too, when his anger is aroused, holding his head very high, and appearing to squint at you along his beak.
>
> After a careful inspection, he may suddenly lose all interest in you, and ruffling up his feathers sink into a doze. Stand still for a minute till he has settled himself to sleep, then make sound enough to wake him without startling him, and he opens his eyes, stretching himself, yawns, then finally walks off, caring no more about you.

No expedition of the American Museum of Natural History has encountered the Adélie Penguin in the field, because none has penetrated its habitat. The species nowhere approaches within several hundred miles of the South American continent. Alleged records for South Georgia all seem to hang upon a single unsubstantiated statement that the bird appears there as an occasional straggler (Bennett, 1926, 5). The records for Bouvet Island (Aagaard, 1928, 5; Riiser-Larsen, 1930, 555) are apparently erroneous; the published photographs of Riiser-Larsen show that the birds which were called Adélie Penguins at Bouvet were in reality *Pygoscelis antarctica*. The vicinity of the South Sandwich Islands seems to mark the northernmost extension of the range of the species, for Wilkins (1923, 474) found the Adélie to be one of four kinds of penguins common about Zavodovski Island in January, the height of the breeding season. The farther south one goes the greater becomes the proportion of Adélies among other penguins, until at length they share the uttermost coasts only with their gigantic cousin, the Emperor.

The specimens of *Pygoscelis adeliae* in the American Museum Collection comprise several from Deception Island, South Shetlands, taken by Mr. A. G. Bennett during December, 1921, one obtained at the South Orkneys by the Scottish National Antarctic Expedition, and several Byrd Expedition examples from the Ross Shelf Ice.

It is very interesting to note that in relative proportions of appendages to bulk the species *Pygoscelis adeliae* and *P. papua* parallel a condition exemplified by the Emperor and King Penguins, and described above. In the present case the size relationship, with respect to climate, is reversed, for the antarctic Adélie happens to be a smaller animal than the pan-antarctic Johnny Penguin. But, since the former species has not only absolutely but also relatively smaller bill, wing, and feet, the principle is identical. The following comparison is based upon published data from ample series of specimens of both sexes:

	Total length	Wing-length	Wing-spread	Bill from gape
P. adeliae	675–785	170–200	480–535	55–62 mm.
P. papua	700–800	223–242	575–600	68–93

The relative disproportion in the size of the foot appears to be even greater in the two species. The bill of *adeliae* is not only proportionately shorter, but it is also densely feathered for half its length. Furthermore, the external nostrils are obsolete and closed, whereas in *P. papua* they are open and presumably functional.

Some, if not all, of these peculiarities of the Adélie Penguin would tend to fit it for a more severe climatic environment than that prevailing in the optimum habitat of the Johnny. (See the discussion of this subject in the account of *Aptenodytes forsteri*.) While they are not to be thought of, in the crude sense, as "adaptations" to south-polar conditions, they belong, nevertheless, to the group of characters which determine for any species the selection of habitat. Structure must, in the main, precede function, and a species genetically endowed with even the slightest mechanical advantages for life in any given environment will be "preadapted" and, other things being equal, will outdistance its competitors and dominate within that sphere. The present ecological position of the Adélie Penguin gives us no clue whatsoever to its origin, remote history, or route of dispersal. We are not justified in assuming that its ancestors were either more or less antarctic than those of the Johnny or of penguins now occurring within the tropics. All we know is that the present equipment of the bird supremely fits it for the hard niche it has come to occupy.

The vigor and perfection of the Adélie Penguin, which are continuously fostered by very high selective mortality, become apparent as one follows its life history. Such fitness may even be reflected in the apparent fact that birds of this species harbor within their digestive tracts far fewer natural parasites than do examples of *Pygoscelis papua* from the same regions (Gain, 1914, 5).

In the American sector of Antarctica the Adélie Penguin has been studied by members of the Swedish, Scottish, and French expeditions, as well as by several individual sojourners. At the South Orkneys, for example, Valette, of the Argentine Meteorological Service, set down an early and delightful account of the species, a record subsequently extended by the 'Scotia' naturalists. The latter discovered fourteen rookeries upon Laurie Island and its outlying islets. Here the Adélie proved the most abundant of all resident penguins, and its numbers during the summer were estimated at not less than five millions (Clarke, 1913, 227).

At the South Shetlands it is much less numerous, but on the Weddell Sea side of Graham Land, *e. g.* on islands between Paulet and Seymour, one again finds colonies containing hundreds of thousands (Andersson, 1908, 21). Likewise, among the islands south of Bransfield Strait, off the western coast of Graham Land, the Adélies establish themselves on rocks and slopes well exposed to the sun, in increasing numbers as one progresses poleward.

Throughout this region these penguins exhibit a more or less latitudinal sequence of vital dates, such as has been noted in the case of *Pygoscelis papua.* Thus the returning migrants may reach the South Orkneys (latitude 61° S.) by the end of the first week of October, when the females are carrying ova about 12 millimeters in diameter, to be ripened and laid before the end of the month, and hatched by December 4 (Valette, 1906, 40). At Petermann Island, four degrees farther south, there may be no established influx until the last week of October, with a proportionate lag in the appearance of eggs and young. The autumnal exodus from the southerly colonies, on the other hand, begins earlier than in milder districts.

Wherever the ranges of the Adélie and Johnny Penguins overlap, the former appears on the scene about a fortnight ahead of its less energetic cousin, and appropriates all the better nesting sites. Although the two may be called competitors in the biological sense, there is little of actual conflict between them. The Johnny seems to know the rules and his place; in other words, he plainly accepts the fact of physical inferiority.

So many charming and detailed life histories of the Adélie Penguin have been published that it would be pointless to attempt in this volume a really exhaustive biography. Quite indispensable to anyone interested in penguins are the accounts of Wilson (1907, 36) and Levick (1914), both based upon field work in the Australian quadrant of Antarctica, and that of Gain, which records the observations of the French explorers in regions south of the South American continent. The summary of habits and behavior that follows rests heavily upon Levick's book, with the interpolation of considerable matter from other authorities.

The rookeries of the Adélies are likely to occupy the most windy sections of the antarctic shore, for the reason that such places are kept more or less bare of snow and furnish, therefore, the solid ground and pebbles necessary for nesting. Cape Adare, in latitude 71° 41′ S., at the western side of Ross Sea, is a typical and well-known continental breeding site. It is cliff-sided except at the tip, and protected by an ice-foot. The nesting ground is on the irregular terrain formed by beach and talus, and also on the promontory itself to an altitude of 300 meters or more.

Cape Adare is far south of the pelagic pack-ice in which the Adélie Penguins spend the winter, but it is by no means one of the most southerly rookeries. Migrant penguins destined for the colony at Cape Crozier, on Ross Island, travel more than 550 kilometers farther toward the pole. They must journey at least 700 to 800 kilometers by water, and a considerable additional distance on foot across the ice. The southbound migrants all appear to have a particular goal, rather than just any landfall, for bands of birds may be seen deliberately passing by a still unfilled colony and making steadfastly for another a long way beyond. In this connection, furthermore, Dr. Charcot's associates found at Petermann Island, during October and November, 1909, eleven of fifty adults they had banded at the locality during January of the same year, or before the winter's absence (Gain). Additional examples of this banded group continued to be recovered up to December, 1910, which means merely that the homing instinct of the Adélie is as pronounced as that of most other birds. It is interesting, by the way, that not one of fifty *young* Adélies banded by the French naturalists reappeared during the following breeding season, a fact substantiating what we now know of the immature life of the species.

On the spring immigration, which signalizes to antarctic explorers the happy end of the polar night, the Adélies vary their method of progression between walking and tobogganing. The normal rate is the same by both means, namely anything up to about 8 kilometers an hour—Brown (1913, 249) says as much as 6 miles (nearly 10 kilometers) per hour— so that the lines of birds, in companies of alternate position, remain unbroken. In the walking posture each stride may extend to about 10 centimeters. The footsteps number about 130 per minute, and the respiration sounds wheezy, as though the birds had become chronically out of breath from their prolonged exertion. The penguins jump over cracks, small ice-ridges, or other low obstacles in their path. If they are unhurried, the tail hangs down so that the stiff central quills cut a furrow in the snow.

When wearied of walking, or when the surface is particularly smooth, the penguins fall forward upon their breasts and push themselves by lusty strokes of the legs behind them, with the tail sticking up in the air. Sections of the line continually change between the upright and the tobogganing positions. When the prostrate birds are alarmed, or hurrying in sport, they use the flippers as well as the feet for propulsion, producing a four-legged gait which is their fastest mode of progression but also the most exhausting. Their rate then, according to Wilson, is as fast as a man can run on snow.

Travelling is continued only during daylight; when night overtakes the birds, they bivouac in line until dawn. The period of the ice-passage may run to two weeks, or even more, throughout which the formation remains unbroken, even though miles of rough ice may wear or cut through the leathery soles until the army is leaving a ribbon of blood in its wake.

Toward the end of their long trek, the penguins seem to become excited, and the lines break into a run for the conclusion of the race, most of the birds skittering along on their bellies with the outstretched flippers and the stern-wheel legs both working as fast as possible. Then, abruptly, the migrants find themselves at the bourne of all their travail—plunged perhaps into the din of a squalling, struggling crowd of predecessors, a situation in strange contrast with the silence of the lonely ice-fields.

At Cape Adare the first migrant Adélies appear about the end of the second week in October. During the next three or four days new arrivals in fine plumage continue to dribble in. After their long journey they seem somewhat phlegmatic and are prone to lie about in sheltered places instead of taking part in immediate recognition or courting activities. Within five days after the arrival of the first birds, the spring migration is under way in earnest, and interminable files can be seen extending to the northerly horizon.

The first activity which points directly toward the breeding period is the occupation of nesting sites by the still unmated hens. Some of the earlier observers, such as the naturalists of the Swedish Antarctic Expedition, reported that it was the male birds which took possession of last year's nests or other desirable sites, there to sit quietly and wait until an eligible female approached (Andersson). The researches of Levick, Wilson, and others have proved, however, that it is the hens rather than the cocks that thus occupy territory previous to mating. At this period the females are quarrelsome among themselves, and those that chance to squat near together strike at one another and make particular efforts to peck each other's mouths and tongues, until one finally withdraws from close proximity. In the frequent blizzards of the early breeding season the birds may leave their nest sites to seek shelter in protected hollows. Under such weather conditions they sometimes get completely covered with beads of ice like frozen tears, which tinkle when they move about (Valette).

In staking claims the hens first thaw the soil slightly with their breasts and then turn about and scratch out a slight circular scoop. They next sit within or beside this hollow, awaiting the attentions of males. The earlier hens to arrive get their family duties under way with a minimum of disturbance, these consisting of the relatively trifling intra-sexual disagreements with other hens which establish the social order. But later migrants among the females are likely to become the objects of much more serious battles between ardent cocks, and such hens may even be held as preliminary property by several suitors before the mating episode reaches a point of fixation.

Since the hen birds choose the nesting site, it is clear that the cocks cannot keep to the same spot during successive years. No mating takes place during the migration, the birds being quite independent upon arrival. Moreover, no hen begins to build a nest while still unmated; she merely claims her territory and forms the scoop.

By October 20, when the temperature at Cape Adare has risen to the neighborhood of –17.8° C. (0° F.), the mating season is thoroughly under way, although augmenting lines of migrants continue to pour in. Newly arrived cocks set about their courtship at once, their procedure being to thread their way through the rookery, stopping every now and then to ruffle up the feathers, close the eyes, and go into a brief doze. This interruption of activity by sleep, after periods of intensive effort of any sort, is highly characteristic of penguins and is doubtless equivalent to the phenomenon which Pavlov and other experimenters have encountered in their studies of dog behavior. After a few moments of relaxation, the cock penguin once more smooths his feathers and goes forward, peering at whatever he sees, and still seeming to be fighting off sleep. Finally he walks up to a squatting hen, sticks his beak against the frozen ground in front of her, and either picks up a pebble or goes through a piece of dumb show with an imaginary pebble. He may then exhibit his charm by standing erect, drawing up to his full height, craning forward his neck, turning up the head, slowly waving the flippers, and emitting a long cackle. This over, he resumes his normal squat appearance and waits to see what impression he may have made.

To such overtures the hen may reply in kind. On the other hand, she may peck the suitor cruelly, to all of which he tamely submits, hunching himself up and shutting his eyes. After a brief display of such fractious temperament, the hen usually becomes appeased, whereupon the abused male rises to his feet, edges up to her in his prettiest manner, and utters soft guttural sounds as preliminary love-making. Both birds may then assume the "ecstatic" attitude, swaying their necks from side to side with crossed beaks, and both uttering shrill cries.

The above refers to a courtship uncomplicated by the presence of a cock already on the ground. Frequently, however, the newcomer begins his addresses when one or more suitors already feel a proprietary interest in a hen. In such instances the approach of the amorous cock seems not to be resented by the others until the courtship pantomime is actually begun. This, however, is the signal for immediate battle, which does not terminate until one of the combatants is completely exhausted and quite ready to leave the field, while the victor crows, with much rocking of the body. Rival cocks may begin a battle with their beaks, but they soon resort entirely to blows of the flippers and end by leaning against each other in a sidewise position and battering away with the "outside" wings, like clinched pugilists, raining blows until the battering sounds a tattoo. Although blood is frequently drawn during such battles, serious injuries are rare, and the end of a combat usually comes when one of a pair is out of breath. Occasionally the hen, the stimulus of the struggle, may be overcome by excitement and take part by adding indiscriminate thrusts of her beak to the blows of her rival suitors. Such fights between cocks become more common and more ferocious as the colony fills up, toward the end of October.

In the actual mating ceremony, the signal comes from the female bird, as she is stretched out beside the nest. Of a sudden she will turn toward her mate, silently and almost furtively, and will lower her head, curve her neck, and appear to inflate her body. The male at once responds by springing upon the forward part of the prostrate female's back, bending over her, eye to eye, and maintaining his equilibrium on the slippery perch by using his wings as balancers. He then incites the female by nibbling about her head, whereupon she raises her beak and holds it in contact with his, thus supplying him with a further point of support. Keeping this bill-hold, the male now works slowly backward until the performance terminates in the rapid genital contact. The male then gently dismounts, and the pair lie for a time face to face with heads lowered. Presently the female arises and, with a shake of the tail, moves deliberately to her place on the nest, while the male may edge over close beside her (Valette). Dr. Charcot's report on the Second French Antarctic Expedition studies is accompanied by an excellent photograph of the mating act (Gain, 1914, pl. 3, fig. 14).

In the construction of the nest which immediately follows pairing, the female bird takes the part of guard and builder, while her mate carries up the stones. These are of various sizes, nearly up to that of an egg. Some birds exhibit a definite predilection for large and others for small stones. The pebbles are laid mostly around the margin of the scoop, though sometimes a mosaic lining is also made. Most of them seem to be selected for their roundness.

In the early days of spring, when the penguin population is thin, stones are taken openly and freely from last year's nests. Certainly a male bird never walks far for one if he can filch it near-by. But with the filling up of a rookery, stealing becomes a punishable offense. Depredators, when conscious of detection or suspicion, make themselves look thin, sleek, and small, and endeavor to lose themselves in the crowd. The offended birds, on the contrary, seem to swell with rage, for they erect their feathers while pursuing the thief, and the plumage at the back of the neck bristles out so as to form a crest and topknot. "Consciousness of guilt," says Levick, "always makes a penguin smooth his feathers and look small, whilst indignation has the opposite effect." Moreover, when the owner of a pile of stones spots a potential but still undeclared thief in the neighborhood, it is laughable to see how the suspect sloughs off his keen, prowling aspect, and walks innocently by as if nothing had been farther from his intentions than the crime of removing his neighbor's landmark.

Levick notes a great difference in the character or temperament of the penguins, as regards their likelihood of being robbed. Some hens are so vigilant and alert that they lose nothing from large piles of stones; others have their foundations constantly pilfered from the rear, and a few are even so weak-natured that they can be robbed with impunity by any sufficiently bold male. Here is definite evidence of the social order discussed heretofore.

Gain reports that after loose pebbles had become scarce at Petermann Island, he has seen a male walk more than a hundred meters to find one. All this bird's labor and peripatetics were still wirhout success, for every time he departed other males looted his accumulated pile, the female being unable to defend the nest against them. Taking pity, the French naturalist himself built up a handsome nest for the pair. Although he was roundly attacked by the returning male, this did not prevent the birds from taking advantage of the unlooked-for bounty.

During the first stages of domesticity, when thousands of lusty cocks are still pouring into the rookery, a new arrival sometimes pays court to a recently mated hen. But after the eggs have been laid, and regular family life is under way, the couples appear to live in undisturbed faithfulness. Among examples of the individuality of temperament shown by the Adélies is the apparent fact that certain mated couples seem constantly tender and affectionate, while others quarrel violently.

Immigration continues, of course, during the courtship and mating activities of the early arrivals, but it normally ceases before the date of appearance of the first eggs. The sign of the end of migration is the presence of wide gaps in the streams of birds coming in from the north. This coincides, roughly, with the arrival of the Antarctic Skuas, the inveterate enemies of the Adélies.

The penguins spread out over the entire available nesting area, but through the working of some peculiar instinctive behavior, which resembles the so-called "foresight" of the social insects, they avoid building nests upon islets which lie in frozen ponds on their breeding grounds. Such sites, although readily reached across the hard ice of spring, would be accessible during the height of the breeding season only through waist-deep, dirty water. When, however, an islet of the sort is connected with the higher ground by a causeway, the penguins do not fail to occupy it to the limit of its capacity.

At Cape Adare the spring migration is over by the last day of October, and the first eggs may be found about November 2 or 3. At other localities the respective dates vary slightly, according to latitude and geographic influences. Between the laying of the first and second eggs there is an interval of three days.

In West Antarctica, the region which especially concerns this book, the largest colony of Adélie Penguins encountered by the Swedish Antarctic Expedition was on Paulet Island, just south of the much larger Dundee Island, to eastward of the tip of the Antarctic Archipelago. Here there were several hundred thousand birds, which began to return from sea on October 12, or as soon as the spring west winds had broken up the ice, so that open water approached within 10 kilometers of land. The snow-free ground was the first to be occupied, but hordes of birds had to squat upon the great areas of still unmelted snow during the courtship period. Soon after November 1, the earliest eggs appeared and by November 7 there were many thousands (Andersson).

At Petermann Island, farther southward on the western side of the same peninsular archipelago, the first Adélies were seen by the 'Pourquoi Pas?' party during early October. This appearance, however, was a flash in the pan, for the birds all disappeared, and on October 21 not one could be found. But next day the immigration began in earnest, and continued steadily throughout the remainder of the month. Most of the penguins were not in the least casual as to destination; they seemed to be hastening back to well-known territory, and even to familiar nesting sites. Many of the females headed straight for what appeared to be a particular goal, and at once took possession of old nests with an air of full propriety. The first two eggs were noted on November 9. On November 25, 325 were counted, and by early December the laying was finished (Gain).

No feeding is done by the newly arrived birds of either sex until after both eggs have appeared, which means that large numbers of penguins fast for very nearly a month during the most trying and strenuous period of their existence. Throughout the whole session of homing, courtship, and mating, the birds pay absolutely no attention to available holes and leads in the sea-ice, which might offer a ready approach to their customary food. By the end of the mating period many of the penguins are bedraggled with mire and bloodstains, but they remain as active and pugnacious as they were at the time of their first appearance. Incubation requires from 30 to 37 days, the average being about midway between these extremes. The temperature of the eggs in the nest has been determined as from 21°–27° C. (70°–80° F.) in all weathers (Sharpe, 1902, 113), this being at least 20° F. below the body temperature of the bird.

Very rarely three eggs rather than two are known to comprise a full set. Three have been found in a single nest, at any rate, and it is hardly likely that there would be an opportunity for a strange hen to be responsible for the third. After a nest has been robbed, the following sets of eggs are usually smaller than those of the first laying, a phenomenon already noted in the case of *Pygoscelis papua*.

When arriving at the breeding grounds after a sea-water régime of many months' duration, the Adélie Penguins quench their thirst by eating snow near the nesting sites. As the adjacent supply melts away because of the rapid absorption of heat by the dark pebbles, the birds show signs of distress by their panting, and presently they begin to make journeys to more distant snowdrifts. At both Cape Adare and Cape Royds cock penguins have been seen carrying to their mates lumps of snow which were accepted and eaten.

The tops of knolls are usually the most crowded districts in a rookery. In such places the nests are as close together as possible, which means that each sitting hen can barely touch beaks with her neighbors. Single boulders a meter or less in height are also occupied as home sites, though one wonders how the birds can keep their perches during gales.

At Petermann Island the French naturalists observed small groups of Adélies, which had found no room for nests in the crowded territory, lying together upon the snow at the outskirts of a rookery until they had melted it down to the underlying soil. In some instances the eggs appeared before a proper nest could be built, and would then have to lie in the thaw water. Under similar circumstances, it has been noted that the sitting birds accommodate both eggs on top of their feet, in the manner of the King and Emperor Penguins. Indeed, it is by no means certain that this is not the normal position of the eggs, even in well-built nests (Mawson, 1915, 2, 116). The hinder egg, at least, seems always to rest upon the feet of the sitter (Menegaux, 1907, 17).

Aside from this interesting suggestion of kinship in habit with *Aptenodytes*, the Adélie Penguins sometimes simulate the ways of still another genus, *Spheniscus*, by burrowing deeply into beds of pebbles cemented by frost, or into snow-drifts. They squat comfortably in such little caves for considerable periods, although they are not known to lay their eggs in them.

Nests on low ground which are threatened by flood from melting slush are built higher and higher by the addition of pebbles, and some birds even appear to work energetically in anticipation of this very calamity. Any suspicion that such behavior is "intelligent" rather than instinctive is dispelled by the reactions of the birds to much simpler contingencies. If their eggs, for example, are lifted out of icy water by a good Samaritan, and set down in a safe and dry spot a few handbreadths to one side, the owners never seem to be able to accommodate themselves to the new *locale;* the eggs, in fact, are evidently no longer recognized, and they are sure to be abandoned. Reference has already been made to the fact that a nest may safely be *built up* by human interference; in other words, the level of the eggs may be changed but not their position.

After both eggs are laid, the hunt for food is renewed. Up to this time the neighborhood of the nests has been stained bright green from the bile in the excreta of the fasting birds. Now this gives place to a splashing of brick-red guano, resulting from the shells of the Crustacea on which the penguins feed. An ammoniacal and rankly fishy odor begins to prevail overpoweringly. Wilson reports that he has smelled the Cape Crozier colony from 50 kilometers to leeward!

The rookeries now tend to become relatively peaceful. The quarrels of courtship are in the past, and the principal combats take place over ownership of a nest, whether through misunderstanding or, more probably, through the attempt of a thwarted individual to appropriate a ready-made cradle and its contents. The general tendency toward order and decorum is, however, so marked that members of several antarctic expeditions have entertained the belief that mated but unoccupied penguins make deliberate efforts to break up the battles that sporadically arise (Bernacchi, 1901, 31; Levick).

Peacefulness is not, however, synonymous with silence.

> The noise is almost unceasing. From a distance it is like a whistling roar, and when, from the cliffs of Cape Adare, we looked down upon the 200 acres swarming with shouting penguins and their whistling, piping chicks, one was reminded of nothing so much as a rink with a thousand chattering skaters (Wilson).

The clamor from such an aggregation is continuous, day and night, for sleep is snatched when and where needed, rather than in any regular rhythm. However, there often is a certain lull about noon, due to the fact that more birds go to sea during the middle of the day than at other hours. Sometimes, too, there seems to be a noticeable cessation of voices about six o'clock in the evening, even though the never-setting sun is still at midday altitude.

The sexes of the Adélie Penguin, which look alike, are easily identifiable on the nest, for the brooding female expands her body, cuddles, clucks, and shows in all ways a henny fondness for the eggs. She turns them solicitously at intervals. She may squabble at safe range with all her nearest neighbors, or stretch her neck to lunge at every passer-by, but she is not easily tempted off the nest. The male, on the other hand, does no more than his duty. He takes his turn at incubation, but is easily distracted into fighting, to the great detriment of the eggs. If one of the latter rolls out of the nest when he springs up with murder in his eye, neither he nor his mate pays any further attention to it. In fact, the first penguin to come along usually breaks the egg with its beak, though it does not eat it (Valette).

The ceremony of relieving guard at the nest requires some time and is accompanied by much conversation. The sitter usually gives the appearance of being reluctant to go. When ready to leave the eggs, it stands up, breast to breast with its mate, and the two rub necks, first on one side then the other, softly cackling all the while. The newcomer is then permitted to see and touch the eggs, and to rearrange a stone or two before the relieved bird makes way for it to settle down (Wilson).

A table of records for a single nest kept by Levick, showed that a particular hen remained incubating for nearly two weeks after the appearance of an egg, a fresh supply of red guano revealing positively when her mate returned for the first time. Then the hen was away at the feeding ground for an equal length of time. After this the change was made more frequently throughout the period of incubation, the birds relieving each other practically every day. After the single chick of this family appeared, both adults were frequently seen at the nest.

After the hatching of the young, the parents assume a new appearance because their stomachs now bulge from the food they are carrying to the nest. The exertion not infrequently makes them nauseated so that they disgorge the supply too soon. Sometimes this happens at the very edge of the nest, when all the labor is wasted, for neither young nor adults are capable of recognizing food as it lies in a heap on the ground.

In feeding young chicks the adults bend over them so far that their heads are quite upside down, the youngsters taking the regurgitated food from the trough between the rami of the maxilla. When the chicks are old enough to stand up in the nest, they feed directly from the beaks or gullets of the adults. Remains of small fish and cephalopods, as well as of the staple shrimps, have been found in the stomach of nestlings. Stones, too, are usually present; some of the chicks examined at the South Orkneys by the Scottish naturalists were "veritable geological museums of pebbles."

Wilson expresses wonder that the chicks hatched at heights of 300 meters or more above sea level can receive sufficient nourishment. Observations show that only two journeys each twenty-four hours can be made by the old birds under such conditions. Yet the hilltop chicks seem as well grown and healthy as those in more accessible nests.

The climbing propensities of the Adélies are not only concerned with nesting, or even with getting themselves to any particular spot. They also climb at random, and sometimes walk up the rough surfaces of antarctic glaciers, where they have been seen standing for as long as two days at the brinks of crevasses which they could not possibly cross.

They are equally fond of climbing the sloping sides of icebergs stranded near shore, while many antarctic photographs show them resting in large numbers on bergs floating far at sea. The naturalists of the Scottish Expedition describe the tenacious efforts of the penguins to gain a footing on such bergs. Taking advantage of the swell, they leap on, and cling to the lower ledges in places where no other creature would have a chance of retaining its hold. After obtaining a firm footing, they work their way as high as possible, and seem to derive great satisfaction from sitting there to rest and gaze about (Clarke, 1913, 260).

The average weight of an Adélie Penguin's egg is in the neighborhood of 129 grams. Levick found the weight of a newly hatched chick to be 85 grams. At the age of five days this bird had more than quadrupled its bulk, and weighed 368.5 grams. At eight days it weighed 702 grams, and at twelve days 1205 grams.

The whole period of growth of the young Adélies, according to Gain, occupies from seven to eight weeks. About the middle of this period, which comes in most localities before January 15, the family unity of the penguins begins to give place to their well-advertised communistic stage. The young birds of more advanced age are pooled in crèches of from twelve to twenty or more individuals, which are guarded and shepherded by a few old birds, so that the others are free to forage. The adults no longer behave as mated pairs nor as specific parents. It does not seem likely that they even recognize their own offspring, but they evidently confine their care to a particular group or crèche, doubtless associated with a special area, for each food-laden bird turns a deaf ear toward the importunities of stray youngsters, or of the massed young of other crèches, and makes straight for the one to which its services are attached. Every old bird has to run the gantlet of insistent young ones, fresh relays of which are continually following and pestering it. The survival of the fittest is well exemplified by the chicks, for the weaker ones fail in their demands for food and droop day by day until a skua drops down and puts an end to them.

Levick entertainingly describes the unmated or "hooligan" penguins which cause much annoyance and do a great deal of damage as the breeding season progresses. Their numbers are constantly increased, presumably through the death of a proportion of the birds. These rogue penguins are particularly dangerous to stray chicks, many of which lose their lives from vicious bullying.

Andersson, who wrote the account on the birds of the Swedish Antarctic Expedition, believed that the great numbers of Adélie Penguins living amid the pack-ice in Bransfield Strait during December, the height of the breeding season, indicated that by no means all adult individuals of the species nest every year. The length of the holiday alternately taken by mated birds during incubation, however, would permit them to travel far from land during these periods of relaxation and feeding, and would readily account for the presence of great flocks at sea.

After change of guard at the nest, the freed penguins proceed to gather in groups on the ice-foot, where they frolic and chatter and chase each other about in high spirits. The one object of each bird appears to be to make some other dare the first plunge. As soon as one takes a header, the others follow like shot poured out of a bottle. Then all is silence until they bob up at the surface, 20 to 30 meters out, and start rolling and splashing while they clean themselves. Their chaffing at this time sounds like that of a crowd of boys. Returning later to the rookeries with glistening plumage, they often mingle with dirty birds bound for sea and show what social animals they are by standing together in small groups chattering. The sea and its ice are their playground. Here the bands of birds play tag and also use the floes in the tideway as excursion boats. Sometimes they crowd on, amid much bantering, until the embarking of each new bird means the pushing off of another on the far side. The tidal current at Cape Adare flows by at a rate of 5 to 6 knots, and when the crowded ice-pans have been carried a kilometer or so, the penguins all plunge into the water and come up easily against the current, perhaps to board a new raft for another joy-ride. Levick saw one of the bathing birds with a large pebble in its mouth hop onto such an ice-floe. The depth everywhere in the vicinity was at least 10 fathoms, which gives a clue to their sounding ability.

In clear water one can see that they constantly go so deep that they are out of sight from the crow's nest of a ship. In the swimming position their black soles are turned upward, thus completing the perfect system of countershading. They wing their way with powerful strokes, often in a zigzag course, especially if frightened. It is no rare feat for them to pass beneath an ice-pan a hundred meters across.

Wilson timed a bevy of Adélie Penguins in the water and found that they remained fishing under a floe for from 30 to 45 seconds after each dive. Donald (1894, 331) held one beneath the water for 6 minutes, during which he compressed the trachea so as to exclude water from the lungs. Although the bird was considerably exhausted, it recovered and was subsequently set at liberty. This experiment was, however, cruel and pointless. It proved practically nothing, for probably many land birds might equally well withstand the same treatment.

The ordinary mode of progression through the water is that of porpoising, during which the penguins travel along from 10 to 30 meters below the surface and then shoot into the air in an arc covering 2 meters or thereabouts, and vanishing with scarcely a ripple. They rarely rise more than half a meter above the water unless they are making a landing. They also swim at the surface, chiefly when resting or loafing, and they float low enough so that they can use the flippers as well as the feet in propulsion. Alternating in this manner, they sometimes follow ships from curiosity, giving their somewhat human cry whenever they come up (Peale, 1848, 261).

In making their famous leaps from the water to the ice-foot, they judge their distance from the surface 30 to 40 meters away, and then, going beneath, head straight for their landing, and shoot out of the water at a point a little more than a meter from the base of the ice. They pop out erectly, looking for all the world like a jack-in-the-box, and clear straight walls of ice of more than twice their standing height. The highest leap recorded by Levick was exactly 5 feet (152 centimeters). The accuracy with which they make their estimate is very remarkable; Levick never saw a bird misjudge its problem, but the observations of others indicate that the penguins are not quite infallible. Their perception as to the condition of the landing surface is astonishing, for if this be of snow, which affords a good foothold, they come down feet-first, while if it be a slippery surface they throw themselves forward and land upon their breasts in the quadrupedal position.

They dive beautifully, varying the angle according to the depth of the water. They frequently dive from a height as great as 4 meters, but apparently show hesitation and reluctance at 6 to 7.

The Adélies sometimes walk long distances from their nests to the leads in which they feed. Gain found their footprints 22 kilometers from the sea, and Wilson tells us that apparently lost individuals have been encountered upon the Ross Shelf Ice 60 miles (97 kilometers) from open water. To reach feeding places far from the nesting ground, they apparently prefer to walk rather than to travel by the easier water route. Their reluctance to enter the ocean unnecessarily seems to be directly related to the presence of their enemy, the sea-leopard, which commonly lies in wait beneath the ice-foot. Levick found the bodies of 18 penguins in the stomach of one sea-leopard, besides which the beast's intestines were stuffed with remains of still earlier victims. The Adélies apparently carry no painful memory of the sea-leopard, for once they are away from its immediate threat they appear to think no more about it. Moreover, when penguins and sea-leopards are close together upon the ice, the birds pay no attention to their foe. The observations of Levick, Wilson, and others go to show that the Adélie Penguins take little notice of the killer whale, which is therefore probably not an important hazard in their lives (Lowe and Kinnear, 1930, 107).

Ashore, the Antarctic Skua is the principal enemy. These predacious birds immediately follow the penguins southward, and the nestling skuas are reared very largely upon a diet of young Adélies. The skuas show a remarkable instinctive aptitude in the way in which groups of them appear to "play" a pair of penguins, while others from behind calmly haul the protesting chicks out of the nest and despatch them by blows on the head. When a skua flies over a rookery, all the penguins in the vicinity unite in a shrill uproar.

Levick cites a curious instance of the constantly inimical reaction of the penguins to the skuas. The latter liked to feed at a scrap heap not far from the British Expedition hut. At this place it seemed that several penguins always stood guard with the sole object of driving away any skua that attempted to alight upon the garbage and carrion, which were of no interest to the penguins.

The Sheath-bill is a hanger-on about a few of the Adélie communities in West Antarctica, but its function is much more that of a scavenger than a foe. The Giant Fulmar, however, actually eats a certain proportion of young Adélies in many localities. At the South Orkney Islands the members of the Scottish Expedition found that this species took a heavy toll of all the resident penguins. Elsewhere in West Antarctica Andersson saw one of these petrels post itself near the border of an Adélie colony, attempting to waylay such chicks as ran out from the protection of their nurses with the object of begging passing adults for food. When the Giant Fulmar was attacked by one of the old penguins it promptly retreated. When, however, it had succeeded in killing or stunning a young penguin, so as to silence its outcries, it was permitted to devour the carcass with impunity. The adult penguins ceased to have any comprehension of what was taking place before their eyes. This is in harmony with the fact that the penguins will brood indefinitely over a dead chick in the nest. It accords also with an experience of the 'Scotia' naturalists who slaughtered many Adélies in the rookery, one October day, both for food and specimens; the birds roundabout paid absolutely no heed, except to help themselves to the pebbles of their slain comrades' nests (Wilton, Pirie, and Brown, 1908, 49). In like manner Adélies on an ice-floe cannot seem to grasp the idea that a man engaged in clubbing their companions, one after another, might be avoided by taking to the water.

Sick or wounded penguins are never molested by their fellows, which is quite unlike the code among skuas. An ailing skua gets no rest from the mob of its own kind until it dies, to be eaten.

As regards the danger of the severe physical environment, the Adélies frequently get snowed under during spring and summer blizzards, and they have been known to live for weeks beneath the crust before they thawed out. No harm necessarily comes to the eggs from this. A returning cock appears to be made very angry, however, by the inability of his mate to leave the eggs when only her head is projecting through the crust of snow! One of the serious dangers to the rookeries, particularly to nests in the lower part of screes, is that of landslides. Sometimes many hundreds of penguin families are buried at once after the beginning of the season of thaw.

During Wilson's stay in the Australian quadrant of Antarctica, the lowest October temperatures to which the Adélies were subjected on their breeding grounds was –42.1° C. (–43.8° F.). Fortunately, such extreme cold was rarely accompanied by wind. Birds remaining on land during the snowstorms usually squatted with their beaks toward the water, so that their feathers were blown the wrong way and became filled with drift. The downy young crowded into groups, all heading toward the center, like a reversed bevy of quail. The inner ones may have been warm, but those at the edge were white with snow.

When the Adélie chicks come out of their eggshells, most of them are clad in uniformly sooty down, but a certain proportion of the progeny of normal parents, in all localities, are pale gray or silvery white with blackish heads and faces. Chicks of this type suggest the young of the Emperor Penguin. After the moult of the first down, both the light and dark nestlings assume a smoky second down which makes their antecedent phase indeterminable.

The feet of the newly hatched chicks are dusky blackish red. This rapidly changes to a clear bright red, which reaches its maximum at the age of three weeks, after which it gradually turns to a pale flesh color on the upper surface, and black on the plantar surface, of the feet. The claws, which are at first black, later become brown.

Some time between the middle of January and the middle of February, depending in part upon latitude, when the chicks in the nurseries are nearly as big as the adults, they begin to shed the down in the characteristic penguin manner, and to expose the distinctive juvenal plumage, in the possession of which they differ from both their congeners, *papua* and *antarctica*. The process begins on the legs and sides, where wear and tear are greatest. The down is lost last from the upper breast and neck, and it is often clogged with ice and dirt before the moult is finished. In the juvenal dress the throat is white, and the dorsal surface somewhat bluer than in even freshly moulted adults. The eyelids remain black, to become white only at the time of the second autumnal moult, when full maturity is attained. The chicks in the southernmost rookeries are later in their moult and other cyclic phenomena than those hatched farther northward.

Soon after completing the moult of the down the chicks begin to show a highly variable predilection to take to the water. Capacity to swim they already possess, as Gain found by tossing fledglings into the sea when they were still plastered with the red muck which testified that they had not been immersed before. But the majority seem reluctant to enter the water. The old birds go through maneuvers evidently calculated to tempt them in, paddling up into shallow water and then calling to lure the young ones after them. Farther back from the edge of the sea many fledglings still clamor for food, but the adults pay no attention to this and so the young are gradually coaxed or forced to take to the ocean.

The annual moult of the adults follows the down moult of the chicks, and after the departure of the latter many old birds still remain, completing their change of feathers. For a good proportion, however, the moult is finished on northward-moving ice-floes, where the individual birds stand so long in one spot that they melt themselves into neat little cavities which are surrounded by rings of feathers. The stomachs of such birds are also filled with feathers, showing that they are forever picking at the litter of their plumage, which is shed in spurious sheets, large numbers of the plumes being held together by the cohesion of barbs and barbules. The size of the moulting bird is prodigious, the old feathers standing out at right angles while the new are imbedded in a thick layer of fat beneath the skin, which diminishes through absorption as the plumage develops. Indeed, so great is the drain upon the vitality of the birds that they all appear thin, cold, and miserable before the moult is completed. Clarke's detailed figures prove that the Adélies average at least 30 per cent less in weight after the end of the moult than they had at the time of their spring invasion of the breeding ground.

Once the moult of the adult penguins commences, all solicitation for the chicks is at an end. Any youngsters remaining under the care of old birds that have reached such a critical stage are abandoned to subsist upon their own fat until hunger and necessity force them to swim and forage. The young soon scatter in various directions, some of them even turning southward, but in most cases a tropistic instinct works effectively to lead them northward toward the pack-ice. It takes fourteen months for the young to assume their adult plumage, and two years for them to reach sexual maturity. The brown plumage often met with at sea is merely the weathered state of the first contour plumage, from which the black has faded while some of the blue color remains. The bleaching power of the antarctic sun is quite extraordinary. This is shown not only by penguins, skuas, and seals, but even more so in the fact that the hair and beards of polar explorers are sometimes bleached to flaxen whiteness during the months of summer sledging. Mawson's (1929, 553) observations with the pyroheliometer have shown, moreover, that the antarctic air lets through 50 per cent more heat than that of the Australian Bight, with the sun at the same altitude in the two localities. The antarctic air is so prevailingly dry, withal, that the remains of penguins destroyed by skuas or other agencies will usually desiccate on the ground before they can decompose.

Near Paulet Island, in West Antarctica, members of the Swedish Expedition saw large flocks of young Adélies begin to move away from the land, across the sea-ice, on February 18 or 19. Some of these still showed small tufts of down on the head and back. On the last day of the month the slopes of Paulet Island were alive with moulting adults, but all of the young had departed. By March 15 most of the old birds had finished the moult, and even those which were still in the throes left the island when the ice closed in a few days later.

March 12 and 14 are dates recorded in two different seasons for the last sight of the Adélies at Cape Adare, on the other side of the antarctic regions. In any locality their final disappearance is the signal that the polar winter has truly begun.

Gain believes that the Adélies go no farther north than they need to, and that, in West Antarctica at least, they might never leave the vicinity of the colonies if the sea remained open. During the wintering period of the French Expedition, Adélies occasionally appeared at Petermann Island, and in the midst of a storm on April 12 about a hundred of them came ashore there. The more normal winter range, however, is the circumpolar pack-ice which forms a belt from 50 to 500 kilometers in width, the southward limit of which may be anywhere between 150 and 650 kilometers north of the continental shores. Here the birds may escape the darkness of the antarctic winter and live where there is always open water teeming with the crustaceans that form their staple food. From March until the latter part of August both young and old are scattered throughout this floating ice; even here they are more or less gregarious, though less so than in the summer range. Here the adults remain for half a year, and the juvenal birds for a year longer. Then, after the second winter, which marks the end of the youthful period, they undergo the moult in which the white plumage of the throat is replaced by black. Following this they return southward with the older birds to breed. The régime fully explains Gain's failure to recover any of his banded young Adélies during the breeding season following that in which they had hatched.

Consensus of opinion indicates that the wintering range of the young penguins is prevailingly farther north than that of adults. In January, 1902, the southward-bound 'Discovery' was in the pack for three days before Adélies were seen. Then most of the first noted were white-throated juvenals. Farther southward the proportion of adults steadily increased, and the vessel was constantly greeted with ringing cries of *Aark! Aark!* (Wilson).

Now a few words as to the reactions of the Adélie Penguins to human beings, a subject which has perhaps unduly interested many of the south-polar visitors. When the birds are incubating in a rookery that has not been seriously disturbed, most of the penguins pay little attention to the strange interlopers. When a man closely passes the nest, the birds may utter a low growl and perhaps bridle a bit, but only rarely do they dash up to batter one's legs. Such attacks, moreover, are usually short-lived, at least during the early part of the breeding season. The plundering of a nest is, as a rule, followed promptly by the laying of a new set of eggs.

The development of the young is correlated with an increased tendency among the adults to take the initiative in defence. During the first visit of the 'Terror' to Ross Sea, in January, 1841, when colonies numbering "millions" of Adélie Penguins were seen for the first time, passage through the nesting ground at Possession Island was likened by McCormick (1884, 152) to traversing a dense bed of thistles, because of the unremitting attacks of birds defending their young.

Gain (1913, 479) sums up as follows the pugnacious qualities of this species:

> The Adélie penguin is a brave animal and rarely flees from danger. If it happens to be tormented it faces its aggressor and ruffles the black feathers which cover its neck. Then it takes a stand for combat, the body straight, . . . erect, the beak in the air, the wings extended, not losing sight of its enemy. It then makes a sort of purring, a muffled grumbling, to prove that it is not satisfied and has not lost a bit of its firm resolution to defend itself. In this guarded position it awaits events. If the enemy beats a retreat, then the penguin abandons its menacing attitude; often it stays on the spot; sometimes it returns and, lying flat on the ground, pushes itself along with all the force of its claws and its wings. Should it be overtaken, instead of trying to increase its speed, it stops, backs up again to face anew the peril, and returns to its position of combat. Sometimes it takes the offensive, throws itself on its aggressor, which it punishes with blows of its beak and wings.

In every rookery there are a few birds easily recognized as cowards, for on approaching them one sees the feathers lie flatter on the head and neck instead of rising into the war crest, and a moment later they run off as fast as their legs can carry them. This, however, is the rare exception. Most of them greet an intruder with a growl, a glare of eyeballs, and a ruffle of feathers.

In collecting eggs for food at Cape Adare, the members of the British National

Antarctic Expedition learned to push the penguins forward off their nests. The response of a bird to this treatment was to stick its beak against the ground and push backward. So long as the pressure from the rear was kept up, the penguin would not relax its effort to stay on the nest, and so the eggs could be extracted without difficulty. The bird arising would look into the empty nest, bristle, tremble with indignation, and then, as a rule, attack the nearest penguin, being quite incapable of realizing who the true robber was. In fact, all their reactions to human beings are extraordinarily fleeting.

The same futility of behavior is indicated by the bearing of the penguins toward an obstacle. Levick tells us that a guide rope from his Expedition hut to the meteorological screen sagged close to the ground at one place, and that it presented an insurmountable barrier to the passage of penguins. When stopped by it, they would back away and push against it several times, but then, instead of walking under it a few paces on either side, where it was higher, they would turn about in their tracks and make a wide detour.

> Time happily for them, is no object; but this at first sight one would hardly guess, their movements being always precise, busy, and preoccupied. It is only when one has watched a little party hurrying along for full half a mile in a direct line, as though upon some urgent business, suddenly stop and all go to sleep, or suddenly turn and go off in another direction, or come back upon some equally urgent call, that one begins to realize that their business is not always so important as it looks.

The Adélie Penguins are excessively curious, at least until they learn better. The naturalists of the first 'Discovery' expedition found that the only stimulus to which they responded with a show of fear was the bumping and clattering of a sledge dragged through their colony. The birds are quick to take an interest in strange objects of most sorts, and will invariably approach a tent, man, or dog that they come upon unexpectedly, either on land or on the sea-ice. By walking into the very jaws of the flesh-hungry sledge dogs they sometimes have their heads snapped off, for the penguins possess no native caution against any beast out of water.

Another example of their positive reaction to unfamiliar phenomena is that they select, with a definite order of preference, bits of tin, glass, jagged quartz, and artificially colored stones placed at their disposal as nest material. Levick found that they ranked red stones above green, and chose either in preference to the ordinarily available blackish lava pebbles. Moreover the unfamiliar and prized pebbles were rapidly distributed throughout the Cape Adare colony by continuous nest-to-nest thievery.

Still another indication of the Adélie's predilection for the unusual is offered by Andersson's observation that two partial albino or isabelline females at Paulet Island seemed to be preferred above normal females by the amorous cocks. Here, however, the seasonally stimulated sexuality of the males may have caused a certain maladjustment of taste, because Gain found that a paint-marked male, which had accidentally received a large splash of red on its head and breast, became an ostracized bird. Its own mate discarded it and took another husband; it was greeted with outcries by every female and with assault and battery by every other male, until it disappeared from the rookery, to be seen no more. This is curious, if the reaction to the red stain was entirely visual, for birds can safely go about when their breasts are reeking with blood. Moreover, when the courting and fasting period has ended, they are often completely smeared with the red remains of crustaceans that cover the ground.

All in all, the reactions of the Adélies partake more of the nature of insect behavior than of mammalian behavior. Most of their apparently purposeful actions prove to be largely or wholly instinctive, although they exhibit certain strange habits of which the motivation and significance are by no means understood. An example is their custom of drilling in formation at the edge of the sea-ice, which is exhibited late in the season. At such times they congregate by thousands between the ice-foot and the leads of open water, the first small bands, which resemble companies of soldiers, fusing with others until a vast army forms. During the maneuvers the penguins turn about and face in unison, and behave in many respects as though the horde were a single organism. The drilling procedure may be continued for hours, and it is sometimes hard to believe that the group motions are not controlled by individual birds acting as prompters.

After such exhibitions as are here suggested, the penguins take to the water in batches. The whole phenomenon is reminiscent of the Emperor Penguins' custom of gathering along the outer edge of the fast ice just before it breaks away from the coast at the beginning of the antarctic summer. The relationship of such behavior may, indeed, be a very old one, preserved today in the two essentially polar species of penguins.

The food of the Adélie, which has been mentioned incidentally above, consists mainly of opossum-shrimps and their relatives, with a lesser proportion of cephalopods and fish. Gain records as much as 400 grams (nearly a pound) of schizopods in the stomach of an adult male. From the edge of an ice-foot the penguins have been watched by various observers while feeding. They swerve from side to side on their dashing course, as they shoot into the denser nebulae of crustaceans. Sometimes, after the arrant gluttons have gobbled until their bellies are distended, a milky cloud spurting from their mouths will indicate that they have emptied themselves, so as to enjoy another Roman banquet without brooking the tedium of digestion.

RINGED PENGUIN

Pygoscelis antarctica

Aptenodytes antarctica Forster, 1781, Comment. Soc. Reg. Sci. Gottingensis, 3, p. 141, pl. 4 (Southern Ocean, from 48° S. to the Antarctic Circle).

Names: Bearded Penguin, Stone-cracker, Antarctic Penguin, "Pingüín de Collar," "Pingüín de Barbijo." *Collar* is Spanish for necklace, while *barbijo* is the strap that holds the gaucho's hat. The South American designation, equivalent to "Chin-strap Penguin," is the most apt vernacular name of this species. It appears to have been first applied by the Argentine meteorologists at the South Orkney Islands. No other specific name than *antarctica* has been current for this penguin, an unusual circumstance to be attributed, no doubt, to the relatively limited range of the species.

Characters: About the size of *Pygoscelis adeliae;* wing-length 17–21 cm. Feathering of the bill, on both mandibles, intermediate between that of *papua* and *adeliae*. Dorsal plumage practically identical with that of *adeliae*, and the white of the ventral surface similarly demarcated on all parts caudad from the throat; on the head the dark and white areas are divided along a line which bisects the lores and passes just above the eye; a narrow black line (the distinctive feature of the species in all plumages) crosses the throat, passing from the auricular region forward at a sharp angle across the chin. Color pattern of flippers intermediate between the condition in *papua* and *adeliae*, the anterior edge being white which, however, does not extend to the external surface. Eyelids feathered as in *P. papua*, the narrow exposed skin being black. Tail reported to be composed of 12 rectrices, but some apparent adults have 14. Iris, pale brown; bill, black; feet, fleshy white; claws, slate gray, basally pinkish.

Published measurements of Ringed Penguins from various parts of the West Antarctic region, together with the data taken from six specimens in the American Museum, yield the following ranges of figures: total length, 675–775; wing, 171–201; wing-spread, 500–530; tail, 132–200; bill from gape, 60–69; exposed culmen, 43.5–52; foot, 102–109; tarsus, 21–24; middle toe and claw, 70–81 mm.

Weights of South Orkney birds, collected by the 'Scotia' party on February 9: 7 males, 3.17–5.33 kilograms (7–11.75 pounds), average, 4.13 kilograms (9.1 pounds); 8 females, 3.06–4.54 kilograms (6.75–10 pounds), average, 3.92 kilograms (8.65 pounds).

The eggs are slightly smaller than those of the Adélie Penguin, with a pale greenish cast and a yellow yolk. Clarke (1913, 225) records a series from the South Orkneys as measuring from 77 x 53 to 69.5 x 55 mm., and having an average weight of 91 grams. Further details are given in the life history.

Distribution: An essentially antarctic penguin of the American quadrant, the extreme eastern extension of its breeding range being barely outside the technical limits of this division, at Bouvet Island (longitude 3° E.). The westward extension, so far as known, does not go beyond the islands off the west coast of the Antarctic Archipelago. Resident at practically all islands of the American quadrant, from latitudes close to the antarctic circle northward to the Falklands. The South Orkney and South Sandwich groups are, however, its principal centers of abundance. At South Georgia, it seems never to have held more than a slight foothold, while at the Falklands its status is scarcely better than that of a straggler. Not known from the continental coasts of South America

Coming down from the mountains to the bleak shores of Antarctic Bay, South Georgia, on March 3, 1913, I made the acquaintance of the Ringed or Chin-strap Penguin. The introduction was through the ear rather than the eye, for my quadrupedal companion, a fox terrier from the brig 'Daisy,' was greeted by two moulting penguins, standing upon a pile of rocks well back from the water, with such a strident clatter and cackling as never could have issued from the throats of Johnny Penguins.

The timbre of many of the Ringed Penguin's notes is, in fact, peculiarly ear-splitting. I suspect that the "Stone-cracker" Penguins, to which James Weddell referred at South Georgia during the early years of the last century, were this species, and that the name came from the voice. A note more acute than that of the Adélie, sounding like a blast upon a split quill; a harsh *Ah kuak kuak kuak*, mingled with prolonged sighs; a deafening and cacophonous uproar continuing both day and night; such are some of the attempts to put the clamor of this energetic bird into words (Valette, 1906, 48; Eights, 1838, 213; Gain, 1914, 62). Nor is the noisiness all bluster, for the Ringed Penguin has the universal reputation of being the boldest, most pugnacious, and most agile member of its genus if not, indeed, of the whole penguin tribe. The relative reactions of the three species of *Pygoscelis*, when brought face to face with man, might be broadly characterized as follows: the Johnny Penguin turns tail; the Adélie stands his ground; the Ringed Penguin charges.

The narrow line across the cheek of this penguin reminded Racovitza (1900, 196) of the sketchy moustache of a musketeer, a feature giving the bird a truculent look quite in keeping with its character. The same author goes on picturesquely to say that the Ringed Penguin is a bad and boisterous neighbor and a strict individualist, constantly quarreling over its personal property. By contrast, the Johnny Penguin exhibits the wisdom and calm of a philosopher, and enjoys the opportunity for leisure that always results from a well-organized social system.

The Ringed Penguin gets on no better with other species than with its own kind. The 'Scotia' naturalists found that it is everywhere the boss, and that it jockeys both the Adélie and the Johnny. It is the only penguin that cannot easily be outmaneuvered by a smart dog and the only one that will deliberately attack a dog. It believes equally in getting in the first blow against man and will often open fire without provocation, either on land or ice-floe. Sometimes a bird will rush forward furiously, jump, and fasten on to a human intruder well above the tops of his sea boots. The visible expression of ferocity is similar to that of the Adélie Penguin, an enraged bird raising a bristling mane, and "growling." A visit to a colony of this species is always likely to be a parlous adventure.

However, the very spunk and quarrelsomeness of the Ringed Penguin near the nesting ground may be translated into a kind of *bon camaraderie* if he meets you where he has no reason to resent your presence. Alone of all the penguins, writes Bennett (1931, 187), who has resided long in West Antarctica, he will pop out of water when one is fishing "and take a rest in a boat, after answering the usual croaking call. There he soon falls into a doze—apparently prepared to stay on indefinitely, unless evicted."

The plumage sequences of the Ringed Penguin are similar to those of the Johnny, a distinctive juvenal garb being wanting. The general coloration varies markedly according to season. Adults arriving at the breeding grounds during November, for example, have the blue and black areas of the dorsal plumage bright and clearly defined, but by February these surfaces turn brown and dingy. During the same month the moult begins, and by April the penguins are clad in new feathers, with still abbreviated tails. An albino adult was collected by the 'Scotia' party at the South Orkneys.

In the history of American Museum expeditions this species has been encountered only by myself—at South Georgia. Our specimens comprise three from this source and a number taken by Mr. A. G. Bennett at Deception Island, South Shetlands, during the antarctic summer of 1922.

Pygoscelis antarctica is the first penguin we have considered which has a segmentary rather than a circumpolar distribution. It is confined to the regions south of the South American continent and of the Atlantic Ocean, the extreme eastern limit of its known range being in the open sea in latitude 55° S., longitude 27° E. (due south of the southern tip of Africa), where examples were observed by the German 'Valdivia' Expedition (Vanhöffen, 1901, 316). Many of the Ringed Penguins seen in this general vicinity were travelling upon icebergs, and it is fair to assume that by such means they originally found their way from the headquarters of the species in West Antarctica to the isolated breeding station of Bouvet Island, which is far down-wind and down-current. The presence of nesting Ringed Penguins at Bouvet is confirmed by the published photographs of Riiser-Larsen (1900, 555), although these are mislabelled "Adélie Penguins."

The easterly positions at which Ringed Penguins were reported by Vanhöffen are closer to the Prince Edward Islands than to any other land. This group, however, although sometimes called antarctic, is well north of the latitude of the Falklands, and outside the Antarctic Convergence and the winter zone of pack-ice. Its mean climatic conditions are very unlike those of Bouvet, South Georgia, or the Sandwich Group, and it is unlikely that it would furnish a suitable habitat for this penguin.

The Falkland Islands, also, may be regarded as extralimital, for the records, old and recent, all seem to refer to stragglers rather than residents (Schlegel, 1867, 5; Abbott, 1861, 164). Bennett (1926, 5) notes that in June, 1915, examples "strayed as far north as Stanley Harbour."

South Georgia is borderline territory. James Weddell does not record the relative numbers of his "Stone-cracker" as compared with the abundant King and Johnny and the somewhat less common Macaroni Penguins. However, the German Expedition of 1881 found only a few breeding examples at South Georgia (Pagenstecher, 1885, 14; von den Steinen, 1890, 237), and the experience of more recent visitors has been similar (Lönnberg, 1906, 86). Odd ones "seen from time to time" in the fiords of the northeasterly coast, is the conclusion of the 'Discovery' naturalists regarding the status of the species (Matthews, 1929, 588). The latest report, by Carcelles (1931, 399), tells of a colony of sixty individuals, keeping themselves quite apart from the large population of *Pygoscelis papua*, at Cooper Harbor, South Georgia. Here six eggs were taken during October, 1929. There is thus no reason for believing that the Ringed Penguin was ever relatively more conspicuous by its numbers at South Georgia than it is at the present day.

To southward of South Georgia, in both easterly and westerly bearings, we come to more heavily icebound regions which are the true home of the Ringed Penguin. At Laurie Island of the South Orkneys, the naturalists of the Scottish National Antarctic Expedition discovered colonies totaling not less than a million birds, with as many as 200,000 in a single aggregation. About the Sandwich Islands it was found by Filchner to be the commonest of the four species of penguins observed. Sir Hubert Wilkins (1923, 491) reported great numbers at Zavodovski Island, the northernmost islet of this archipelago, during January, 1922. Zavodovski is conical, the slopes terminating in low cliffs. A blue volcanic vapor rises from caves on the slope and a sulphurous odor pervades the lee of the island. Apparently this does not affect the bird life, for Wilkins found the hillside, as well as the stranded icebergs, covered with penguins. The Ringed Penguins, he notes, would gather about the water line of the oscillating blocks of ice, and leap well over a meter to slippery footholds above. They crowded the bergs in such numbers that birds already there would be pushed off into the water again.

The South Shetlands, although more southerly, lie to windward of the main drift from Weddell Sea and are therefore freer of pack-ice than either the South Sandwich or South Orkney Isles. In keeping with this fact, it is probable that the Ringed Penguin is somewhat less abundant, though everywhere present, at the South Shetlands. Perhaps the difference is merely that the colonies are smaller and more scattered. At any rate, James Eights, writing in the early part of the nineteenth century, reported the species as numerous as any of the other resident penguins at these islands. He states that some of the rookeries extended alongshore for a mile or more, and that the nesting birds could be barely made to give way for a man to pass through. The floating icebergs whose sides admitted of ascent, he adds, were tenanted by large assemblies, the chattering chorus of which could be heard for an incredible distance across the water.

Still farther south in West Antarctica, members of the Belgian, Swedish, and French expeditions found many colonies of the Ringed Penguin on the islands north and west of De Gerlache Strait, as far southward as the 65th parallel. Beyond this latitude there were no nesting groups but only small wandering bands, which were noted as far south as Petermann and Wandel Islands during November. Some of these birds, which the French naturalists took to be yearlings, acted as though they had merely followed the migrant Adélie Penguins southward. At Brabant, Trinity, and Nelson Islands were particularly populous rookeries, the nests crowding some of the roughest surfaces of the high hills. Large flocks were seen swimming in open water between the South Shetlands and the edge of dense pack-ice to eastward, during the month of January. In general, these penguins seemed to avoid colonization of the so-called "mainland" Danco and Palmer coasts and to cling to the outlying islands. Neither did the Swedish naturalists observe the species during their work along the east coast of Graham Land, *i. e.* within the limits of Weddell Sea (Menegaux, 1907, 23; Andersson, 1908, 32).

From these brief notes on distribution it seems that, as regards climatic correlations, the Ringed Penguin stands midway between the Adélie and the Johnny. The last has its center in the main circumpolar belt of pan-antarctic islands; the Adélie is truly polar. The Ringed belongs to the islands of the Scotia Arc, from where it has spread as far to leeward as Bouvet. On the south-polar side it does not follow the Adélie as far as Weddell Sea breeding grounds, nor to any others beyond the antarctic circle. To northward it may be said barely to reach South Georgia as a resident bird. In between these extremes it occurs in varying proportions with its two congeners, and with such other penguins as *Aptenodytes patagonicus* and *Eudyptes chrysolophus*.

With these facts in mind, a glance at a map in south-polar projection goes far to explain the limited distribution of the Ringed Penguin. Although the species is not adapted to the extreme antarctic coasts, it could in all probability thrive in certain parts of the periphery of the Australian quadrant, such as, for example, the Balleny Isles. But a natural pathway for the slow expansion, such as is implied by the spread or "invasion" of a species, has been barred by the absence of suitable circumpolar breeding stations. Both east and west of the Graham Land region the antarctic coasts retreat to very high latitudes; to westward there are no suitable islands in the milder parts of the pack-ice zone; to eastward, beyond the Sandwich group, Bouvet alone offers a habitat possessed of the right characteristics. The chain of sub-antarctic islands south of the Indian Ocean lies in too low a latitude to answer the requirements. If a second series of islands extended eastward close to the 60th parallel, it is likely that *Pygoscelis antarctica* would have become a circumpolar penguin.

During the parts of its life in which it is a pelagic bird, the wanderings of the Ringed Penguin may carry it well outside the breeding zone in any direction. Thus the 'Scotia' party encountered examples among the ice as far as latitude 71° 22′ S., longitude 16° 34′ W., on March 18, 1904. This and other localities where the species was noted are not far from Coats Land, on the eastern border of Weddell Sea (Clarke, 1913, 259). On the other hand, none was seen during the long cruise of the 'Pourquoi Pas?' southward and westward toward Peter Island and beyond. The antarctic circle and the 70th meridian seem to mark the limit in the range of the species on the western side of the Antarctic Archipelago.

The combination of structural and ecologic factors which so subtly fix the ranges of animals becomes understandable only as we learn a great deal about their habits and their physiology. In the case of the Adélie, Ringed, and Johnny Penguins there are clear geographic correlations which can be described even though not yet adequately explained. Indeed the three species of *Pygoscelis* present an extraordinarily good example of the climatic selection of range and of some of its far-reaching distributional consequences.

In many essentials of its life history the Ringed Penguin agrees with one or both of its congeners, particularly with the Adélie. Like the others, it migrates southward with the coming of the antarctic spring, the date of its arrival in localities shared by the three species being considerably later than that of the Adélies and not infrequently even later than that of the Johnnies. At the South Orkneys it rarely appears before the opening of November. Whether the Ringed is a sedentary species in the most northerly parts of its breeding range is uncertain, but the German Transit of Venus Expedition took at least one specimen at South Georgia in June or midwinter. As already noted, eggs are laid during October at South Georgia, illustrating the expected relation between latitude and the biologic cycle of the species.

The pattern of courtship and mating resembles very closely that of the Adélie Penguin. Little seems to have been written about this subject, but excellent photographs by Bruce and Wilton, published as Plate XVIII in the Zoölogical Log of the 'Scotia,' show the similarity in detail.

In one respect the Ringed Penguin seems to differ markedly from its congeners.

The temperamental characteristics which Racovitza whimsically summed up under the term "individualism" are reflected in the social organization of the colonies during the later development of the nestlings. For this penguin does not become communistic when the chicks approach full growth. On the contrary, the fledglings remain within the territory of their respective family sites, and are dependent upon their own parents until the end of their upbringing. Such behavior is perhaps to be associated with the prolonged state of dispute concerning property rights, the eager pugnacity, skill in combat, unequalled vociferousness, and generally dominating personality of the doughty little species. The whole matter urgently needs further investigation in the field.

The nest of the Ringed Penguin is a simple scoop in the soil, rimmed with pebbles enough to keep the eggs from rolling out. There is rarely or never such a heap as the Adélie amasses. Bones of departed ancestors may be mingled with the pebbles, and the structure is then rather luxuriously lined with moulted tail quills. Late-comers to the limited area of the breeding grounds, or the less aggressive birds among the migrants, are likely to be crowded out from the bare terrain onto the snowbanks without, however, suffering any inhibition of their courtship and homemaking. Under such circumstances, the nest is duly built upon the snow, which subsequently melts down beneath the incubating bird, until the whole ménage is at the bottom of a well. Bennett (1920, 31) states that even in nests which are frequently flooded with snow water the eggs usually survive and hatch. The normal temperature of the bird is given as 38.4° C. (101.3° F.) (Valette). In fine weather the brooding penguins often sit half upright against the eggs.

As noted above, the Ringed Penguin migrates southward about a fortnight later than the Adélie. In getting under way with nesting operations, the species is still more tardy, the first eggs usually lagging even after those of *Pygoscelis papua*. At the South Orkneys and elsewhere in West Antarctica, few Ringed Penguin eggs are laid before late November, the earliest date noted being November 5, at the South Shetlands. The Swedish Expedition found that laying had just begun at Deception and Livingston Islands on November 24, and most birds of the species were still incubating at Cape Roquemaurel on December 27 (Andersson). At Saddle Island, South Orkneys, the Scottish naturalists found that a few nests undisturbed by man still contained eggs on February 4.

Two eggs constitute the usual complement, though some nests contain one and some three. Bennett makes the extraordinary assertion that the Ringed Penguins have the custom of exchanging eggs from nest to nest so that few sitters are likely to be incubating their own eggs exclusively. This habit, he states, explains the remarkable diversity in the size and age of chicks frequently observed in the same nest.

Because of the late average date of laying, the majority of the Ringed Penguin chicks come into the cold world weeks after those of *adeliae* and *papua*. By way of compensation, it would seem as though their rate of growth is somewhat more rapid than that of their relatives. In any event, chicks hatched about the end of the first week in January at the South Orkneys were beginning to show the chin-strap of their first contour plumage by February 11, and were thus quite as advanced as their cousins of the other species. The moult of the adults in various localities is likewise contemporaneous with that of the other penguins (February, March), and all depart northward from the southernmost common breeding stations at about the same time. The latest autumn emigrant at the South Orkneys was noted by members of the Scottish Expedition on April 28.

The Ringed Penguin is quite as fond of high places as its relatives. Indeed, Valette, who knew all the West Antarctic species, calls this the alpinist among penguins. Many of the birds nest close to rocky foreshores, but some members of each colony clamber up steep slopes and headlands, for no apparent reason, and make their homes 100 meters above the water. Certain islets, especially in the southerly parts of the range, seem to be occupied only toward their summits.

The smaller clusters of nesting birds are usually mingled with, or sometimes surrounded by, other species. Adélie, Johnny, and Macaroni Penguins, and Blue-eyed Shags, have all been reported as neighbors. The larger rookeries are usually pure cultures of Ringed Penguins, which fact, however, adds nothing by way of peaceful atmosphere.

Deception Island, of the South Shetlands, was formerly well populated by Ringed Penguins, and had rookeries both close to the beaches and on higher parts of the old crater which nearly encircles a whaleman's harbor. Volcanic activity is not yet dead at this island, and the very beach that forms one of the main penguin highways toward the sea exudes strong fumes, and bubbles with warm springs. For many years the Ringed Penguins here have supplied a heavy toll of eggs for human food, a drain which has greatly reduced the numbers of the birds. New sets of eggs are laid after despoliation, but the species seems far less able than *Pygoscelis papua* to hold its own when put to such half domestic use.

Figures given by Gain indicate extraordinary reduction in egg size as a result of repeated layings. Normal eggs are slightly smaller than those of the Adélie, and show a similar wide variation in form. The shell is pale greenish white, with the usual chalky coating. The yolk is yellow, quite unlike the red yolk of *Pygoscelis papua*. Gain records South Shetland eggs of the first and second layings as measuring from 64–75 millimeters in length by 49–53 in breadth, and weighing from 91–118 grams. But eggs of the fourth or fifth layings from the same nests measured as little as 42.5 × 35.5 millimeters with weights under 70 grams, and in some instances no yolks.

A newly hatched chick of the Ringed Penguin is clad in silky white down, which in certain lights appears silvery or even bluish. In many instances the young birds are so stained with filthy ice-water that the true color is indistinguishable. The head is of the same tone as the back, not dark as in the young Adélie and Johnny Penguins. The bill is black, with a brownish tip and a white mark around the egg-tooth. The eyelids are black, the feet yellowish or pinkish, with dark claws (Gain).

The second down is close and furry, grayish brown on the dorsal surface, passing into light gray on head and cheeks and into blackish on the lores, chin and throat. The remainder of the under surface is drab-gray, paler on the abdomen. The tail feathers appear, and grow to a length of 5 centimeters or thereabouts, while the young birds are still in the down. From the downy state the chicks moult into a plumage resembling that of adults, with a fully developed chin-strap and a richly blue dorsal surface.

This penguin appears to have certain peculiarities in its manner of progression upon land or frozen surfaces. On ice or hard ground it walks; when passing to an area of snow it falls prone and propels itself by a sort of stern-wheel action of the feet, without coöperation of the flippers; when climbing it becomes quadrupedal. So far there is nothing to distinguish its actions from those of other penguins, but, when hurrying along a more or less level surface, it usually brings its wings into play synchronously instead of alternately. The result is a form of progression that resembles rowing. With each stroke the body of the bird bobs up and then falls forward. In general, the Ringed Penguins scuttle on their bellies less than the other species, perhaps because they are far less prone to flee when stimulated by the presence of human beings.

The food of the species seems to be the same as that of the other forms of *Pygoscelis* in the same regions—crustaceans, chiefly euphausiids or their relatives, with an admixture of small fish. The latter figure slightly if at all in the pabulum carried to nestlings. The nesting season is preceded by the usual prolonged fast, which is not broken until incubation begins. Round worms and other alimentary parasites, or their cysts, according to the findings of the French naturalists in West Antarctica, are much less numerous in this species than in *Pygoscelis papua* but more so than in *adeliae*.

The enemies of the Ringed Penguin are those of its relatives, namely, the skua in the nesting colonies and the sea-leopard (*Hydrurga leptonyx*) in the ocean. The latter is swift and crafty, graceful beyond any other antarctic seal, and a devourer of penguins both along the coast of their breeding grounds and in the pack-ice. Male sea-leopards reach a length of 3 meters, and females of nearly 5. Their capacity for destroying has been mentioned in the accounts of other penguins. Sea-leopards lurk in wait beneath the ice-foot of the penguins' thoroughfares to the sea. They likewise cruise about offshore from the rookeries, sometimes making astounding leaps out of water to land and rest upon rafts of ice. They capture penguins by sheer bursts of speed, usually seizing them in the depths. Before eating a victim, however, the seal brings it to the surface and literally tears it out of its skin by violent shaking, which makes the foam fly. Most of the skin and feathers then float off before the wind, and the hot, stripped carcass is bolted with very little dismemberment. Not only is the gullet of the sea-leopard extraordinarily large and distensible, but also the beast's windpipe is flat and ribbon-like so that it takes up a minimum of space in the thick neck. For such reasons practically entire penguins are sometimes found in the sea-leopard's stomach. I have already noted the 80-kilogram meal of King Penguins which I took out of one of these seals.

ROCKHOPPER PENGUIN

Eudyptes crestatu.

Aptenodytes crestata J. F. Miller, 1784, Var. Subj. Nat. Hist., pl. 49 (Falkland Islands).

Names: Rocky Penguin, Jumping-jack, Sea-cat; Crested Gorfew, from the French "Gorfou" which, in turn, comes from "Geirfugl," the Icelandic name of the Great Auk; Victoria Penguin (New Zealand region). The name Macaroni Penguin is sometimes applied to this species as well as to *Eudyptes chrysolophus*. "Kalaouina," according to Oustalet, is the name used among the southern Fuegians; "Pingüín Real" and "Pingüín de Penachos Amarillos" are adopted by recent South American writers. The list of synonyms of the specific name is a long one, owing to great confusion regarding the real identity of this penguin. It includes *chrysocome*, *saltator*, *serresianus*, *nigrivestis*, *demersus*, *chrysolophus*, *cirrhata*, *gorfua*, and *catarractes*, with an equal variety of generic names. Almost as many additional names have been tagged to supposed subspecies inhabiting various island groups within the range.

Characters: The smaller of the two American species of *Eudyptes*, with a length of about 60 cm., and a wing of 16–18 cm. Crown covered with slender glossy black plumes, increasing in length from the mid-line outward, and further adorned by lateral tufts of still longer sulphur or pinard yellow feathers, each of which has numerous straight, elongate, filamentous barbs; these yellow aigrettes, which measure up to 70 mm. or more in length, form the free extension of a sharply defined superciliary stripe, which begins above the gape at a distance of 5 mm. or so from the beak; maxilla feathered to the nostril in the angle between culminicorn and latericorn; dorsal plumage, caudad from the crown, substantially as in the three species of *Pygoscelis*, each black feather-shaft being flanked and tipped by webs of "penguin" blue; newly moulted birds are very blue, even on the external surface of the flippers, while worn examples are blackish or brownish; posterior border of flipper white, due to one row of white and one of parti-colored marginal feathers; anterior edge grayish, because of the mixed pattern of minute, scale-like feathers; tail, said to be composed of 16 quills (most specimens show fewer), black, with more or less bluish in the vanes of fresh feathers; cheeks, chin and throat duskier or more slaty than the dorsal plumage, the dark hood projecting slightly caudad in the mid-line on the throat; remainder of ventral surface white. Some specimens have a few black spots, each composed of one or several feathers, in the white plumage of the breast and flanks. Iris, red, perhaps varying in hue with season; bill, ochraceous brown to red; feet, fleshy white, pinker during the breeding season, with black soles and brownish claws.

Measurements of adult Rockhoppers from the Falkland Islands and the Cape Horn region are as follows:

3 males: wing, 170–185; tail, 90–98; longest crest feather, 64.3–68; culmen, 45.5–49; bill from gape, 54–56.7; width of bill, 21.8–23; depth of maxilla, 12.5–14; foot, 108–121.5; middle toe and claw, 74.4–75.4 mm.

2 females: wing, 160–164; tail, 91.5–103.3; longest crest feather, 61–65; culmen, 42.5–42.7; bill from gape, 51–53.5; width of bill, 20.5–21.5; depth of maxilla, 11.5–12.5; foot, 104.8–105; middle toe and claw, 68.3–70.8 mm.

Mr. Beck apparently collected only one Rockhopper egg of normal size. This was taken at Bleaker Island, Falklands, on December 12, 1915. It measures 72.5 x 55.5 mm. The largest egg in a Falkland series recorded by Vallentin (1924, 290) measured 74 x 48 mm. Verrill (1895, 462) records the following data for a series of about a hundred eggs from Gough Island:

Largest	88.1 x 53.5 mm., volume	168 cc.
Smallest	57 x 44	52
Average	65.8 x 50	80

Of these Verrill writes:

These eggs vary much in form, the majority being regularly ovate, but many are much shortened from the typical ovoid and tend to a spheroidal form, while others are elongated ovoids. The surface is smooth with very shallow depressions and small, sharp pits. The color is pale greenish blue, a few are partly covered with a very thin, dirty yellowish-white, calcareous layer; . . . a few more show traces of it, the rest none at all. The eggs from Kerguelen do not differ appreciably from those of Gough Island.

Distribution: Circumpolar in a mainly temperate sub-antarctic belt; primarily a penguin of the west-wind zone, reaching a high sub-antarctic extension in the Indian Ocean sector of the range. In the American quadrant it does not closely approach the Antarctic Convergence, and records for South Georgia and West Antarctica are erroneous. The Fuegian region, Falkland Islands, and Tristan da Cunha with Gough Island, comprise the breeding range within the South American-Atlantic area. To eastward the species is resident at the Prince Edward and Crozet Islands, Kerguelen (but not Heard Island?), St. Paul and Amsterdam. In the New Zealand region, Macquarie, Auckland, Campbell, and neighboring islands are the easterly outposts of distribution, no suitable habitat existing elsewhere in the southern Pacific. Macquarie Island and the Cape Horn district (latitude 56° S.) mark the southernmost extensions of the breeding range on opposite sides of the world. The northernmost colonies, at Tristan da Cunha and Amsterdam Island, lie close to the Sub-Tropical Convergence.

Picture a penguin, smaller than any of the preceding kinds, with a yellow pompon over each eye, and a gait that caused the early visitors to the Falkland Islands to dub it the "Jumping-jack" (Clayton, 1776, 103). Instead of walking, it progresses in "a series of bounds executed with . . . an elasticity of motion such as is exhibited by kangaroos" (Eaton, in Sharpe, 1879, 161). You approach it or, rather, "them," for it would be hard to find a Rockhopper alone, and the drooping yellow plumes are erected so that they stand out at right angles, and each tends to divide into two separate tufts. At the same time the pointed feathers of the crown curve upward to form a shining black crest, such as one might associate with a bird of paradise, and the plumage of the cheeks puffs out like short whiskers, producing a somewhat cattish countenance which is responsible for one of the sealers' names for the bird. The crimson eyes, often half-closed in the daylight, are now wide open and alert, but the pupils are contracted to pinhead size. The expression of the little creatures is half-impish, half-scared. However, unless you are actually among the nests, their preponderant emotion is doubtless merely short-lived curiosity.

When the Rockhoppers move casually, they step in an uncertain manner, leaning forward and lifting the feet high, without a trace of the balance or confidence of an Adélie Penguin. But when prompted by an impulse to go anywhere in particular, they begin the jumps, which are like those of a man running a sack-race. They thrust their heads forward and downward when landing on both feet; then the heads bob up and the fat bodies straighten and bounce off the ground for another leap (Brooks, 1917, 143). "Away they go, hop-hopping rapidly off, stopping after every jump to recover and make sure of the equilibrium, and altogether ludicrously like a crowd of hunch-backed old men with their feet tied" (Campbell, 1877, 63).

Unless, as noted above, you have invaded the nesting area, most of the Rockhoppers accept you with indifference rather than with fear or resentment. Here and there, however, you are sure to meet a champion whose endocrines fill him with ire at the first sight of you, and who comes forward like David to meet Goliath. From such there is no escape except by retreat. You may toss him aside with your boot-tip, or push him over a bank, but within a moment he is back, scolding furiously and hurtling upon you. His beak, owing to its stoutness, its pronounced hook, and the truncation of the lower mandible, is a more formidable weapon than that of any species of *Pygoscelis*. Furthermore, the Rocky may jump high before taking hold. If he chances to clamp upon your sleeve, you may swing him in the air as you might an excited puppy and still fail to shake him off.

Many erroneous records of the Rockhopper Penguin have been published for the American Antarctic, such as those for South Georgia (Ogilvie-Grant, 1898, 638; Bennett, 1926, 6) and the Graham Land region (Reichenow, 1908, 548). These have been due to confusion with the Macaroni Penguin (*Eudyptes chrysolophus*), or with the "Stone-cracker" of Weddell, which is probably the Ringed Penguin. Both of the latter species are truly antarctic birds. The ranges of Rockhopper and Macaroni overlap slightly, but the two exist together in anything approaching equal numbers only at Kerguelen Island, in the southern Indian Ocean. At the Falklands the Macaroni is found but sparingly, as a sort of waif among the Rockhoppers; whereas the latter do not reach at all the typical habitat of the Macaronis among the permanently snow-capped islands to southward. A similar gap between the ranges is almost certainly represented by the comparatively slight distance between Kerguelen and Heard Islands (*viz*. less than four degrees of latitude). Both species occur at Kerguelen, but only the Macaroni at Heard, which is as heavily glaciated as Bouvet Island where the Macaroni is also the only representative of its genus.

The American range of the Rockhopper includes the seaward coasts and islets of Tierra del Fuego on the southern and eastern sides. To westward occupation is blocked at the point where bare shores give way to those supporting forests of beeches or other trees. This explains the absence of the species from the Pacific coast of the continent, whereas on the Patagonian side it is casually known to the gauchos and other residents as far north as the Province of Buenos Aires (Fauvety, 1888, 322; Gibson, 1920, 89; Dabbene, 1920, 8). De Agostini (1924, 234) mentions it by description, though not by name, as an inhabitant of small islets off the north coast of Staten Island, and Hartert and Venturi (1909, 256) record eggs from Año Nuevo. The Great Falkland colonies have, of course, been known from the earliest days of discovery. Diego Ramirez Islets, southwest of Cape Horn—the dreaded "Rámerees" of English-speaking mariners—comprise probably the southernmost breeding station of this penguin in all the world.

From such continental fringes we must pass to the remote oceanic islands of the Tristan da Cunha group, and Gough or Diego Alvarez Island, before finding the next breeding grounds of *Eudyptes crestatus*. Whether the mid-Atlantic birds are subspecifically distinct from those of the Falklands is still a question. Murray believed that they constituted a well-marked variety, with longer plumes than the American birds (Sclater and Salvin, 1881, 131), but such figures as are available do not support this opinion. Moseley (1879, 175), contrasting in his memory the Rockhoppers of Tristan da Cunha with those of the Prince Edward Islands, Kerguelen, etc., believed that the Tristan birds were slightly larger. Also Captain George Comer, an American whaleman and sealer and an excellent observer, states that the Rockhoppers of Gough Island are larger than those he had seen elsewhere, which would include both Kerguelen and the Falklands (Verrill, 1895, 462). Yet the average measurements of large series of Rockhopper eggs collected by Comer at Kerguelen and Gough, respectively, give the same figures to within two one-hundredths of an inch!

A well-known psychological error may be involved in *a posteriori* conclusions regarding the size of the Tristan birds. At the Falklands, Kerguelen, and other southerly localities, the Rockhopper is the smallest among several resident penguins. At Tristan and Gough it is the only penguin, and it may seem larger than it is. In the absence of specimens the problem cannot be settled.

The American Museum representation of this penguin comprises the following: 14 skins and a few eggs collected by Beck at islands near Cape Horn during December, 1914, and at the Falklands a year later; one which probably came from Tristan or Gough Islands; one from Macquarie; 11 from Antipodes Island, or the surrounding waters, obtained in February, 1926, by Beck and his associates of the Whitney South Sea Expedition. The combined series illustrate fairly well the stages of growth and moult, besides throwing light upon the extent of geographic variation or, rather, the probable lack of it.

A careful comparison fails to reveal any of the alleged subspecific distinctions between the Magellanic and the New Zealand specimens. The following average measurements are based upon five adults from the Falklands and Cape Horn, and seven from Antipodes Island. The range falls well within that of individual variation.

	Magellanic region		Antipodes I.	
	3♂	2♀	4♂	3♀
Wing	173	162	162	143 mm.
Tail	93.8	97.4	112.3	103.6
Crest (longest feather)	66.1	63	55.8	49.5
Culmen	47.5	42.5	47.4	40.2
Bill from gape	55.7	52.2	56.2	49.5
Width of bill	22.8	21	20.8	20
Depth of maxilla	13.4	12	13.8	12.8
Foot	113.5	104.9	103.5	96.5
Middle toe and claw	74.8	69.5	71.1	65

Maximum and minimum dimensions are recorded above.

Worthy of special notice is the sexual dimorphism in the bill, as revealed by the average figures. This is important in connection with a detail of the life history, because certain observers, especially at the islands of Tristan da Cunha, have noted that the sexes in life are distinguishable by the appearance of their bills. Upon the accuracy of this discrimination hangs the truth of the statement that the male Rockhoppers return to the breeding ground some days before the females, at least at the Tristan group. Prior occupation of nesting sites by the males is just the opposite of the behavior exhibited by the Adélie Penguins.

Our series of immature birds shows the stages of growth from the newly hatched to the yearling. The youngest examples, just out of the egg, were collected at Ildefonso Island, Chile, and at Bleaker Island of the Falklands. These are distinguishable from the same stage of *Spheniscus magellanicus*, with which they were associated on the nesting ground, chiefly by the shape of the bill, in which the ridge of the dertrum forms the greater part of the length of the culmen.

The down on these youngest birds is clove-brown on the upper surface, chin, and throat, darkening to fuscous black on the pileum; the ventral surface is grayish white. The iris is recorded as brown, the feet as blackish, and the bill as blackish with a flesh-colored tip.

Older specimens have a longer down of practically the same color and pattern, with feet of a dark flesh color. The loss of the down is well illustrated by Magellanic specimens taken in January and birds from Antipodes taken in February. Such chicks are moulting to expose a plumage similar to that of adults but very blue on the dorsal surface and with a grayish chin and throat. The crown feathers are already elongate, but the yellow superciliary stripe and tufts are indicated, if at all, only by a faint line. The iris is still brown, but the feet are whitish as in adults. A noteworthy point about such specimens is their small size, especially apparent in the bill. Evidently the moult of the down in this species takes place considerably before completion of growth.

Beck's yearling birds still have slender bills, incipient tufts, a sprinkling of gray upon the throat, and brown eyes. Sutherland (1923, 34) reports that crimson irides appear by the ninth month.

In adults fully half of the crest plumes are black, the yellow tufts being only the most lateral feathers. The tufts really begin as short feathers in the middle of the feathered portion of the maxilla, from where they run straight back as a superciliary stripe extended by long yellow plumes. The dark plumage of the throat does not terminate in a straight transverse line, as is stated in many descriptions. It has a median caudad extension which, however, is much less pronounced than in *Eudyptes chrysolophus*. The tone of the throat and cheeks is in all cases browner than that of the dorsal plumage.

Nicholls (1910, 41) noted that the plumage of a recently moulted Rockhopper in bright sunlight appeared of a dull leaden color until it was wet. It then assumed a rich blue tint due, in the author's opinion, to a reflection from oil secreted by the skin. When swimming the birds leave an oily wake.

Beck records the eyes of his adults merely as red. In the literature they have been described as "dull red," "crimson," "reddish orange," "deep pink," etc. In like manner the bill is called "dark yellow," "orange," and "red." The color of the mandibles may vary seasonally.

Among our Falkland Rockhoppers is an isabelline male, which was breeding when it was taken at Cochon Island on November 5, 1915. The pattern is normal, but all dark pigment is wanting and the upper surface is pale buffy or creamy. The yellow feathers of the tufts are as in other birds.

During the course of the Brewster-Sanford Expedition, Mr. Beck became well acquainted with the Rockhopper Penguins of the Magellanic region. His notes first report them at Caroline and Ildefonso Islands, Chile, where they were brooding young in December. Ildefonso lies 30 kilometers out in the open ocean off Cape Horn. There is no anchorage, and the islet is continually swept by heavy seas from the westward. To effect a landing one must choose the rare second or third of successive calm days. Then comes the scramble over slippery rocks and up muddy banks to the grass-covered plateau where the Rockhoppers may be found, mingled characteristically with nesting Black-browed Albatrosses and burrowing Jackass Penguins.

On April 12, 1915, Beck's notes record an immature Rockhopper swimming in Lort Bay, False Cape Horn, together with the comment that this species is seldom seen among the inland waterways except after storms.

During the following spring, October to December, 1915, Mr. Beck saw much more of the species at rookeries on Kidney, Cochon, Bleaker, Pebble, West Point, and other islands of the Falklands. In November the laying season was commencing, and the islanders were making their annual visits to gather baskets and boat-loads of eggs. Indeed, throughout the early years of the War then in progress, apprehension of a shortage of provisions, due to possible ravages of German men-of-war, led to a more thorough than usual cleaning out of successive sets of eggs. In the great rookery of Cochon Island, inhabited by Rockhoppers along nearly 2 kilometers of cliff front, Beck saw some 13,000 eggs gathered during one short visit. Ordinarily November 9, which is Lord Mayor's Day, is fixed by the Falkland folk as the date for an egging picnic. The collectors pay a certain tax per thousand, and the eggs are sold cheaply and tend to break the monotony of a diet of mutton. After the eggs of the first laying are taken, two more are almost invariably laid. Sets may even be laid after subsequent pillaging but, as among other species of penguins, the later eggs are of progressively reduced size (Vallentin, 1924, 290). Four such "runts" collected at Kidney Island, on November 6, 1915, measure between 50 by 39 and 32 by 28 millimeters. Each of these was fresh, and was covered by an incubating adult.

For at least a century and a half the Rockhoppers at the Falklands have been supplying eggs for human consumption. To the sealers and whalemen of early days the rookeries were heaven-sent larders from which they might at no cost fill their ships for long voyages. Thus Captain Edmund Fanning (1924, reprint, 60) wrote in 1833:

> I have kept these penguins' eggs in a good state of preservation, on board ship, for a period of nine months, by first immersing them in seal oil, . . . then packing them in a cask with dry sand; a layer of sand, then a layer of eggs, and so on until the cask is filled, placing them all on their sides, with one end towards the bung, then heading the cask up, and stowing it bung up, in such a place as it can be got at on the third day, in order to be turned bung down, and so on; being turned every third day, until wanted for use, this method keeps the yolk from settling to the shell, and the sand mixing with the oil, forms a crust of sand and oil over it, by which the shell is kept perfectly air tight, and thus the egg is preserved from destruction.

The same author adds that when his vessel left the Falklands for Mas Afuera Island, he had fifty-six barrels of the favorite Rockhopper eggs among his stores. The eggs are yellow-yolked and excellent eating. Many persons prefer them to hens' eggs, although Beck's notes state that he found the Rockhopper eggs less palatable than those of their fellow citizens, the Black-browed Albatrosses.

Formerly the Rockhopper Penguins were extensively destroyed for their oil. It was the custom for the crews of visiting schooners to hold round-ups when the penguins first came ashore in spring, and were fattest, and to drive the birds by thousands into corrals. Each penguin yielded about a pint of oil, which was worth two shillings sixpence. In 1857 four small schooners at the Falklands tried out 50,700 gallons (230,480 liters) of penguin oil, implying the slaughter of nearly half a million birds during a single season. Much more recently one captain reports killing 70,000 penguins annually, but the whole traffic is now stopped (Sclater, 1868, 528; Brooks, 1917, 142).

At the Falkland Islands the Rockhopper is probably as numerous as all the other resident penguins combined. There are two large rookeries not far from Stanley, one at Kidney Island, south of the entrance to Berkeley Sound, and the other at Sparrow Cove, off Port William. The landing place of the latter is in a small basin with very steep rocky sides fully 30 meters high. Formerly, upward of 25,000 Rockhoppers could be seen at one time about this amphitheatre (Cunningham, 1871, 292).

Some of the colonies occupy territory at considerable distance from the shore, with which they are connected by well-defined paths. The actual landing and launching place, however, is more likely to be a steep and jagged declivity than an easily negotiable cove or strand. Ancestral routes are not readily abandoned by the birds. The weathering away and collapse of a cliff, as at Keppel Island, are insufficient cause for the Rockhoppers to seek a new and more practicable approach to an old colony. They seem, in fact, to enjoy struggling up difficult slopes. Their toes, unlike those of the Johnny and Magellanic Penguins, are very flexible and prehensile. The feet leave three sharp nail-prints with every footstep in soft and peaty soil. Wherever exigencies of a rocky surface force successive penguins to follow a single narrow track on their climbs, the stone itself becomes deeply scratched. There are many such scratched places on the rocky floor of the trails, sometimes at levels far above the water (Vallentin, 1905, 48). Although the origin of the marks has been disputed, Beck (1918, 14) concluded, after careful examination, that the penguin "toeholds" in the rock are just what they purport to be and that they are easily distinguishable from the pits and seams of natural erosion.

In approaching the shore, wrote Fanning, the Rockhoppers

> . . . make choice of a spot where the sea breaks directly against the side of the rocks, and while yet some seventy yards from the landing place, swimming moderately along in solid columns of hundreds together, toward it, commence diving and coming up again to the surface at short distances; this is continued until about within thirty feet of their landing, when they dive again, and come up in the surf ten or twelve feet from the rock.

Before attaining certain of their landing places, the penguins must pass through heavy masses of kelp writhing in the swells. Several observers say that sometimes they shoot out of water erect, with their feet forward, in the manner of antarctic penguins; but ordinarily they are left on all fours by the recession of a wave, whereupon they clamber quickly out of reach of the next one, using their stout beaks as a fifth member (Loranchet, 1915, 155). Rows of the birds may sometimes be seen hanging in the crest of a roller, just before it breaks. To be dashed against the rock is no inconvenience to them, and if they are sucked off by the back-wash they dive into the base of the next wave and try again.

Returning to the ocean down the banks and cliffs, the Rockhoppers slide and bounce as though on skiis. They leap across crevices, and sometimes fall without mishap over surprising drops as their momentum becomes too great for them to check themselves. Now and then, however, one will tumble into a pit from which there is no escape, and thus fall a prey to slow starvation. The Rockhoppers jump feet foremost from ledges into the sea, not diving as the Adélie Penguins do.

These penguins are highly migratory, and in most parts of their range they spend half the year at sea. In many old accounts of long voyages, such as those of Captain James Cook and Lieutenant Wilkes, one finds references to flocks of small, red-billed penguins, different from the species found amid pack-ice, encountered far at sea in the forties and fifties of south latitude. Pelagic Rockhoppers are doubtless responsible for a good proportion of such uncertain records. Stray individuals of the species have been captured as far from breeding grounds as the coasts of Australia, southern Africa, and northern Argentina. Indeed, the type specimen of *Eudyptes chrysocome* (a synonym of *crestatus*) came from Adventure Bay, Tasmania, an extralimital locality. Little is known, however, about the normal wanderings of the species, other than what is suggested by casual references. The U. S. S. 'Monongahela' was once followed nearly all day (January 19) by a penguin presumably of this species, at a position about 1000 kilometers from the nearest land (Kidder, 1875, 45). Buller (1905, 84) mentions a specimen with a number of long barnacles on the toes, a growth which would hardly have been possible unless the penguin had remained away from land for a period of many months.

At the Falklands the birds return to the nesting ground in October. During the latter part of this month numberless pairs are hidden away in the tussock grass adjacent to the actual rookeries, where most of the growth is likely to have been obliterated by long occupation. In Beck's notebook I find a reference to the tunneled avenues between the hummocks of long, arched grass (*Poa flabellata*), at Kidney Island, in which the Rockhoppers were strolling about during early November, 1915, some of them to take part in the founding of new settlements at a distance from the main colony, which extended along the cliff. At Cochon Island he also found hundreds of thousands of Rockhoppers on November 6, so that he had hard going to make his way through them in any direction. At Bleaker Island he noted that this penguin, as well as other species, had become thoroughly accustomed to the presence of sheep, through flocks of which the birds passed without concern.

The nests of the Rockhoppers vary according to the nature of the soil, vegetation, and drainage. At Bleaker Island Beck found eggs in unlined depressions.

Elsewhere he saw nests lined with grass or even with woody twigs. Some of his photographs show Rockhoppers standing upon the high mud cylinders of the Black-browed Albatrosses. Clayton reported more than a hundred and fifty years ago that the albatross nests are appropriated by Rockhoppers as soon as the builders abandon them.

In more southerly regions, as at Marion Island of the Prince Edward group, the nests may be made entirely of pebbles which raise the eggs barely above the mud (Moseley). At Kerguelen both stone and grass nests have been reported, and Moseley even found a group of Rockhoppers breeding in the blackness of a deep cave. At the islands of Tristan da Cunha and Gough, the most luxurious nests of the species are apparently built, some of the grass bowls being 8 to 10 centimeters high. Everywhere the Rockhoppers show the family trait of stealing one another's foundations whenever opportunity offers.

The Rockhoppers seem particularly prone to tolerate other species as guests within their breeding territory. Throughout the more southerly islands of the range, a few examples of the Macaroni Penguin make isolated nests here and there in the colonies of their smaller cousins. The presence of Black-browed Albatrosses among the Rockhoppers of the Magellanic district has already been referred to, while at Tristan da Cunha a species of Yellow-nosed Albatross occupies a similar place. In the American region, moreover, the brightly colored King Shag (*Phalacrocorax albiventer*) is a fairly constant neighbor of the Rockhopper. Beck saw these shags nesting indiscriminately among the penguins at Kidney Island and elsewhere in the Falklands during November. At stealing the structural material of nests the shags are even more accomplished than the penguins. The resident skuas of the Falklands nest close to, though not actually among, the Rockhoppers. The laying season of the skua, however, comes about a month after that of this penguin, so that by the time there are hungry skua chicks to be fed most of the young Rockhoppers are old enough to be more or less out of danger (Abbott, 1860, 337).

At the Falklands the first eggs of the Rockhopper Penguin are laid during the last few days of October. Within three days after the very earliest is noted, a colony will be well sprinkled with them, and before a week has passed there will be at least one egg in practically every nest. That one egg of each normal set of two is usually larger than the other has been noted not only at the Falklands, but also at Kerguelen, Gough Island, Inaccessible Island (Thomson, 1878, 154), and elsewhere. Captain Comer and other authorities (unless the latter were merely repeating Comer's observations) specifically state that the first egg laid is the smaller of the pair (Verrill). Eaton in 1879 went so far as to suggest that the different sizes of the eggs might be correlated with the production of opposite sexes (Sharpe). The surmise apparently antedates by many years other recognition of sexual dimegaly in birds' eggs. Riddle, in a series of papers, has maintained that among pigeons and domestic fowls eggs of smaller size, higher water-content, and lower energy-content (as measured by the amount of fat and of phosphorus) are male-producing, while those showing the converse characters are female-producing (Riddle, 1917, 19).

Regardless of the problem just stated, it is a rare occurrence for more than one young Rockhopper to be reared by its parents, so the chances of survival must be nearly equal for young chicks of either sex.

Very little seems to have been published about the care and development of the nestling Rockhoppers. Beck (1917, 458) has, however, recorded rather casually an observation which may have much significance. He noted at the Falklands that when the young were about two-thirds grown they left the nests and gathered into bands of a dozen or twenty. Seeing such huddled groups, he wondered how the parents could select their own offspring when ready to deliver food. The answer, of course, may be that the Rockhoppers develop a nursery system similar to that of two species of *Pygoscelis*. Only more exact field studies can determine the facts.

The call of the chicks is said to be a single piping note (Hall, 1900, 32). The voice of the adults is described elsewhere in this biography in the words of several hearers. Eaton says that the ordinary call is like the syllables *gurougha*, *gurougha*, *gurougha*, but he neglects to tell us how "gurougha" should be pronounced.

At all breeding grounds these penguins are fond of washing themselves in running streams, ponds, and puddles, or in the salty rock pools.

The moult at the Falklands begins toward the end of January, and Beck states that the yearling birds undergo the process during the same season as the adults that have just completed the rearing of families. Great clouds of feathers, like flurries of snow, are blown to leeward from the rookeries during puffs of wind. A captive Rockhopper, in Australia, completed its moult in "about a fortnight," the old feathers on the head being the last to drop off. When tossed into the water during the moulting period, it always scrambled out as quickly as possible (Nicholls).

Stomachs of Rockhopper Penguins of the Cape Horn region, during February, were found to contain both crustaceans and fish (Oustalet, 1891, 242). The same was true of January specimens from Kerguelen, the crustaceans being in excess, and including species of amphipods, copepods, and parasitic isopods (Sclater and Salvin). Ainsworth reports that the greater part of the food carried to young Rockhoppers at Macquarie Island consisted of crustaceans (Oliver, 1930, 71). A captive penguin, which was kept in an Australian sea bath about 20 meters square, swam after fish very rapidly and with wonderful turns and twists. It seemed to strike its prey with the beak, stunning the victim before actually seizing and swallowing it beneath the surface (Nicholls).

As regards major enemies, the Rockhopper is harried more or less by skuas and gulls, though it probably suffers less than the pan-antarctic penguins. Giant Fulmars have been seen eating dead examples, but this petrel is not nearly so predatory at the Falklands as it becomes farther south. Even such a relatively harmless bird as Scoresby's Gull will devour the carcasses of Rockhoppers which lose their lives among the rocks.

Morrell (1832, 64) reports that the "hair-lion often feeds upon penguins." His description, and those of other old-time visitors at the Falklands, fit the sea-leopard, however, rather than the sea-lion. The former seal was once much more common about the islands than at present, and Fanning's account leaves little doubt that the sea-leopard is the species referred to. After describing the habits of the Rockhoppers, Fanning writes:

> The gratification derived from beholding a scene like this, is in a great measure counterbalanced, in the destruction committed among them by the sea-lions, which place themselves a few rods from the landing place, in the water, watching the time that the penguins are about to commence diving to land, at which period they are the most compact. At this moment, the lion settles himself under water with the intention of swimming under them, and when a suitable opportunity offers, rises suddenly in their midst, and seizes one or more of the birds in his jaws; then raising part of his ponderous body out of the water, he bites and shakes this, his prey, until they are torn in pieces, then devouring them. It frequently happens that some of these birds get badly wounded in the legs or wings, and land in this maimed condition; whenever this is the case, they are instantly attacked by their comrades, who peck and bite them until they rise up and take their places in the line of march, or until, by this tormenting, they are killed.

No penguin illustrates better than *Eudyptes crestatus* the widely varying seasonal régime of physiological activities, correlated with latitudinal breadth of range. The accompanying table indicates certain of these relationships, the data being taken from sources cited in this biography.

	Cape Horn region	Falklands	Tristan region	Kerguelen	Macquarie	Antipodes
Arrival		Oct.	July–Aug.	early Nov.	mid-Oct.	
Mating		Oct.	late Aug.	Nov.		
Eggs	Nov.	Oct.–Nov.	Sept.	early Dec.		
Hatching	Dec.	Dec.	Oct.	early Jan.		
Moult of young .		Jan.	Nov.			Feb.
Pre-moult exodus of adults . . .			Dec.		Mar.	
Moult		Jan.–Mar.	Feb.–Mar.	Feb.		Feb.
Departure			Apr.	Mar.	June	

Early in the nineteenth century many curious legends about penguins began to be widely disseminated. In particular, their social organization was enlarged upon, and a variety of stories, with or without a moral, found their way into literature in fanciful forms, as exemplified by narratives, essays, and works of fiction too numerous to cite.

The special application of this fact is that the Rockhopper Penguin seems to have been the model for such tradition. The original sources of information were no doubt scattered and dubious, but two of them can be definitely traced by earmarks that cling to later versions. These were accounts by actual observers, both published in the year 1832. One of them was strictly factual, and came from the pen of Augustus Earle (1832, 327), a draughtsman on the 'Beagle,' who was stranded at Tristan da Cunha in March, 1824, and spent more than half a year on the island. The other and, unfortunately, the more popular source was the lengthy journal of a swashbuckling Yankee seafarer, Captain Benjamin Morrell, whose highly readable "Narrative of Four Voyages" appeared about the same date as Earle's book. Morrell's work contains numberless ornithological observations, many of which are valuable because of their basis of fact, but the author was incurably fond of pulling the long bow. His account of the nesting compact between the Rockhopper Penguins and the Black-browed Albatrosses at the Falklands, carried out jointly by the birds "after a deliberate consultation on the subject," is one of the best bits of romanticism since "Gulliver's Travels." Morrell describes meticulously how the penguins clear the ground, build their enclosing walls, lay their streets at right angles; and then how at each intersection of these highways an albatross constructs her nest, which is flanked in four directions by penguin nests!

In Morrell's yarn, which doubtless seemed verisimilitude to readers of an unsophisticated era, we can recognize the source of the circumstantial penguin biographies in Edgar Allan Poe's "Narrative of A. Gordon Pym" (1838) and Ballantyne's "Coral Island" (1858). In short, the Rockhopper began a century ago to fill a definite niche in the world's imagination. Recently it has been displaced as a type by the Adélie Penguin, owing to the rapid spread of impressions derived from modern antarctic exploration.

Perhaps the most compendious information we have about *Eudyptes crestatus* relates to the habits of the species at the three islands of the Tristan da Cunha group. The possibility that the Rockhoppers of this region represent a distinct race, and the fact that the climatic environment and seasonal régime are different from those in other parts of the range, make it advisable to treat the life history of the Tristan penguins separately from that of the Magellanic birds.

The oldest detailed account is that of Earle, whose residence at Tristan is referred to above. His text is worth quoting *in extenso*.

Sept. 12, 1824. This day we visited what they call a "penguin rookery." The spot of ground occupied by our settlers is bounded on each end by high bluffs, which extend far into the sea, leaving a space in front, where all their hogs run nearly wild, as they are prevented going beyond those limits by those natural barriers; and the creatures [penguins] who, at stated periods, come up from the sea remain in undisturbed possession of the beaches, beyond our immediate vicinity.

The weather being favourable, we launched our boat early in the morning, for the purpose of procuring a supply of eggs for the consumption of the family. We heard the chattering of the penguins from the rookery long before we landed, which was noisy in the extreme, and groups of them were scattered all over the beach; but the high thick grass on the declivity of the hill seemed their grand establishment, and they were hidden by it from our view. As we could not find any place where we could possibly land our boat in safety, I and two more swam on shore with bags tied round our necks to hold the eggs in, and the boat with one of the men lay off, out of the surf. I should think the ground occupied by these birds . . . was at least a mile in circumference, covered in every part with grasses and reeds, which grew considerably higher than my head; and on every gentle ascent, beginning from the beach, on all the large grey rocks, which occasionally appeared above this grass, sat perched groups of these strange and uncouth-looking creatures; but the noise which rose up from beneath baffles all description! As our business lay with the noisy part of this community, we quickly crept under the grass, and commenced our plundering search, though there needed none, so profuse was the quantity. The scene altogether well merits a better description than I can give,—thousands and hundreds of thousands of these little two-legged erect monsters hopping around us, with voices very much resembling in tone that of the human; all opening their throats together; so thickly clustered in groups that it was almost impossible to place the foot without despatching one of them. The shape of the animal, their curious motions, and their most extraordinary voices, made me fancy myself in a kingdom of pigmies. The regularity of their manners, their all sitting in exact rows, resembling more the order of a camp than a rookery of noisy birds, delighted me. These creatures did not move away on our approach, but only increased their noise, so we were obliged to displace them forcibly from their nests; and this ejectment was not produced without a considerable struggle on their parts; and, being armed with a formidable beak, it soon became a scene of desperate warfare. We had to take particular care to protect our hands and legs from their attacks; and for this purpose each one had provided himself with a short stout club. The noise they continued to make during our ramble through their territories the sailors said was "cover 'em up, cover 'em up." And, however incredible it may appear, it is nevertheless true, that I heard those words so distinctly repeated, and by such various tones of voices, that several times I started, and expected to see one of the men at my elbow. Even these little creatures, as well as the monstrous sea elephant, appear to keep up a continued warfare with each other.

As the penguins sit in rows, forming regular lanes leading down to the beach, whenever one of them feels an inclination to refresh herself by a plunge into the sea, she has to run the gauntlet through the whole *street*, every one pecking at her as she passes without mercy; and though all are occupied in the same employment, not the smallest degree of friendship seems to exist; and whenever we turned one off her nest she was sure to be thrown amongst foes; and, besides the loss of her eggs, was invariably doomed to receive a severe beating and pecking from her companions. Each one lays three eggs, and, after a time, when the young are strong enough to undertake the journey, they go to sea, and are not again seen till the ensuing spring. Their city is deserted of its numerous inhabitants, and quietness reigns till nature prompts their return the following year, when the same noisy scene is repeated, as the same flock of birds returns to the spot where they were hatched.

After raising a tremendous tumult in this numerous colony, and sustaining continued combat, we came off victorious, making capture of about a thousand eggs, resembling in size, colour, and transparency of shell, those of a duck; and the taking possession of this immense quantity did not occupy more than one hour, which may serve to prove the incalculable numbers of birds collected together. We did not allow them sufficient time, after landing, to lay all their eggs; for, had the season been further advanced, and we had found three eggs in each nest, the whole of them might probably have proved addled, the young partly formed, and the eggs of no use to us; but the whole of those we took turned out good, and had a particularly fine and delicate flavour. It was a work of considerable difficulty to get our booty safe into the boat—so frail a cargo—with so tremendous a surf running against us. However, we finally succeeded, though not without smashing a considerable number of eggs.

The next, and more important, source of knowledge of the Tristan penguins is contained in published notes by various members of the 'Challenger' expedition. These are in part original observations and in part gleanings from the experiences of the German brothers Stoltenhoff, who had been marooned for many months on Inaccessible Island before the arrival of the 'Challenger.' The noteworthy point is that the separate writings of Campbell, Thomson, Moseley, Spry (1876, 102), and Murray (in Sclater and Salvin) are in substantial agreement. The following is an attempt to combine their accounts.

When the 'Challenger' drew near Inaccessible Island, in October, 1873, the ship was surrounded by multitudes of penguins. Most of them were swimming under water, but every now and then they would rise to rest at the surface, their bodies remaining almost submerged. Still oftener they merely porpoised. In fact, the 'Challenger' naturalists, new to the southern hemisphere, mistook the first penguins they saw for tiny porpoises. Moseley wrote:

I could not imagine what the things could be, unless they were indeed some most marvelously small cetaceans; they showed black above and white beneath, and came along in a shoal of fifty or more, from seaward toward the shore at a rapid pace, by a series of successive leaps out of the water, and splashed into it again, describing short curves in the air, taking headers out of the water and headers into it again; splash, splash, went this marvellous shoal of animals, till they went splash through the surf on to the black stony beach, and there struggled and jumped up amongst the boulders and revealed themselves as wet and dripping penguins.

Thomson, failing to observe that the power behind the penguins' leaps came from the flippers, curiously attributed it to the exercise of muscles of the back, with the wings appressed against the sides, an error which has been many times repeated in subsequent literature.

At the landing place of Inaccessible Island, hordes of Rockhoppers were constantly going and returning between the rookery and the ocean. Offshore the rolling blank surface would suddenly begin to twinkle with rising birds, which would then move shoreward with no more than the heads above water, and scramble out by hundreds. Once beyond reach of the surf, they would prink for a few moments and then hop and flop across the shingle, all making for a gangway leading into the jungle of tussock. Elsewhere an equally large body of penguins might be issuing from the grassy wilderness by another avenue. Once on the beach, these too would stop, not to preen but rather to chatter together and seemingly to take in the open view after the blind labyrinth of the tall grass. Within a few minutes their original impulse would return, and with one consent they would scuttle into the water. Soon the long ripples, spreading from their place of submergence, would be the only indication of a host of birds speeding out to sea.

Many hundreds of thousands of nesting Rockhoppers were found by the 'Challenger' party at the three main islands of Tristan da Cunha, and on the rocks and islets off Nightingale Island. Nightingale itself had one rookery covering 40 to 50 acres, extending a quarter of a mile back from the water and up to an altitude of 50 meters. Moseley estimated the population of this island and its small outliers to number 400,000 penguins. Part of the main rookery lay upon an old lava flow, the flinty surface of which had been worn smooth by the feet of the birds. In most places, however, the concentrated centers were in the beds of ravines opening on the shore, and on slopes above them, where the ground was well covered with the long-stalked native tussock grass (*Spartina arundinacea*), a species quite different from the pan-antarctic tussock of the Falklands and South Georgia. Between tasselled *Spartina* hummocks as high as a man's reach, the main penguin thoroughfares meandered inland from the beaches, and on either side narrower but well-trodden lanes of black soil led to the nests, which were clustered around the pedestals of the grass. In some places six nests were contained within 2 square meters. Many of the nests were little more than scrapings in the humus, but others had a considerable bowl of grass.

From a distance the incessant noise sounded like innumerable hounds tongueing in all possible keys. From still farther—as heard, for example, on the 'Challenger' at her anchorage—the chorus resembled the moan and roar of heavy surf. But when one was among the penguins, the fiendish individual voices could be likened, according to Campbell, only to something between the last notes of an ass's bray and the bleat of a deep-voiced sheep!

According to Campbell, the peregrinating Rockhoppers kept mostly to the left side of their avenues, so that bands of birds meeting on the way would pass in the manner of all good Britishers! On the beaches, or elsewhere in the open, the 'Challenger' naturalists found the penguins mild enough. Here they seemed not to think of attacking, but would look curiously and fixedly at their human visitors. When they chanced to take fright, they might all turn about together and the serried ranks of white breasts and pink feet would instantaneously change to a hopping mob of slate-colored things, with a thousand pairs of yellow crests shaking above them.

When, however, a man had occasion to cross through one of the colonies, the temper of the violated penguins proved quite different. The following account of such an adventure is not a direct quotation, but a picture compounded by freely mingling the phrases of Professor Moseley and Lord Campbell. Be it understood that they were both kindly gentlemen, up to that time innocent of personal acquaintance with penguins. If they had realized the shambles for which they were about to be responsible, no doubt they would have avoided the experience.

It is impossible to conceive the discomfort of making one's way 'across country' through a big rookery. The grass grows six feet high, matted and tangled, while thousands and thousands of penguins swarm between the tufted stems. You plunge into one of the lanes in the grass, which at once shuts the surroundings from your view. You tread on slimy, black, damp soil composed of the birds' dung. The stench is overpowering; the yelling perfectly terrifying—I can call it nothing else.

In the path only a few droves of penguins, on their way to and from the water, are encountered, and these stampede into the side alleys. You lose your road, and in a twinkling you are on the actual breeding ground. The nests are placed so thickly that you cannot help treading on eggs and young at almost every step. If you stop to see where you place your feet, you are instantly attacked by a host of infuriated harpies.

A parent bird sits on each nest, with its sharp beak erect and open ready to bite, screaming savagely *caa*, *caa*, *urr*, *urr*, its red eye gleaming, its plumes at half-cock, and quivering with rage. No sooner are your legs within reach than they are furiously bitten, often by two or three birds at once. Even if you are so fortunate as to be wearing strong leather gaiters, there may still be an exposed inch above—a very tender part—where you will get horribly tweaked.

At first you try to avoid the nests, but you soon find them so thick that it is useless; so you have just to tramp on as fast as possible, striking out forwards and sideways vigorously, every step knocking down, kicking, and treading on an india-rubbery substance, which, if you dare to look down, you will find is a penguin; or smash, smash, as you stamp on eggs by the dozen; or—more dreadful still—squash, squash, as you crush small black creatures—horrible! horrible! Add to all this the slippery dirty ground (it all reminded me of that line, "The slithy toves did gyre and gimble in the wabe"), the furies biting hard incessantly—reaching not only that inch of stocking aforesaid, but higher up, too, as you sink into a hole—the deafening brayings, the insufferable smell, the clouds of small black flies, which if you open your mouth you are bound to swallow *en masse*, the hard work fighting through the snarled grass without being able to see where you are going or when it will all end.

Then maddened by the pain, stench, and noise, you have recourse to more deliberate brutality. Thump, thump, goes your stick, and at each blow goes a penguin. Thud, thud, you hear from the man behind, as he kicks them right and left off the nests; and so you go on for a bit, thump, and smash, whack, thud, *caa*, *caa*, *urr*, *urr*, and your wake is strewn with the dead and dying and bleeding

> But you make miserably slow progress, and, worried to death, at last resort to the expedient of stampeding as far as your breath will carry you. You put down your head and sprint through the grass, treading on old and young haphazard, and rushing on before they all have time to bite.
>
> The air is close in the rookery, and the sun hot. Out of breath, and running with perspiration, you come across a mass of rock fallen from the cliff above; this you hail as 'a city of refuge.' You hammer off it hurriedly half a dozen penguins who are sunning themselves there and, mounting on the top, you take out your handkerchief to wipe away the perspiration, rest awhile, and try to see in what direction you have been going, how far you have got, and whither you are to make the next plunge. Then when you are refreshed you make another rush, and so on.

On a similar occasion the 'Challenger' sailors located one of the ship's spaniels in the middle of a bare patch within the penguin rookery of Nightingale Island. The dog was howling in a heart-rending manner, and was attempting to hold at bay a circle of hissing and braying tormentors. The unfortunate animal had been driven so mad by its passage through the colony that it could never be caught or coaxed out. A second spaniel was recovered and carried to safety by its master, but not before it was soaked with blood from innumerable wounds.

Less vivid and personal information about the Rockhoppers was taken down by the 'Challenger' naturalists from the Stoltenhoffs. The male penguins annually begin to return to Inaccessible during the last week of July. At first only a few small groups are to be seen, but by early August the stream of arrivals swells to maximum numbers. Toward the middle of the month there is an interval of a few days during which no newcomers are noted, a fact readily determinable because the homing penguins do not again take to the ocean for weeks after they have made their springtime landing. The impatient males, which have come home in advance of their mates, are very fat at this season, and spend most of the time lying on the shore or amid the tussock, lazy and half asleep. Although they do no feeding, they poke about in the dead grass at the base of the hummocks, and pick up bits of it as though already spurred by the instinctive reaction to begin preparation of the nests.

After the quiet interval of two or three days, the female penguins begin to land about August 12, whereupon courtship activities, accompanied by ceaseless fighting, are at once under way. The cocks hop ludicrously about the objects of their desires, and are characteristically quick to switch from love to arms. Unlike some of the other penguins, they damage each other more by biting than by blows with the wings. Often one may be seen hanging on doggedly to the bill, or worse, to the tongue, of another. Males with an eye destroyed are no uncommon sight during the mating season.

Fasting is the rule throughout this period. But although the penguins do not enter the sea to feed or swim, they occasionally wash themselves at the edge of the beach, or lie in little freshets of rainwater for the same purpose. When rain is falling, they appear to spread themselves to the downpour and to drink the fresh water by scraping it from their feathers with the bill.

Before the end of August, or within about a fortnight after the return of the female penguins, the first eggs are said to appear. When the sets are complete there are two, or more rarely three, in each nest. The bulk of the eggs are not laid until mid-September; Earle, it will be remembered, expressly states that most nests in the Tristan colony held but one egg on September 12. With the laying of the first egg, of course, one bird of each family repairs to sea, where flocks of such vacationists can be seen rolling and stretching on the surface to clean and limber themselves before seeking the feeding grounds.

Although the sexes alternate in incubation, the female exhibits a more specialized brooding behavior, as is known to be true of certain other penguins and perhaps of waterfowl in general. Only in female Rockhoppers, according to the 'Challenger' naturalists, is a bare brood-patch discernible. In changing places upon the nest, the mates exercise the usual speed and circumspection, even though the Tristan Rockhoppers doubtless suffer much less from skuas and other predatory birds than do the penguins of more southerly localities.

The period of incubation is variously given as five to six weeks. Probably the latter figure is excessive. It may in reality represent the term between the appearance of the first eggs and the average date of hatching throughout a colony.

By December the chicks have grown up and passed through the moult of their down, whereupon all the penguins, young and old alike, take to sea, so that silence and emptiness reign over the site of the once swarming settlements. That such a period of absence precedes the moult of the adults is a very interesting departure from the régime of the antarctic penguins.

Early in January, the adult Rockhoppers, mingled, according to Barrow (1910, 276), with juvenal birds hatched the preceding year, begin to return to the islands in anticipation of their annual moult. It is clear that in the vicinity of Tristan da Cunha, or of the Falklands for that matter, there would never be a possibility of undergoing any part of the moult upon floating ice in the manner of several antarctic species. The penguins come ashore in the mood for their Ramadan, for they proceed to spread all over such an island as Inaccessible, climbing to what might seem unattainable situations, finally to squat torpidly while the loss and renewal of the plumage are taking place.

In other parts of the world the complete moult of the Rockhopper is said to occupy somewhat less than a month, and Wilkins (1923, 496) reports that at Tristan the greater part of the process is undergone during March. Many birds land so early in the year that their fast must extend to three months or longer. Then, instead of departing individually as the moult is completed, they exhibit a rhythm which affects the whole community, for during a single night in April the birds all leave the island together. The exodus was witnessed during successive Aprils by the Stoltenhoff brothers, who declare that on one evening the penguins were all with them, while next morning not one was to be seen, except a few sick birds. According to the Stoltenhoffs, not a single penguin comes to Inaccessible Island between mid-April and late July. Wilkins found none at Gough Island on the first of June. Other observers state, however, that small scatterings of Rockhoppers sometimes haul out on the lonely beaches of the Tristan group during this southern-winter season, indicating that the species does not necessarily abandon that general part of the Atlantic. Earle encountered a few ashore in early June, at which time they were so tame and unspirited that they could be walked up to and knocked on the head.

MACARONI PENGUIN

Eudyptes chrysolophus

Catarhactes chrysolophus Brandt, 1837, Bull. Sci. Acad. Imp. Sci. St. Pétersb., 2, p. 315 (Falkland Islands).

Names: Sometimes called Rockhopper through confusion with the preceding species. "Pingüín Macaroni" and "Pingüín de Frente Amarilla" have been used by South American ornithologists. The only important synonym of the specific name is *diadematus*, but one or another of the names belonging to *Eudyptes crestatus* has often been mistakenly applied.

Characters: Larger than *Eudyptes crestatus;* length about 70 cm., wing 18–20 cm. Closely resembling *crestatus* in general form and pattern but distinguishable as follows: the cornuate plumes, which are orange or deep chrome rather than yellow, extend backward instead of outward, and proceed not from superciliary stripes but rather from a crescentic patch of the same color which extends across the forehead; all of the orange feathers, except those of the elongate lateral tufts, are tipped with black, which tends to streak or partially conceal the forehead patch; no black plumes occur on the posterior part of the crown, and the barbs of the orange aigrettes are short and obsolescent, making the tufts more stringy than in *crestatus;* feathering has encroached less upon both maxilla and mandible than in *crestatus*, and the fleshy angle of the mouth is conspicuous and, in life, of a bright pink hue; bill, not only larger than in *crestatus*, but also with a more pronounced relief in its modeling, and a tendency toward transverse rugosity along the culmen; throat grayish, due to a flecking of fine white feather shafts; the caudad extension of its dark area more pronounced than in *crestatus;* whitish or yellowish webs upon a few of the central upper tail coverts produce a more or less distinct spot at the base of the rectrices, which are 14 in number. Furthermore, the outer surface of the flipper is whitish only along its posterior border, while the inner surface has a broad black anterior border. Iris, garnet red; bill, brownish ("hazelnut brown") with a red tip and purplish cutting edges; legs and feet, pinkish or yellowish, with gray webs and black soles, the claws whitish above and dark brown laterally and distally. It seems probable that many of the flesh colors are brighter during the breeding season than at other times.

Measurements of eight Macaroni Penguins in the American Museum Collection, from the Falkland Islands, South Georgia, and Deception Island, are as follows:

3 males: total length, 685–690 (688); wing, 180–198 (189); tail, 98–111 (107); longest crest feather, 65–72 (69.4); culmen, 58–64.2 (60.3); bill from gape, 65–74 (70); width of bill, 22–24.3 (23); depth of maxilla, 12–15.2 (14.1); foot, 124.8; middle toe and claw, 70–82.5 (75.2) mm.

5 females: total length (one), 695; wing, 174–185 (182); tail, 96–116 (102.2); longest crest feather, 52.6–63 (57.7); culmen, 53–57 (54.6); bill from gape, 60–71.5 (64.7); width of bill, 20.5–22.5 (21.3); depth of maxilla, 12.8–13.4 (13.3); foot, 106–112 (109); middle toe and claw, 70 mm.

The following additional figures are from Gain's table of measurements of Deception Island birds (1914, 69, 70):

Average of 6 males: wing-spread, 526; total length, 703; wing, 200.8; tail, 156.6; culmen, 59; tarsus, 23.4 mm.

Average of 5 females: wing-spread, 511; total length, 694; wing, 189.6; tail, 153.8; culmen, 52.6; tarsus, 23.4 mm.

The only important discrepancy between the French Expedition figures and mine lies in the length of the tail quills. Obviously male birds average slightly larger in most dimensions than females.

The eggs of the Macaroni Penguin are a little bigger than those of *Pygoscelis papua*, variable in form between spheroidal and elongate ovate, and variable in the amount of their chalky encrustation. The departure of the shell from whiteness is in the direction of a very pale bluish (rather than a greenish) tinge. Two eggs from Kerguelen Island measure 74.5 x 56.3 and 77 x 53.8 mm.; one from South Georgia, 79.6 x 58.5 (Verrill, 1895, 458). Gain (1914, 72) lists 11 Deception Island eggs, exclusive of one that might be called a "runt." These varied in length between 71.5 and 80.5 mm., and in breadth between 53.5 and 61 mm. Their weight ranged from 120 to 153 grams, the average being 139 grams.

Distribution: More southerly than that of *Eudyptes crestatus*, and restricted to the American and Indian quadrants of the pan-antarctic regions. Breeds at the South Shetland and South Orkney Islands, South Georgia, the Falklands (casually), South Sandwich group, Bouvet, the Prince Edwards and Crozet groups (probably), Kerguelen and Heard Islands.

Between certain fiords of South Georgia, on promontories exposed to the swell of the sea, or on islets at a little distance from the main island, are colonies of the Macaroni Penguins. Their nesting sites more or less alternate, therefore, with those of the Johnny Penguins (*Pygoscelis papua*), for the latter tend to seek the sheltered heads of the fiords, and to make their landing upon shingly beaches rather than rocky steeps. The Macaronis have a goatish and forbidding smell, and they are bolder, tougher, and in all respects less friendly than their neighbors of the inner bays.

Such temperamental characteristics have at least been ascribed to the Macaroni Penguins by all visitors to their South Georgia rookeries, and to most colonies elsewhere. The traits seem quite in keeping, considering the close relationship of the species with the Rockhopper Penguin. From the antarctic breeding grounds of Deception Island, however, the French naturalists brought quite a different impression. Comparing the Macaroni with the Ringed or Antarctic Penguin, Gain (1914, 70) wrote:

> Le Pingouin "huppé" est aussi calme que l'Antarctique est bruyant, aussi pacifique que l'autre est batailleur. . . . C'est un animal tranquille, . . . confiant, se laissant facilement approcher quand il est sur son nid, et même caresser, cherchant rarement à donner un coup de bec ou d'aileron.

Whether such pronounced and well-authenticated differences are due to chance, climate, or the human approach, has yet to be determined.

The Macaroni Penguin has been much confused with the Rockhopper, in the field as well as in the literature. The uncertainties go back, indeed, to very early times, for it is probable that Forster had a composite of both species in mind when he created the specific name *chrysocome*, which is now regarded as a synonym of *crestatus* (Sclater and Salvin, 1881, 127).

The two species are, nevertheless, readily distinguishable by measurements and by the characteristics of adult plumage noted in the description above. The line of demarcation between white and dark plumage on the throat is alone sufficient for discrimination between birds seven months or more in age, for in *chrysolophus* the dark area has a caudad V-shaped extension, while in *crestatus* the line cuts more nearly squarely across the throat (Sutherland, 1923, 34).

With reference to geographic range, *chrysolophus* belongs to a decidedly colder zone than *crestatus*, but the breeding grounds of the two meet at the Falklands and at Kerguelen Island, and perhaps also at the Crozets and Prince Edwards. The status of the crested penguins of the last two groups of islands is not yet satisfactorily known. Several West Antarctic records for *Eudyptes crestatus* are based upon misidentification of *chrysolophus*, and the reverse is probably true of certain temperate zone records of the latter species. The Macaroni, for example, is doubtless the crested penguin of the South Shetlands, listed by Lönnberg as *chrysocome* (1908, 3). Carcelles (1931, 399) has fallen into the same error with reference to South Georgia breeding birds. In east-west extent of range, the

Macaroni has progressed a stage farther than the Ringed Penguin (*Pygoscelis antarctica*), for it has occupied not only Bouvet Island but also the available pan-antarctic breeding sites in the Indian Ocean as far eastward as Heard Island. It has not, however, succeeded in encircling the earth, as its smaller congener, *crestatus*, has done.

During the Brewster-Sanford Expedition, Mr. Beck collected at the Falkland Islands three adult Macaroni Penguins in breeding condition. The single male was reported by gatherers of Rockhopper eggs at Kidney Island, on November 5, 1915. The two females were taken in another Rockhopper colony, at Bleaker Island, on December 18 and 23, respectively. One of these had apparently come ashore merely to rest during a period of very rough seas.

The American Museum's further representation of the species comprises a female from Cape North, South Georgia, collected by J. G. Correia on February 2, 1915, and five adults from a colony at Deception Island, obtained by A. G. Bennett during February, 1922.

Members of the Second French Antarctic Expedition found these penguins breeding at several of the central islands of the South Shetland group, the southernmost colonies being at Deception Island, in about latitude 63° S. (Gain, 1914, 69). Andersson (1908, 38) records them from the same region, and also one bird from Paulet Island, which is just south of Joinville Island at the eastern side of the Antarctic Archipelago. This seems to be the southernmost record for the species. The Scottish Expedition obtained the first specimens at the South Orkney Islands (Clarke, 1913, 232) where, however, Captain C. A. Larsen had previously observed breeding colonies, and where Bennett (1920, 32) has since confirmed their presence. Wilkins (1923, 491) reported them as one of the four species of penguins common in the waters around Zavodovski Island of the little-known South Sandwich group. Excellent photographs by Riiser-Larsen (1930, 555) establish the species as a resident of Bouvet Island, where it nests characteristically among the Ringed Penguins. Little is known about the residence of the Macaroni Penguin at the western islands of the Indian Ocean, but Reichenow (1908, 549) records it as a breeding species of the Prince Edwards, and Campbell (1877, 88) states that on December 29, 1873, a flock of *Eudyptes* penguins came to the surface about the 'Challenger' when she was 206 miles from the Crozet Islands, the nearest land. The birds made their presence known by cries of *Wh-a-a-a! wha-a-a!* Heard Island was first established as a breeding station by a skin collected by sealers (Kidder, 1875, 45). The more northerly colonies at Kerguelen, South Georgia, and elsewhere have been reported upon by many observers.

The Macaroni Penguin seems to exhibit two different modes in its nesting habits, according as to whether it is geographically "at home," *i. e.* residing in the zone of optimum climatic conditions, or whether it is nesting at the outer fringes of its range. At all the icy southern islands, for example, it forms homogeneous rookeries, whereas outside the Antarctic Convergence, at the Falklands, only scattered pairs nest among the masses of Rockhoppers. This seems to have been as true in earlier times as it is at present (Sclater, 1868, 527).

At Kerguelen Island, too, the Macaronis are reported mostly as interlopers among the Rockhoppers, conspicuous because of their larger size and the pink patch of tumid skin at the base of the beak (Sclater and Salvin, 1881, 127). Formerly, however, they were evidently more abundant at Kerguelen, for Moseley (1879, 195) and Studer (1879, 110) refer to populous rookeries at Christmas Harbor in January, 1874. Forty years later Loranchet (1915, 156) found them still numerous about Port Curieuse.

Thus it seems that wherever the Macaroni is present in only small numbers, it seeks the company of other species, especially of its congener, the Rockhopper. In September, 1858, Abbott (1861, 163) saw one among the Rockhoppers at Eagle Point rookery in the Falklands, paralleling Beck's experience of 1915. Again, Abbott (1860, 338) found about fifteen nests among those of twenty thousand Falkland Rockhoppers. There was but one egg in each of nine Macaroni nests; the others were empty. Sclater and Salvin (1881, 127) remark that although three eggs are the usual complement, this species ordinarily rears but one chick, and more rarely two. The southern sealers have a legend that the Macaroni Penguin nearly always thrusts one or two of its three eggs out of the nest.

Gain, of the French Expedition, studied several colonies of Macaroni Penguins at Deception Island. He found that they got on peacefully with their neighbors, the truculent Ringed Penguins, a fact that would seem to be confirmed by Riiser-Larsen's photographs of the intimate mixtures of these two species at Bouvet Island. West of the entrance to Port Foster, Deception Island, Gain found a colony of approximately five hundred birds about 30 meters above sea level. When he picked up a mated pair from the nest, another couple, which had apparently not yet taken possession of territory, immediately pushed out the uncovered egg and appropriated the home. During the middle of December Gain visited another colony, east of the entrance to the same harbor. This one was composed of close to two thousand birds, divided into small clusters of about a hundred. Each nest examined contained one egg, and the parents were taking turns at brooding. Judging from the size of the embryos, Gain concluded that egg-laying at Deception must have begun between November 15 and 30, and that most of the eggs would have hatched before the end of December (Gain, 1914, 69).

Bennett (1920, 32) states that the chicks take to the water from six to ten weeks after hatching.

At South Georgia, the Macaroni Penguins come to land at their nesting grounds in October. Carcelles (1931, 399), for example, encountered thirty at Rosita Harbor during that month, although he mistook the species for *Eudyptes crestatus*. There are rookeries of thousands of the birds at Bird and Willis Islands off the northwestern end (Filchner, 1922, 129; Wilkins, 1923, 486), at Cooper Island to southward, and on many exposed promontories of the mainland (Matthews, 1929, 588). Members of the German South Georgia Expedition took examples in moult during early March (Pagenstecher, 1885, 15; von den Steinen, 1890, 239). By May the bulk of the birds have left their breeding grounds, but it is not certainly known whether they remain throughout the winter in the vicinity of South Georgia, or whether, like the Rockhoppers, they make long pelagic migrations.

One of the fullest accounts of the species is based upon the observations of Matthews (1929, 588) at South Georgia. It is here quoted substantially in full:

The Macaroni Penguin, called locally "Rocky Penguin," is extremely abundant at South Georgia and in the waters round the island, though it rarely comes on land except at its rookeries. The rookeries as a rule are large, containing thousands of birds: they are situated on the tussac-covered slopes above the cliffs in exposed parts of the coast outside the bays. . . . Seen from the sea the rookeries present a characteristic appearance; the crowd of white breasts of the birds surrounded by a dark green ring where the tussac grows luxuriantly, and beyond the pale yellow-green of the ordinary tussac. . . . The following notes were made during a visit to a rookery between Cape Saunders and Fortuna Bay on November 30th, 1925, to gather eggs which were then new laid.

The rookery was situated on some steep sloping land at the top of the cliffs, with cliffs rising again behind to a height of about a thousand feet. The penguins jump out of the sea on to the rocks and hop up the cliff to the rookery. There are many thousands of birds in the rookery and they are packed tight wherever there is standing room. The noise they make is deafening, especially when they are disturbed by anyone walking through the rookery, and the smell of it is beyond description. Individually the birds have a strong goaty smell. Their nests are made of small stones, or of mud and tussac, but many of the eggs are laid on the loose stones of the rookery without any nest. The main part of the rookery where the birds are most thickly congregated is quite bare, but I saw odd birds among the tussac on the mountain cliff as high up as about eight hundred feet above the sea. As we walked through the rookery most of the birds moved aside to let us pass, making all the while a tremendous braying, but a few of them would not leave their eggs, which they defended stoutly with their bills and flippers. Though they were thickly packed it was apparent that they were all in pairs.

Their voice is very loud, something like the trumpeting of the Gentoo Penguin, but much harsher and deeper. The two birds of each pair were frequently to be seen braying to each other. When they did this they held their flippers widely open, pointing upwards and backwards at an angle of about 45 degrees from the shoulder. They then stretched the head up and threw it back so that the beak was pointing up into the sky behind them, and started calling. All the time that they were braying the head was moved from side to side with a wriggling motion, so that the tip of the bill nearly touched the tip of each upraised flipper alternately. This bout of braying was usually preceded by both birds of the pair bowing to each other so that the bill touched the ground, and when their heads were close together like this they gave a low grunt. Frequently they repeated this after braying.

There is only one egg to each pair and it varies greatly in size and shape, from short and round to long and pointed. When the birds are walking about the rookery or hopping up and down the cliffs they hold their flippers in front of them, but as soon as they stop moving they hold them elevated behind them. In climbing up the cliff they hop from point to point, making quite long jumps, and when scrambling up a difficult bit they use the bill to help them. Even when hurried they were not seen to toboggan as the other penguins do. They are very quarrelsome, pecking each other and walloping each other with the flippers unmercifully; any bird walking through the rookery comes in for a shower of pecks and blows from all his neighbours as he passes. Many of the birds get very dirty with the mud in the rookery, which is very wet, as several small streams descend the cliff behind. There were many Skuas flying round the rookery and settling on the neighbouring rocks, but as soon as one tried to alight in the rookery, no doubt to steal eggs, it was attacked by the penguins and driven away. There were also some Sheathbills in the rookery but these were left unmolested although they too are egg stealers.

This rookery was again visited on February 14th, 1926, when the following notes were made:

We found most of the young hatched and half grown; they were covered with down, black on the back and white in front, and had black bills, pink feet and dark brown iris. . . . A few of the old ones were still sitting on eggs, probably addled ones. We did not see any small young ones in their first down coat. About half of the old ones were moulting. Their yellow head plumes were nearly all shed and the old feathers were coming off in patches, leaving the new ones showing underneath. They also shed the casing of the beak; in most of them it had not yet peeled off, but was scaly, and dull in colour. The scales on the feet too were being shed and the irides of the moulting birds were light brown. When they enter the water they, like the Gentoos, wash themselves and then swim away.

At Kerguelen Island the nesting season agrees with that at South Georgia, the first eggs being reported about November 20 (Verrill, 1895, 458). Gain's data indicate that the period is about the same at the much more southerly South Shetland Islands.

Albinos of this species have been reported from the Falkland Islands (Schlegel, 1867, 7).

At Deception Island, Gain (1914, 73) measured the intestine of a Macaroni Penguin, and found it to be 5.9 meters in length, and only 5 millimeters in diameter.

Stomachs of birds examined at various localities contained euphausiid crustaceans, cephalopod beaks, or both.

MAGELLANIC PENGUIN

Spheniscus magellanicus

Aptenodytes magellanicus Forster, 1781, Comment. Soc. Reg. Sci. Gottingensis, 3, p. 143, pl. 5 (Staten Island, Tierra del Fuego, and the Falkland Islands).

Names: Jackass Penguin. "Pájaro Niño" and "Pájaro Manco" are the common South American names, meaning, respectively, "child bird" and "armless bird" (Dabbene, 1920, 8); "Burro," a name used along the Strait of Magellan, is the Spanish equivalent of Jackass. "Choncha" is a Fuegian Indian name recorded by Oustalet (1891, 99). Synonyms of the specific name include *magnirostris*, *brasiliensis*, *trifasciatus*, *modestus*, and *demersus*, the last properly belonging to the South African member of the genus. The Magellanic species has also been confused in the literature with *Spheniscus humboldti*, the range of which is confined to more northerly parts of the west coast of South America.

Characters: Length about 70 cm., with a wing of 17–18 cm., and the shortest bill among the three New World species of *Spheniscus*. Dorsal surface dark slaty gray, shot with bluish in fresh plumage, and varying with wear; the feathers have shafts which are distally black but proximally brown, and the concealed parts of the webs are also brownish, which gives a duller cast to worn dorsal plumage; chin, throat, and sides of head blackish or brownish black; a narrow, U-shaped black band crosses the breast and extends down the sides and flanks, more or less disintegrating into dark mottlings toward the thighs and crissum; between this band and the black mask a broad blackish collar, with a median forward extension, runs from the dark dorsal plumage across the neck, which in front view shows, therefore, alternating pairs of white and dark bands; the anterior white band begins as a superciliary stripe in the lores, or sometimes practically at the bill, extends caudad above the aural region, and then loops downward between the dark nape and cheeks to outline the face and to form the most conspicuously contrasting pattern on the living bird; ventral surface white, with sporadic black spots composed as a rule of single feathers; external surface of flippers slaty black, with a white posterior edge due to the extension of two or three rows of the white under coverts; internal surface of flippers white, flecked with black; the white lining extends to the anterior edge, but scarcely around it on to the external surface; tail of 20 rectrices, with black shafts and slaty vanes like the dorsal contour plumage; under tail coverts mostly white, but with a variable intermingling of brownish feathers. Iris, brown; skin around eyelids, black; flesh-colored skin usually showing more or less through the sparse feathering of the lores; bill, blackish horn-color, axially striated toward the base of both mandibles, and sometimes with a yellowish horny transverse bar on the mandible and part of the maxilla, near the nostril; feet, blackish brown, with gray or whitish mottlings on the webs and joints; soles and posterior aspect of legs, black.

Measurements of adult birds from a broad extent of the range are as follows:

9 males (Cautín and Corral, Chile; Ushuaia, Tierra del Fuego; Falkland Islands; Mar del Plata, Argentina): wing, 178–185 (180); tail, 24–39 (30.5); culmen, 54–59 (56); bill from gape, 65–73 (68); nostril to tip of bill, 24–30.6 (28); foot, 100–117 (111); middle toe and claw, 70–77 (71.5) mm.

6 females: wing, 159–180 (171); tail, 22–39 (31.6); culmen, 49.6–54 (52); bill from gape, 61.5–65.5 (63.6); nostril to tip of bill, 24–27.5 (26); foot, 101-115 (109.6); middle toe and claw, 64–75 (68.3) mm.

Females evidently range slightly smaller than males. The tail-quill measurement is probably unduly short, through abrasion, for several newly-moulted chicks in the collection have much longer rectrices.

The wing-spread of a female was 1 foot 8½ inches or 521 mm. (Peale, 1848, 258).

Brooks (1917, 145) weighed a number of these penguins at the Falklands. The heaviest was an immature bird (he does not say whether a fledgling or a yearling) which weighed 12 pounds, 6 ounces (5600 grams). Adults weighed between 9 pounds, 12 ounces (4400 grams) and 10 pounds, 12 ounces (4880 grams).

The intestine of a bird of this species measured 26 feet (7.92 meters) in length (Fauvety, 1888, 322).

Beck seems to have collected only two sets of eggs of this species, both taken from burrows near Port Stanley, Falkland Islands, November 1, 1915. One is a set of two fresh-laid eggs, with a chalky but smooth surface texture, creamy white, with a few buffy and greenish stains. They are alike in form, both being short and rather sharply pointed at the small end. They measure 71 x 57 and 70.4 x 57 mm. The other is a rotten egg, stained dark brown, and taken from a burrow containing one chick. It measured 71.6 x 56.5 mm.

Vallentin (1924, 293) reports that a large series of eggs from the Falklands measured from 64 to 74 mm. in length, and from 56 to 58 mm. in breadth.

Distribution: Breeds at the Falkland Islands and at islets along the Patagonian coast from about latitude 41° S., southward to Staten Island, Cape Horn, Ildefonso and Diego Ramírez and other outliers of the Horn, and thence northward along the Pacific coast to Santa María Island, Bay of Arauco, and the Juan Fernández Islands offshore. A widely distributed nesting species on islets of the Strait of Magellan and other Fuegian channels. During migration it ranges northward along the Atlantic coast to southern Brazil and, at times, as far as the harbor of Rio de Janeiro. On the Pacific coast it reaches Coquimbo (30° S.). Numerous published records for South Georgia are based upon errors of identification or interpretation.

The Jackass Penguin is a harlequin creature, clad in a striking plumage of black and white. The piebald pattern is carried out even on the black bill and feet, which are commonly flecked with white, while the gleaming white breast is more rarely spattered with black spots like polka dots. Its stout and wicked bill, and the readiness with which the bird lunges forward in its burrow to use it as a weapon, make it more formidable than any of the preceding species of penguins. "One of them bit me as I was trying to secure it," writes Moseley (1879, 560), "and cut a strip out of my finger as clean as if it had been done with a razor." Brooks (1917, 144), too, states that it does not peck, but rather uses the hook of the maxilla that dovetails between the sharp double blades of a truncated mandible to tear ribbons of flesh from the hands of an interloper.

Nor is the formidable bite due entirely to the sharpness of the bill-sheaths. Extraordinarily massive jaw musculature also plays its part in making the Jackass Penguin and its close relatives birds to be approached with circumspection. The temporal muscles, taking their origin in a deep fossa of the skull and leading to the inner face of the mandible, are much more strongly developed in this genus than in any other penguins except perhaps the most heavy-billed species of *Eudyptes*.

This species, like the other members of the genus *Spheniscus*, has a somewhat wall-sided head, so that its eyes cannot point forward in bifocal vision. Therefore it has the habit of twisting the head slowly or rapidly, alternating the eyes with which it inspects any important object at close range, such as a man who has cornered it. The curious swaying, weaving action entailed by this constant shift of eye is often accompanied by a nervous clattering of the mandibles. The habit has been observed from the earliest times, and has been attributed to all sorts of causes, from inquisitiveness to hypnosis!

The common names of the species, whether Jackass in English or "Burro" in Spanish, are not far to seek. Forster, the scholarly companion of Captain James Cook, and the first scientific describer of this penguin, wrote of it in the eighteenth century: "Vox rauca, clangens, et etiam crotali instar crepitans, fere asina." "It brays all the time it is ashore," says Vallentin (1924, 293), "except during its moulting period, when it becomes almost dumb. It is particularly noisy at night, the operatic chorus in a colony taking on redoubled strength at sunset and continuing until daylight. Three staccato brays followed by one long one constitute the ordinary pattern of the song." Snow (1857, **1**, 277) tells of digging out four Jackass Penguins at the Falklands and carrying them on board his ship. But, he adds, "I was unable to keep them as I had hoped to do. . . . During the night they made such a terrible noise that it was impossible to get rest or peace. In vain did I go on deck once or twice to try and quiet them. The braying, or something worse than braying, continued incessantly."

Cobb (1933, 65) muses about the voice of this penguin at the Falklands, as follows:

> . . . the melancholy bray uttered by these birds, which is such a familiar sound on any island inhabited by them, . . . might easily be that of the four-footed jackass. On a calm evening one will stand at his door, lift up his head and his voice, and start a bray, putting all the misery possible into it, as if he felt he was the most-to-be-pitied being down on Misery Farm. Hearing it, others who lay claim to the title, answer and echo it with their own particular woebegone bray, passing along the doleful dirge further afield, until the whole district is mourning in chorus.
>
> Not only do Jackasses bray standing ashore, but also while afloat, and possibly their "hull-o-o-o-ws" have something to do with those hails from the ghosts of shipwrecked sailors heard periodically by certain scarey individuals.

The Jackass Penguin was probably the first of the family to be observed by Europeans, for Magellan and his men described the "strange geese" as they found them in the Gulf of San Matías, on the Patagonian coast, toward the beginning of the southern-winter season of 1520. Pigafetta, the diarist of Magellan's circumnavigation, wrote that the flocks were so huge that the whole fleet (then composed of five ships) might easily have been laden with them. In 1598, certain Dutch navigators referred to great numbers of penguins along this same coast, and were responsible for the naming of the group of islets off

Puerto Deseado which is still known as Los Pingüinos. Today, as in the sixteenth century, serried ranks of the penguins may be seen at the right season from water level to the weathered sky line of Estorbo and other islets of this bare and rocky pile. Nowhere, however, are the numbers of the birds what they were before the invasion and spoliation of their kingdom.

The reliance that the early voyagers placed upon the Jackass Penguins and their eggs is indicated by many successive accounts. In 1578, Sir Francis Drake described the "great store" of penguins on Santa Magdalena Islet, south of Elizabeth or Isabel Island, near the eastern entrance of the Strait of Magellan. He said, "such was the infinite resort of these birds to these Ilands, that in the space of 1 day we killed no lesse than 3000" (Crawshay, 1907, 155).

Apparently this colony became a regular stopping place for vessels bound through the Strait, for in 1594 Sir Richard Hawkins made another visit at the expense of the unfortunate penguins, and has left us the following breezy and illuminating account:

> The Penguin is in all proportion like a Goose, and hath no feathers, but a certaine downe vpon all parts of his bodie; and therefore cannot flee, but auayleth himselfe in all occasions with his feet, running as fast as most men. He liueth in the Sea, and on the Land feedeth on fish in the Sea, and as a Goose on the shore vpon grasse. They harbour themselues vnder the ground in Burrowes, as the conies; and in them hatch their young. All parts of the Iland where they haunted were vndermined, saue onely one Valley which (it seemeth) they reserued for their food; for it was as greene as any Medow in the moneth of Aprill, with a most fine short grasse. The flesh of these Pengwins is much of the sauour of a certaine Fowle taken in the Ilands of Lundey and Silley, which we call Puffins, by the taste it is easily discerned that they feed on fish. They are very fat, and in dressing must be flead as the Byter; they are reasonable meate rosted, baked, or sodden; but best rosted. We salted some doozen or sixteene Hogsheads, which serued vs (whilest they lasted) insteed of powdred Beefe. The hunting of them (as wee may well terme it) was a great recreation to my company and worth the sight, for, in determining to catch them, necessarily was required good store of people, euery one with a cudgell in his hand, to compasse them round about, to bring them, as it were, into a Ring; if they chanced to breake out, then was the sport, for the ground beeing vndermined, at vnawares it failed, and as they ranne after them, one fell here, another there, another offering to strike at one, lifting vp his hand, sunke vp to the armepits in the earth, another leaping to auoid one hole, fell into another. And after the first slaughter, in seeing vs on the shoare, they shunned vs, and procured to recouer the Sea: yea many times seeing themselues persecuted they would tumble down from such high Rockes and Mountaines, as it seemed impossible to escape with life. Yet as soone as they came to the Beach, presently we should see them runne into the Sea, as though they had no hurt. Where one goeth, the other followeth, like sheepe after the Bel-weather: but in getting them once within the Ring close together, few escaped, saue such as by chance hid themselues in the borrowes, and ordinarily there was no Droue which yeelded vs not a thousand, and more: the manner of killing them which the Hunters vsed, beeing in a cluster together, was with their cudgels to knocke them on the head, for though a man gaue them many blowes on the body they dyed not: Besides the flesh bruized is not good to keepe. The massacre ended, presently they cut off their heads, that they might bleed well: such as we determined to keepe for store, we saued in this manner. First, wee split them, and then washed them well in Sea-water, then salted them, hauing laine some sixe houres in Salt, we put them in presse eight houres, and the bloud being soaked out, wee salted them againe in our other caske, as is the custom to salt Beefe, after this manner they continued good some two moneths, and serued vs in steed of Beefe (Crawshay, 1907, 155).

Clayton (1776, 103), in the eighteenth century, refers to Falkland Island food supplies for mariners in the form of eggs of the "Holey Penguin," so called from its habit of nesting in burrows. Captain Benjamin Morrell reported in 1832 that at Cape dos Bahías, latitude 45° S., on the Patagonian coast, Jackass Penguin eggs were so abundant in October that a ship's crew could collect fifty barrels of them within a few days (Morrell, 1832, 43).

Abbott (1860, 336) describes the egg-hook, made of a section of iron hoop fixed to the end of a pole, with which Falkland settlers of the last century extracted eggs from burrows. However, the Jackass Penguin eggs have acquired the reputation of not keeping fresh as well as those of other species. Of present-day conditions at the Falklands, Cobb (1933, 66) writes:

> Egging for Jackass eggs is not very popular, for although the eggs when fresh are more like hen eggs than those of either of the other species [gentoo and rockhopper], and are very good for eating, they are difficult to collect in large numbers, and the collector runs the risk of being smothered in Jackass fleas, which will remind him unpleasantly for several nights of his otherwise enjoyable expedition.

The American Museum possesses about twenty-five specimens of the Magellanic Penguin, not counting a more recently acquired series in the Rothschild collection. The majority were taken by Beck, while on the Brewster-Sanford Expedition, at such well-diversified localities as the Juan Fernández Islands, Corral, Ancúd, and Ildefonso Island, Chile; Ushuaia and Mar del Plata, Argentina; and the Falkland Islands. In addition, we have specimens collected at Mocha Island and the mainland coast of Cautín, Chile, by D. S. Bullock. The entire series covers, moreover, most of the stages of growth and moult.

During the course of the Brewster-Sanford Expedition, Mr. Beck first encountered the Magellanic Penguins near Corral, the seaport of Valdivia. Along this section of the west coast the range of the species overlaps that of the Peruvian Penguin (*Spheniscus humboldti*), and here Beck took examples of both forms during September and October, 1913.

On April 7, 1914, he found the Magellanic Penguins among the beach boulders of an islet off Ancúd, Island of Chiloé. Between this date and the following July, he frequently saw large numbers of the penguins, with immature birds predominating, fishing in company with shags in the estuaries of streams, and close to wharves and anchored craft, along the coast of Chiloé. On July 4, he recorded big flocks, jumping out of the water like porpoises, off Calbuco in the Gulf of Ancúd.

During subsequent wanderings along southerly coasts of South America, Beck was among the Jackass Penguins at many places southward to Cape Horn, and thence northward along the Atlantic coast to the Río de la Plata. Characteristic extracts from his journal are as follows:

1914

Aug. 20, Off the Río de la Plata. Jackass penguins in flocks.

Dec. 18, Caroline Island, Chile. Jackass penguins in their burrows, with two large young in each, and both rockhopper penguins and black-browed mollymauks nesting on the surface above them. A large band of jackasses was climbing a gully to the grassy top of the island, where the birds had nests a hundred feet or so above the water.

Dec. 26, Lort Bay, False Cape Horn. Many seen.

1915

Feb. 27, Cape Horn. Jackass penguins fishing with shags and kelp gulls two miles off Sandy Point.
Oct. 28, Sparrow Cove, Port William, Falkland Islands. Many occupied penguin burrows, four or five feet deep, near the beach.
Dec. 7, York Bay, Falkland Islands. Mingled companies of jackass and gentoo penguins; the former were much more shy than their relatives. A heavy southerly wind was in progress. Bands of jackass penguins swam along parallel with the shore in the high surf, paying scant attention to the breakers that churned them about and tossed them high.
Dec. 10, East Island, Falklands. Penguin burrows everywhere in the tussac, with the sleeping-wallows of sea-lions among them.
Dec. 13, Bleaker Island, Falklands. Many nests in the old tussac, with two young in most burrows.
Dec. 16, 17, Sea Lion Island, Falklands. Nesting abundantly in the tussac bogs. Also many swimming in a pond two hundred yards behind the beach. Others, apparently approaching their annual moult, standing about the beach in flocks.

1916

Jan. 7, Sea Lion Island. Jackass penguins abundant along the beach.
Jan. 10, Tussac Islets, Falklands. Abundant; several young ones with their parents at the mouths of the holes; others whimpering to be fed.

During a later American Museum expedition, Dr. Frank M. Chapman visired the Jackass Penguin colonies on wooded islets of the Chonos Archipelago, as will be recounted below. Still more recently, in November, 1932, D. S. Bullock, an old correspondent of the American Museum in South American ornithology, made a reconnaissance of Mocha Island, Chile, which lies off the coast about halfway between Concepción and Valdivia, close to latitude 38° S. Here he found the Magellanic Penguins at one of their northerly breeding grounds on the Pacific coast. Mr. Bullock collected two adult males at Mocha on November 22, and obtained eggs as late as December 2, when other nests contained well-grown young birds. His photographs show both burrows and surface nests, as well as a group of about eighty adults on the rocks beside a cove of the Isla de las Docas, a small outlier of Mocha. Information obtained from residents led Mr. Bullock to record that examples of the species can be found about the shores of Mocha throughout the year.

As regards the relationships of the four existing species of *Spheniscus*, and the probable center of origin and dispersal of the genus, we are warranted in drawing certain inferences from two lines of evidence.

The first is morphological, and in a later biography I shall attempt to show that the relationships of the species of *Spheniscus* are not as have been commonly deduced from the pattern of black and white bands across the throat and breast. Such marks are eye-catching to a taxonomist, just as they are useful recognition marks to the birds themselves. They are particularly important, no doubt, in the life history of closely related species occurring in the same or contiguous regions. But genetically they are but superficial and highly plastic characters, such as have arisen over and over again as mutations in laboratory animals. In more fundamental details the relationships of the four species of *Spheniscus* reflect the order of their distribution on the surface of the earth, with *demersus* of Africa at one end of the series, *mendiculus* of the Galápagos at the other, and *magellani-*

cus and *humboldti*, in their proper geographic sequence, in between. The data for such conclusions are presented in the biography of the Galápagos Penguin.

The second line of evidence is geographic. I have already shown that several species of penguins have in all probability become distributed varying distances to northward and eastward from the American quadrant of the antarctic and sub-antarctic regions. This natural oceanic route—down-wind, down-current—is especially evident in the transportation of the Ringed and Macaroni Penguins, by various natural agencies, toward Bouvet Island and the islands of the southern Indian Ocean.

In the same manner, it seems highly probable, the ancestors of the African *Spheniscus demersus* followed the currents of the west-wind zone from a South American source into the present range of the species. Tristan da Cunha, which lies close to the counterclockwise warm-water circulation of the South Atlantic, was barred to these birds either by chance, by physical characteristics of the seawater, or perhaps because the small islands had already been fully appropriated by the aggressive Rockhopper Penguins. But the cool, rich waters of the Benguela Current, to which the African Penguin is still restricted, offered substantially the same life conditions that the far-wandering penguins had left behind in Fuegia.

The ancestors of the two species of the Humboldt Current region, namely the Peruvian and Galápagos Penguins, likewise spread northward, beyond a doubt, from a point of dispersal near Cape Horn. This does not imply that the pronounced throat pattern of *magellanicus* represents the primitive pattern of plumage. On the contrary, the simpler, more embryonic pattern shared by both African and Peruvian penguins is more likely to be that of the common forbear of the group. And, judging by analogy with animals of the northern hemisphere, a new plumage-pattern, such as that of *magellanicus*, would be at least as likely to arise in a species still dwelling near the center of dispersal as it would in one that had emigrated toward the periphery of the generic range.

During the nesting season *Spheniscus magellanicus* and *Spheniscus humboldti* replace each other geographically along the west coast of South America. Whether their breeding ranges overlap, or even come into contact, is not yet certainly known, but in winter birds of the two forms intermingle throughout at least ten degrees of latitude. The Magellanic species wanders as far north as Coquimbo, latitude 30° S. (Hellmayr, 1932, 422). Cobb's (1933, 64) record of an example at Taltal, in May, is too casual to be acceptable; it probably refers to the Peruvian species. The latter, as noted above, was collected by Beck, off Corral, latitude 40° S.; but Lane (1897, 314) states that *magellanicus* is particularly common at Corral in winter. Therefore, when Beck's notes report large flocks of penguins in the ocean from 2 to 4 miles off Corral during September and October, 1913, it is uncertain to which species he refers.

Paessler (1909, 102; 1914, 273) records the Magellanic Penguins from Valparaiso Bay during mid-October, and great flocks of them as far north as Santa María Island, in the Bay of Arauco, where they breed. Santa María (just south of Concepción) is perhaps close to the northernmost nesting station on the continental coast, but the Juan Fernández Islands, several hundred kilometers to westward and in latitude 32° S., are an even more northerly breeding place. The resident penguin of Juan Fernández has been several times recorded as *Spheniscus humboldti*, but Lönnberg (1921, 16) has identified two young specimens from Mas Atierra as *magellanicus*, and the capture of three others by Beck confirms the point. Johow (1896, 29) states that the penguin is a permanent resident of Juan Fernández. On Santa Clara Islet, off the southwestern tip of Mas Atierra, he found an adult on its eggs, and he saw another in Cumberland Bay, on the northern side of the main island.

Southward throughout the Magellanic waterways, historic references to the widespread abundance of this penguin are too numerous to cite. Doubtless it formerly nested on every suitable island in this complicated region. At various periods it has been reported as everywhere common among the channels and islets of Tierra del Fuego, and at Staten Island (Cunningham, 1868, 489; Philippi, 1879, 161; Oustalet, 1891, 99; Salvadori, 1900, 634; Crawshay, 1907, 153; Paessler, 1909, 102).

Burmeister (1888, 321) writes that from about latitude 41° S. on the Patagonian coast the Jackass Penguins are more or less regular denizens of the islets, peninsulas and mainland beaches. To southward of the Gulf of San Jorge they occur, or formerly did occur, in vast numbers during the breeding season, which commences, according to latitude, in either September or October.

To northward of the Gulf of San Matías I find no records of nesting along the Atlantic coast of South America. Apparently the optimum breeding range coincides with the Patagonian zone of westerlies, in which the rarely interrupted offshore winds produce constant upwelling of cold ocean waters and, in turn, a rich development of the ecologic cycle of marine life upon which the existence of the penguin population depends. Nevertheless, the winter emigration in the Atlantic regularly carries the species farther toward the tropics than is true along the opposite coast of the continent. At first glance this seems anomalous, since littoral waters of low temperature are highly constant and extensive in middle latitudes of the Pacific side. In Peru and northern Chile, however, the field is already occupied by a closely related and competing species (*Spheniscus humboldti*), whereas the Atlantic littoral possesses no rival penguin to northward of the sub-antarctic belt.

Reference has already been made to Mr. Beck's sighting of Jackass Penguins off the Río de la Plata in August (midwinter). During the same season of the year Friedmann (1927, 143) saw examples about his steamer off the coast of Uruguay. Von Ihering (1907, 36) and Dabbene (1920, 8) cite records from various parts of the coast of southern Brazil, between Rio Grande do Sul and the Island of São Sebastião, off São Paulo. At times the birds go even farther, crossing the tropic of Capricorn and reaching the great bend in the continental coast of Cape Frio. Dr. George W. Field, of the United States Biological Survey, tells me that he has on occasion seen penguins taken in nets at Rio de Janeiro, where the fishermen were so unfamiliar with them that they scarcely knew whether to call them birds or "tartarugas" (sea turtles).

Throughout the range, therefore, the Magellanic Penguins obviously make long coastal, and even pelagic, migrations. By such means, no doubt, they originally reached Juan Fernández, their breeding station most distant from the continent. In September Mr. Beck saw a number feeding at the surface, in the midst of a flock of shearwaters, 125 kilometers due north of Staten Island. In January the 'Scotia' naturalists saw others in the offshore Atlantic more than 300 kilometers north of the Falkland Islands. Whether or not birds native to the Falklands and Juan Fernández cross over at times to the mainland is yet unknown. The species is, however, chiefly a spring and summer resident at the Falklands, where the bulk of the birds arrive with extraordinary regularity during the second or third week of September, and depart in the latter part of March or early April (Cobb, 1910, 66; Vallentin, 1924, 293). An occasional bird is seen during the winter season. October to April is the recorded period of residence at nesting stations in Tierra del Fuego (Oustalet, 1891, 99).

According to Burmeister (1888, 321), the season of reproduction begins either in September or October, the later dates applying to higher latitudes. Oustalet (1891, 99) reported the first eggs in the Cape Horn region toward the end of October. At Santa Magdalena Island, in the Strait of Magellan, and at the Guaitecas Islands, Chile, (44°–45° S.), the first eggs appear in early October (Cunningham, 1868, 489; Philippi, 1879, 161). Abbott (1860, 336) states that at the Falklands these penguins commence laying on October 7, "almost to a day," but most recent observers name the middle of the month as the approximate time of this function. The distinction between the date of the first eggs and the average period of egg-deposition must, of course, be kept in mind. Probably the last week of October is the height of the season at the Falklands, and newly laid eggs have been found as late as the middle of November (Vallentin, 1924, 293).

Fauvety (1888, 322), who spent four months upon one of the penguin islands of the Patagonian coast, states that the nuptial season is preceded by bloody combats between male Jackass Penguins for the possession of mates. Conquered birds minus an eye, he says, are frequently seen. Moseley (1879, 156) reports that captives he took during the 'Challenger' expedition "fought hard in the boat and tried to bite one another's eyes out."

This species is singularly independent of the physical conditions in its terrestrial environment. The Rockhopper Penguin, as we have seen, tolerates no surface vegetation more woody than grass, and its breeding range in the Fuegian region stops abruptly at the line between the grass-covered islands of the west and the densely forested islands that begin toward the Pacific. The Jackass, however, has more catholic tastes or tolerations; it is as much at home among thickets and tangled roots as on islands covered only with the green stalks and black mould of tussock grass.

At the New Year season of 1924, Dr. Frank M. Chapman, cruising among the Guaitecas Islets in a small chartered steamer, visited a Jackass Penguin colony in the forest. His description of the surprising experience is as follows:

Our first days in the Guaitecas offered so many possibilities that there was no time to go to the rocky islet on which I had pictured the Penguins living. When, finally, I asked the Captain where the *Pájaros-niños* nested, to my amazement he replied: "Aquí están, Señor" ("They are here, Sir"), and pointed to the island off which we were anchored. But surely this was no place for Penguins! Every foot of the shore line was concealed by overhanging limbs; from shore to summit the ground seemed covered by trees and luxuriant vegetation.

Great as was my desire to meet Penguins at home, I hoped even more strongly that the Captain would not depart from Darwinian standards of truthfulness. Could it be possible that in his desire to please he had ventured an unwarranted prediction? Almost I was inclined not to put him to the test, but, in response to my request to go ashore, without hesitation he ordered a boat lowered, and within a few minutes we were pulling slowly along the fringing limbs.

The performance seemed to me to be a farce. It could not be possible that the Captain and I were applying the same name to different birds for we both used *Pájaro-niño*, the term by which the Penguin is universally known in these waters. Whatever a Penguin may be, in the annals of classification it certainly is not a perching bird, and it seemed equally certain that only a perching bird was fitted for life in the dense growth that we were passing.

Suddenly the Captain said: "Van aquí" ("They go here"), and ordered the boat turned and its bow shoved beneath the overhanging branches. A shelving shore of rocks was now revealed, and, worn in it, a narrow pathway crossed from the water and disappeared in the undergrowth. Beyond question, some form of aquatic life made its home on this island, and without pausing to ask further questions I followed the trail. When it passed from the rocks to earth it widened to from one to two yards and shortly began the ascent of the island at an angle of about 45 degrees. Here the ground was cleared of leaves, and the exposed roots looked as though a rope ladder had been placed there to assist the climber.

About forty feet above the shore, a small path left the main traveled road and disappeared in a hole beneath a fern growing from the side of a bank. "Casa del Pájaro-niño," said the Captain, who seemed to take the whole experience as an every-day event and showed no signs of the excitement that I no doubt exhibited. The house, however, was empty and we resumed our explorations. These led us up the broad highway to the flattened summit of the island, about seventy-five feet above the water. Here the ground was trampled and cleared for several hundred square yards forming a plaza-like opening, and in the neighboring banks and slopes were the entrances to many *casas*. One after the other was examined and my suspense was ended by the discovery of two young Penguins. The island was in truth the home of *el Pájaro-niño*.

I wanted now to be alone. The sailors talking, laughing, prodding the Penguins' homes with sticks, worried me. This was not the way to make friends with these strange little people. So we returned to the *Yates*, and my subsequent visits to the island were made unaccompanied.

The Penguins had chosen a rarely beautiful place for a home. The vegetation suggested the Tropical, rather than the Temperate, Zone. Seated on a log in the "plaza" I was surrounded by ferns and vine-hung, moss-grown trees. The brilliant green foliage and the scarlet blossoms of the *coihue* sparkled in the sunlit, dustless air. Through window-like openings in this wall of luxuriant growth there were vistas of blue water and distant islands. It was a place for Parrots not for Penguins. I had not long to wait before a dumpy little figure clad in gray and white, arms hanging loosely, came waddling up the trail from the shore. He bore no resemblance to a bird, but seemed rather to be some kind of wood sprite. I had no means of assuring him that I was a friend, and at sight of me he turned, scrambled down the path and disappeared. In vain I waited for him to return or for the appearance of one of his fellow townsmen. The nesting season was evidently near its close and there were but few Penguins remaining on the island. I found several additional pairs of downy Penguin twins still in their burrows and two more adults. On a neighboring island Walcott and I secured a motion picture of a bird that posed reluctantly and scampered back into the forest as soon as the sitting was over.

What a remarkable scene this island must have presented earlier in the season when the highways and byways were filled with quaint little figures hurrying to and fro across the plaza, climbing and descending the rope stairway in pursuance of their family cares! (Chapman, 1933, 362).

Nor do grassy slopes and woodland cover represent the entire variety of the Jackass Penguin's nesting sites. Along the arid Patagonian coast Fauvety

(1888, 322) saw many burrows in bare clay or phosphate formations. He found the holes in tiers along the faces of bluffs, sometimes extending as high as 70 meters above the beach. In the same manner I have seen the closely related Peruvian Penguins occupying rows of burrows in soft sedimentary material, beneath bands of hard conglomerate, along the fronts of wave-cut banks.

When the Jackass Penguins nest on sloping ground rather than in the face of the bluffs, writes Fauvety, they usually begin to dig beneath the base of a plant if any is to be found. Cobb's (1933, 65) description of the burrowing process and the consequent unpopularity of these penguins at the Falkland Islands is as follows:

> This is done with their powerful feet working at a tremendous pace, often in peaty ground or where tussac has grown, and, if the weather be wet, the Jackasses get themselves into no end of a mess in the process. Some nests become flooded and quantities of diddle-dee are used for soaking up the wet and making a more sanitary bed to lie on in these subterranean holes. . . .
>
> Acres of good ground are spoiled by these burrowing penguins. . . . On ground badly riddled with holes, horses generally refuse to proceed, which adds another difficulty to sheep-gathering in these parts.

At the Falklands both peat banks and sandhills serve as nesting sites. Unlike the homes of Gentoo Penguins, however, the Jackass Penguins' "warrens" are never at a great distance from the water. After a burrow has been dug, the two adult birds can usually be found inside until the first egg is laid. Thereafter one bird holds the fort alone, at least during daylight hours.

> Round the mouths of their burrows and even on the surface of the banks, between the holes, the birds lay out pebbles which they must carry up from the sea-shore for the purpose. The pebbles are of various colours, and the birds seem to collect them from curiosity, at least there appears to be no other explanation of the fact (Moseley, 1879, 560).

Fauvety refers to the use of pebbles, small sticks, dried leaves, feathers, etc., for the construction of the little mounds within the burrow upon which the two eggs are laid. Throughout incubation these nest mounds are commonly replenished from time to time. Whatever the object of this, it at least serves the good purpose of keeping the eggs above the level of water, which sometimes accumulates in the holes. At West Point Island of the Falklands, on January 31, 1916, Mr. Beck saw a penguin come out of its burrow, walk some fifteen yards from the entrance, and fetch back a large billful of tussock roots which it carried below ground.

> Small tussac roots . . . come in handy for soaking up water in burrows, and in some seasons the Jackasses pull up hundreds of newly set tussac plants from fenced-in tussac paddocks, which does not add to their popularity (Cobb, 1933, 65).

The relation of heavy rainfall to these burrowing penguins is indicated in the accounts of several observers. Fauvety (1888, 322) records an extraordinarily heavy downpour of rain, which endured for several hours on the Patagonian coast, inundated most of the penguin burrows, and drowned at least a quarter of the unfledged young, many of which were subsequently drawn forth and devoured by gulls and caracaras. The remaining drowned chicks were thrown out by their parents, which reoccupied the burrows as rapidly as they drained, although they did not lay eggs again. The last interesting comment confirms the same author's testimony concerning the fixed pattern of the reproductive cycle. He says that if the eggs are removed from a Jackass Penguin burrow while incubation is young, the birds will lay again, and even yet again. This never happens, however, if the chicks have hatched out, or even if incubation is well advanced.

In December, 1915, at the Falklands, Beck found that the large nest piles, composed mainly of diddle-dee twigs, were not as a rule placed at the inner end of the burrow, but rather a foot or more away from it, toward the entrance. The distal end of the excavation was always lower than the nest itself, and not infrequently it contained a puddle, or at least was soaking wet. This would suggest a protective and instinctive nest-placing habit correlated with the danger to eggs or young from precipitation and seepage. At Sparrow Cove, Port William, Beck opened a burrow with two eggs in it, and the sitting bird backed into a bath of water that lay in the cul-de-sac beyond the nest.

The depth of the burrows varies very greatly according to climate, circumstances, and the individual experience of the birds. Brooks (1917, 144) found most of the Falkland nests at Kidney Cove "about right for using a walking stick for removing the eggs." The Newfoundland dog of the 'Challenger,' however, dug out nests that were 8 feet deep (Sclater and Salvin, 1881, 125). Vallentin (1924, 293) notes that wherever the birds have been much molested by human beings the burrows are likely to be very long. At Hooker Point near Stanley, Falkland Islands, he found some 10 feet in depth, so that the inmates could be heard braying directly beneath one's feet at that distance from the nearest entrance. Sclater (1868, 527) quotes Lecomte regarding Falkland burrows 20 feet in length, but this is, to say the least, out of the ordinary, because even in such rainy regions many burrows are so shallow that they scarcely offer sufficient shelter to the inmates. Under the pedestal of a large tussock hummock, for example, a slight depression may be quite sufficient, providing no animate enemy is feared, the matted overhanging grass furnishing ample protection from the elements.

At Mocha Island, where the precipitation during the breeding season is very much less than in the Fuegian region, Mr. Bullock found most of the Jackass Penguin holes to be a little over a meter in length, with the nest-chamber 45 to 50 centimeters beneath the surface of the ground. Here, too, however, many other nesting sites could not by any stretch of the imagination be termed burrows, for they were nothing more than hollows scooped out at the base of a clump of wild mustard.

Wherever possible, the Jackass Penguins seek a nesting site free of stones, and especially of pebbles impacted in a hard soil, such as would make the process of excavation difficult. This was noted long ago by Delano (1817, 262). At some of their nesting stations, however, they must necessarily content themselves with stony foundations for their homes, and under such circumstances they make the most of meeting the conditions. Doello-Jurado (1917, 10) visited the colony on Estorbo Island of the Pingüinos group, off Puerto Deseado, Patagonia, on February 21, 1916, when all of the young penguins were in the fledgling stage. Here he found that many of the nests were nothing more than basins on the surface of the ground, although the majority of pairs had endeavored to construct some sort of burrow. The latter, however, were at best shallow, the distance to the end being not more than 80 centimeters. The average diameter across the mouth was about 25 centimeters.

It is curious how far the uses of the burrow transcend the breeding function in the economy of the Jackass Penguin for, as Fauvety remarks, they have little to fear from birds of prey, and in most places they were practically without terrestrial enemies before the arrival of man. Nevertheless, at night, practically all the penguins of this species retire to the burrows for shelter. This is such a fixed custom of birds remaining ashore that some of them are forced to invade burrows not their own where, after more or less altercation with the inner occupants, they spend the night as unwelcome guests. During the moult, also, the penguins remain much within the burrows.

By day, the Jackass Penguins are fond of standing more or less directly above the mouths of their homes, a habit that reminded Brooks of prairie dogs. Their sight is keen enough to warn them to retreat underground when a man is still some distance away. At the Falklands they are by all odds the shiest of the penguins ashore, though they appear quite fearless of man when in the water (Brooks, 1917, 144).

The two eggs, which are laid several days apart, are white, but they naturally do not long remain so in the damp and muddy nest. Cobb reports that the mated parents take turns of six hours or so in sitting on them. Fauvety (1888, 322) states, however, that during the first eight or ten days of incubation the female alone covers the eggs, and that afterwards the birds alternate. He says also that the eggs hatch within 22 to 24 days, which is probably erroneous since the period is considerably longer in other penguins. Kearton gives 28 days as the incubation period of the closely related South African Penguin (*Spheniscus demersus*).

According to Fauvety, the chicks wear their down for about 40 days before the beginning of the moult.

Newly hatched chicks in the Brewster-Sanford Collection, from Ildefonso Island and the Falklands, are distinguishable from similar stages of *Eudyptes* and *Pygoscelis* by the shortness of the unguis of the bill. These, and somewhat older specimens, also show the sequence of early plumages. The first down is dark argenteous gray above, slightly lighter on the throat; the breast and belly are grayish white. The second down is clove-brown on back and throat, with the belly, chin, and lores white (*i. e.* the white area of the face is the part which is black in the adult). With age, the brown down fades to a paler color, and is moulted to give way to the first juvenal plumage in which the back is very blue. In this stage the crissum, or entire under surface of the tail and the margin of the lower belly are dark, a condition retained apparently until the first moult into the adult plumage.

In the American Museum Collection is a yearling male, taken at Cautín, Chile, on February 28, 1908, which shows the first complete moult of the contour feathers. The bands across the throat and chest are not present in the juvenal plumage, the entire throat and fore neck being grayish. In this stage the chicks of *magellanicus* and *humboldti* are difficult to tell apart.

During the moult of the down, the young Jackass Penguins continue to feed greedily from the throats of their parents, although the adults, of course, fast during their own moulting seasons. Before each feeding of the offspring, according to King (1839, 388), the old birds hold their heads in the air and go through a peculiar haranguing performance. After a few moments of clatter, they lower and open their bills, and receive the heads of the chicks well within their throats. An alternation of loud sounds and silent feeding may then go on for some minutes.

According to information gathered from residents of Mocha Island by Mr. Bullock, the Jackass Penguins frequently assume care of other young than their own. He himself kept in an empty room a mated pair of adults which he intended to take to the zoölogical park at Santiago. When a young bird was added to this group, it was promptly adopted by the couple, which watched over, fondled, and fed it. Presumably these old birds were conditioned for such reactions by the cycle in their own lives that had been interrupted by their capture and confinement.

The youngsters get rid of their down mostly before the older birds begin the annual change of garb. Bands of recently moulted chicks sometimes congregate from scattered nesting grounds during the latter part of January, and spend much time together on some comfortable sandy or pebbly beach, as if in anticipation of the next move.

The moult of "last year's birds," meaning the juvenals, begins at the Falklands before the end of January, according to Beck's notes. That of mature, breeding penguins follows during February and March. The moulters spend part of the time in their burrows, or hide among the tussocks and shrubbery if such cover is available. Beck reports that when moulting birds were surprised by him they would fall on their breasts and skitter on all fours, leaving a trail of feathers behind them. After completion of the moult, the Jackass Penguins take to the ocean, make their travels, and fatten up for the next breeding season. The general emigration of both young and adults takes place some time before the end of April, though at the Falklands a few Jackasses are likely to be found on the beaches at almost any season.

Vast numbers of these penguins have sometimes been observed together in the ocean or in the Fuegian inland waterways. To eastward of the Atlantic entrance to the Strait of Magellan, Nicoll (1908, 161) saw many lying on their sides with one leg out of water, an attitude which others have called especially characteristic of the genus *Spheniscus*. Paessler (1922, 438) saw great flocks in the Strait, companies of them sometimes porpoising, clearing the water by at least half a meter, and travelling so rapidly that they would outdistance a man-of-war steaming at 11 knots. Blaauw (1912, 43), who also saw them jumping in strings or lines (49 in one line) in the Strait of Magellan, believed that the penguins did not apprehend the presence of a steamer until it had come very close, when the birds would suddenly stop at the surface for observation, as quickly dive again, and then, perhaps, pass under the ship's keel to reappear on the other beam. At the surface the Jackass Penguins lie so deep in the water that the black U-stripe of the breast rarely shows (Peale, 1848, 258). When bucking waves, they dive through instead of riding over (Friedmann, 1927, 143).

Fauvety (1888, 332) reports that in Patagonia the coastal waters about the Jackass Penguins colonies, usually support a good growth of kelp (*Macrocystis pyrifera*). This seaweed is favorable to the existence of cuttlefish, organisms which appear to constitute the principal food of the penguins during the season of breeding and the rearing of the young. Throughout this period Fauvety found no other food in the stomachs examined. Six rosy white cuttlefish measuring up to 10 centimeters in length were found in one adult, and others of the same sort in penguin chicks. The cephalopods seem to be enormously abundant in the bays and bights where the penguins feed, for the undigested lenses of their eyes were always among the material regurgitated upon the ground by the penguins.

Other observers, including Doello-Jurado (1917, 10), report that the Jackass Penguins eat also fish, particularly when they are at a distance from their nesting grounds. This agrees with the observations of Beck, who often saw the penguins fishing with other sea birds among the shoals of "sardines" in Magellanic bays. Moreover, fish bones, as well as pebbles and cuttlefish beaks, have been taken from their stomachs at the Falklands (Sclater and Salvin, 1881, 125).

Pebbles of various colors, which Moseley, as previously related, thought the Jackass Penguin gathered from preferential curiosity, as the Adélie Penguin and other species are known to do, are often regurgitated near the burrows, either with or without traces of food. Some such pebbles are too large to have been swallowed, but the majority of them are small. In so far as these stones have strong or unusual colors, they may signify a primitive aesthetic sense, but a notion of the old-time sealers at the Falkland Islands is at least worthy of investigation. This is that the Jackass Penguins regularly eject such pebbles from their stomachs when they come out of the water, and as regularly swallow them again as ballast just before they go back (Sclater and Salvin). Kearton states definitely, as recorded in the biography of *Spheniscus humboldti*, that the South African Jackass Penguins swallow stones before they take to the ocean after completion of their annual moult.

Little is known about the normal enemies of the Jackass Penguins. It is certain, however, that disease finishes off large numbers of them—regularly during the winter migrations, and perhaps to a greater than ordinary extent at rhythmical intervals of years. No special study seems to have been made of the causes and the cycle of the malady, but it is doubtless similar to the destructive pests so familiar among sea fowl along the Pacific coast of South America. At Mar del Plata, Argentina, on October 27, 1914, Mr. Beck saw many dead penguins along the beach, counting 17 within 50 meters. Wetmore (1926, 42) found more than a hundred dried bodies on the beach at La Paloma, Uruguay, on January 23, 1921. Fishermen told him that many penguins came ashore every winter, and that the mortality was always heavy. The same phenomenon is regularly reported along the eastern coast of the Province of Buenos Aires.

Formerly, many Jackass Penguins were killed for their oil, which was used in tanning. During the last quarter of the nineteenth century, moreover, the penguin skins found a market in Buenos Aires and Montevideo, where the white-feathered parts were used in trimming women's clothes (Fauvety, 1888, 322).

PERUVIAN PENGUIN

Spheniscus humboldti

Spheniscus humboldti Meyen, 1834, Nov. Act. Acad. Caes. Leop.-Carol. Nat. Cur., 16, Suppl., p. 110, pl. 21 (Callao, Peru).

Names: Humboldt Penguin. "Pájaro Niño" is the vernacular name in Peru and Chile; "Petranca" is the name used by the Araucanian Indians. Synonyms of the specific name are *chiloensis*, *meyeni*, and *flavipes* The name *magellanicus* has often been applied, and the literature discloses considerable confusion between this and the preceding species.

Characters: About the size of *Spheniscus magellanicus*, males in the flesh measuring from 67–72 cm. in total length, but with larger bill and feet and slightly shorter flippers. The outstanding difference in plumage-pattern is due to the fact that *humboldti* lacks the anterior broad blackish band across the fore neck, in this respect resembling *Spheniscus demersus* of South Africa. *Spheniscus humboldti* differs from *magellanicus* in the following additional particulars: parts of face adjacent to bill (except forehead and mentum) practically naked of feathers during the breeding period; chin white (usually); white superciliary stripe narrower than in *magellanicus*, and passing well above the eye instead of reaching to it; U-shaped band wider in the pectoral region. Iris, reddish brown (but varying as described in the text); naked part of face, parti-colored, being pinkish on the anterior part where it is in contact with maxilla and mandible, and also around the eyelid; behind the pinkish or flesh-colored area it is black in an irregular stripe which adjoins the white superciliary feathering, loops behind the pinkish eyelid, and extends thence downward as a broad black band, across the gape and the unfeathered base of the mandible, to the chin feathering; all of this bare facial region is papillate, especially at the base of the mandible, and has a thin growth of short filoplumes; bill, heavier as well as longer than in *magellanicus*, and more strongly rugose at the base of both mandibles, black, with a few lighter, horny spots; feet, blackish brown, the webs often blotched with white.

Four adult Peruvian Penguins of unknown sex which I weighed at the Chincha Islands on October 14, 1919, tipped the scales at 17 kilograms, an average of 4250 grams, or about 9 pounds, 6 ounces. Coker (1919, 456), however, records a male weighing 11 pounds, 2 ounces (4946 grams) which is heavier than the largest adult of *Spheniscus magellanicus* weighed by Brooks (1917, 145). Coker's largest specimen had a length in the flesh of 72 cm. and a girth of 48 cm.

Other dimensions of specimens from the coasts of Peru and Chile are as follows:

5 males: wing, 163–182 (173.5); tail, 20–33 (26.4); culmen, 61–68 (65); bill from gape, 67–77 (73); nostril to tip of bill, 31–34 (33); foot, 113–125 (117.6); middle toe and claw, 71–82 (76.2) mm.

4 females: wing, 158–172 (164.5); tail, 24–31 (29); culmen, 58–62 (60.2); bill from gape, 67.5–73 (69.6); nostril to tip of bill, 29–32 (30); foot, 107–116 (111); middle toe and claw, 72–72.6 (72 3) mm.

The eggs of this species are indistinguishable from those of *magellanicus*. One from Algarrobo, Chile, measured 74.3 x 56.7 mm. (Philippi, 1873, 126). A set of two from an unnamed Peruvian locality measure 69 x 51 and 69 x 52 mm.

Distribution: Breeds from islets off Algarrobo (33° 20′ S.), 45 kilometers south of Valparaiso, Chile, northward along the Pacific coast of South America to Lobos de Tierra Island, Peru (6° 30′ S.); ranges southward in migration to the vicinity of Corral, Chile.

A memory of no scientific significance, but of extraordinary vividness, relates to a day in December, 1924, when I pointed out to my three children, aged six, nine, and ten, their first wild penguin. The scene was neither frozen, nor tempestuous, nor remote from the haunts of man. We had come to Chorillos, an ocean suburb of Lima, on the afternoon of a Peruvian summer holiday. The colorful coast that stretched toward the Punta at Callao in a curve of singular beauty was drenched in tropical sunshine, and bathers were bobbing in the swells that broke close to the water line, or were sunning on the Herradura strand. Above the murmur of the waves I presently heard a familiar but half-forgotten bray, and a moment later a "Pájaro Niño" was seen coming ashore, with chin high and stubby tail stuck up like a wren's.

At the water's edge it bore down on its flippers, stood upright on the sand, shivered violently, and shook its tail. Then it trotted briskly away from the waves, spun its head in what might easily have been taken for two or three complete revolutions on the neck, and sank back on its heels. The head was drawn down to the shoulders and the throat pushed forward; the profile was more or less like that of a cat on its haunches. Very babyish it seemed to the children, even though it went back into its great bath before we could come within a stone's throw of it. Little did my daughter and sons suspect the change that would have come over the ingratiating creature if we had succeeded in cornering it among the rocks behind the beach. But I had seen a Peruvian Penguin before under such circumstances—raucous barks coming from its spiny, snapping mouth; the tumid, black-rimmed skin about the beak livid with rage; flippers swinging, feet dancing, the whole bird gone berserk.

Many are the causes from which birds have diminished before the advance of European man, but none more strange than that affecting the Peruvian Penguin. For it appears that the very breeding grounds of this species have been dug up and borne away in the holds of ships! The sites remaining are for the most part restricted, stony, or otherwise unfavorable, in a region where islands once had their crusts as full of penguins as a Cheddar is of skippers. I refer, of course, to the guano layers that formerly covered the islands of the Peruvian and northerly Chilean coasts with a heap of soft and dense substance in which the penguins could readily excavate their homes.

Raimondi (1856, 735) describes conditions shortly after the middle of the nineteenth century, when the Pájaro Niño still abounded on the south island of the Chincha group, even though the exploitation on the north island, with its gangs and crews pouring the remnant of the guano beds into the chutes, had already driven the birds from that neighboring stronghold. Scores of other happy isles of the Peruvian coast were at the time practically untouched, however, and the penguins still throve with only a scant foretaste of their doom. This coast had been their home for countless ages, perhaps since first the young Andes and Humboldt Current had stamped it with the geographic character it still bears. Among the ancient eggs from guano beds described by Raimondi are those of penguins—buried under many meters of the embalming deposit, and dating back thousands or even tens of thousands of years.

Today all the hundred and more Peruvian islets present only rocky slopes and plateaus, which are periodically allowed to become merely ankle-deep in new guano before they are again swept clean. The breeding penguins must resort, therefore, to precarious nesting sites at places where the few and narrow strands run up to the base of cliffs, to the fastnesses of caves where they need no burrows for their eggs, or to the three or four large and high Peruvian islands, such as San Lorenzo and Isla Vieja, where there is more or less true soil, or where cut-banks with strata of sedimentary material offer a convenient place for digging. Practically the whole of the mainland coast is, of course, barred to them because of the presence of wild dogs and other predatory mammals. No doubt the penguins have always nested to a certain extent in caves, but in former times all the caverns of the insular and continental shores together would not have summed up space enough for their numbers.

Contributing causes to the vast diminution of the penguins are found in the activities of the native coastal fishermen, who eat the eggs whenever they can get them, and also carry off the young penguins to their villages, or to peddle in Peruvian cities. Several times I have seen pet adult birds being carried through the streets of Lima. Coker (1919, 457) says, moreover, that penguin oil is esteemed by the fishermen and guano workers, who also make "fur" caps of the skins. "When the natives capture them," he writes, "they do so by striking them on the back of the head with a club or with a stone thrown at them, for their bills are too strong and vicious in defense to make a close approach entirely safe. Once it is slightly stunned, a penguin may be safely taken up by the back of the neck. Even after an extremely severe blow they soon recover and appear to be in good health."

During the Brewster-Sanford Expedition Mr. Beck first encountered this penguin at Ancón, Peru, a little north of Callao, in early May, 1913. At the neighboring Pescadores Islands, he found a pair of adults, in breeding condition, in one burrow. Thereafter he noted the birds at various dates southward along the coast. At Antofagasta, Chile, he saw flocks of them fishing on August 27, and at Corral he met with many others, and collected adults as well as birds in immature plumage during early October.

On my own first and second expeditions in Peru, I observed the species at many localities along practically the entire coast of the Republic, from Mollendo northward to Lobos de Tierra. I saw no living penguin at the latter island, but in January, 1920, the skin of a freshly killed example lay on the beach near one of the fishing shacks. Furthermore, the manager of the guano operations informed me that large numbers of penguins formerly burrowed in the guano of small islets off Lobos de Tierra. Coker (1919, 455) noted the species as far north as the neighboring island of Lobos de Afuera (7° S.).

Later, Mr. Francis L. Jaques, of the American Museum, made a visit to a number of the guano islands with the object of painting the illustrations that adorn this book. His journal reports numerous observations of penguins between Independencia Bay and Salaverry. Most notable among his data is a record of about two hundred penguins in one flock on the shore of Vieja Island, in February, 1926. The largest group seen by Coker during a long stay in Peru (1906–1908) was one of sixty in the same locality. Perhaps the penguins are gaining in numbers under the partial protection now afforded by the Peruvian Guano Administration.

The specimens of this penguin in the American Museum Collection comprise twelve or more, including my own from the Chincha and Pescadores Islands, Beck's from Ancón, Peru, and Corral, Chile, and others taken by Mr. Thomas Hallinan and Mr. Carlos Reed north of Coquimbo and elsewhere along the Chilean coast. I have examined also many additional specimens in American museums and abroad.

Hellmayr (1932, 423) writes: "Humboldt's Penguin is evidently but a northern race of *S. magellanicus*. Still I refrain from using trinomials, as both may eventually turn out to be conspecific with the African *S. demersus*."

With this opinion I find it necessary to differ. Three of the four members of the genus *Spheniscus* do, indeed, comprise a very closely related group of birds, as we may conclude from their structure, plumage-pattern, "song"-pattern, and unique breeding habits. Nevertheless, it seems to me better for a variety of reasons to regard such representatives of an ancient family as species rather than races.

In the first place, the breeding ranges of *magellanicus* and *humboldti* appear to meet, possibly to overlap, and yet no intermediates or hybrids have been discovered. This alone would indicate that by the usual biological criteria the two are distinct species.

Secondly, the ranges of the African and Magellanic Penguins are widely separated in space, as they doubtless are in elapsed time since the date of their respective establishment, yet the two forms differ no more from each other than the Magellanic does from the Peruvian penguin. Furthermore, as I shall show in the next biography, *humboldti* reveals a hitherto unsuspected degree of kinship with the Galápagos Penguin, and the latter can on no account be regarded as conspecific with *magellanicus* or *demersus*.

Finally, it appears probable that the forms *magellanicus* and *humboldti* exhibit one difference very obvious in life but hard to detect in museum specimens. The degree of this difference would be determinable only through examination of a series of both species collected during the period of courtship or incubation. I refer to the extent of bareness and tumescence on the face. In youthful plumage all forms of *Spheniscus* have fully feathered faces. With the approach of reproductive activity, however, the condition changes more or less in each species. The African Penguin, so far as I can judge, undergoes the least alteration, the faintly pinkish skin of the loral space merely beginning to show through its covering of short and well-separated feathers. The breeding condition in *magellanicus* seems not to have been described but, as indicated by a few birds taken on eggs, the feathers are moulted from the loral space, and to a lesser extent from the base of the lower mandible, while the skin becomes tumid and highly colored. In both sexes of *humboldti* the naked and swollen area is more extensive, forming a pink and black facial mask which encompasses the eye and carries a broad stripe across the jaw behind the sheath of the mandible.

I infer that the corresponding condition in *mendiculus* generally resembles that in *humboldti*, and that the whole change in all the species is entirely a nuptial mark. Together with other seasonal phenomena, it remains to be elucidated. It seems likely that the hue of even the iris changes periodically, as it is known to among certain other penguins. Thus the Peruvian species usually has a reddish brown eye, but on November 16, 1919, at Santa Rosa Island, I examined two living adults in very worn, faded, and puffy plumage, which looked as though the moult was about to begin, and discovered that both of these had milky white eyes. The iris of one was filled with fine red reticulations, giving it a pinkish cast. In both these birds the irregularly polygonal pupil, characteristic of all penguins, showed up much more clearly, of course, than in brown-eyed birds.

It is a mistake to believe that the Peruvian and Magellanic Penguins can be distinguished in all full-grown stages by measurements alone. Not only does an average sexual discrepancy in size, applicable to both forms, complicate matters but, contrary to prevalent opinion, *humboldti* is not a smaller bird than *magellanicus*. The wing of the former may average slightly shorter, but its bill and feet are larger; its length and weight are about equal to those of its southern relative. Marcus (1933, 87, 91) errs in his diagram in which he depicts *humboldti* as of inferior size to *magellanicus*, and then uses the two as illustrations of Bergmann's zoögeographic law of increased bulk correlated with higher latitude. But far more erroneous is this author's use of the *Pygoscelis* penguins with the same object for, as I have demonstrated above, *Pygoscelis papua* is not the smallest, but by far the largest, member of its genus.

Much of the literature shows uncertainty and confusion regarding the identity of the Peruvian and Magellanic Penguins in various parts of their combined ranges. In the main these two replace each other geographically, during the breeding periods, along the west coast of South America. The problem is confused, however, by the fact that *magellanicus* has a fixed or climatic type of breeding season during the austral spring, whereas *humboldti*, like so many other sea birds of tropical regions, appears to carry on its reproductive activities throughout most of the year. Therefore some members of the population are likely to be engaged in oceanic wanderings while others are at their nests. During the migrations, especially in the southern-hemisphere winter season, the Magellanic and Peruvian forms mingle freely throughout at least the ten degrees of latitude separating Corral from Coquimbo.

Coker writes (1919, 455):

> At Guañape [two islands in 8° 36′ S.] very young penguins were seen on the rocky shore in March, 1907, or late summer of the southern hemisphere. At the Ballestas Islands . . . in May, 1907, . . . most of the nests contained eggs, some of which were just hatching; a month later a number of grown but immature birds were seen at the Bay of Independencia. These observations would suggest that the breeding season extends over the greater part of the year, since we find young penguins in late summer and eggs and immature young in early and midwinter.

Other dates and localities connected with records of eggs and young penguins in Peru are as follows:

Jaques's notes report many three-quarter-grown birds at Santa Rosa Island

Independencia Bay, in February. During November, at the same locality, I saw numerous chicks out sunning themselves. At the approach of a man they would scamper to cover. In the same month my Indian boatmen brought me a set of penguin eggs from a cave under the cliffs of Santa Rosa. On December 4, I found a half-grown chick in a cleft among boulders on Gallinazo Islet, of the Pescadores group, off Ancón.

Paessler (1922, 438) states that *Spheniscus humboldti* nests in grottoes along the Chilean coast, from six to ten pairs often occupying one such retreat. He also says that fresh eggs, incubated eggs, and young birds in various stages can be found on the same date. This agrees with the preceding information as regards the flexibility of the breeding season of *Spheniscus humboldti*, and emphasizes a physiological trait in which it apparently differs sharply from *magellanicus*.

The development of a year-long breeding season seems to have been achieved by both Peruvian and African penguins, in other words by the two members of the genus *Spheniscus* which have invaded warm-temperate and tropical environments. Moreover, evidence is presented below to indicate that the birds of one or both of these species are capable of rearing two broods of young within a single year.

Now such departure from the ordinary reproductive régime of penguins is akin to many well-known physiological changes having a genetic basis, such as broodiness and enhanced egg-laying in poultry. Among the penguins, as among species under controlled observation, there is every reason to regard such an unusual trait as a result of mutation. The reproductive cycle of wild birds in general is closely correlated with the seasonal succession, but in the reproductive differences between *Spheniscus magellanicus*, and *Spheniscus humboldti* we see characters of a physiological order which are not only unlike in two close relatives but which show as well a gradient of different heritable traits paralleling the gradient of the respective climatic environments.

The biological function of reproduction is not merely to provide another generation of organisms but also to produce individuals that have combinations of characters different from those of their parents—combinations that may better enable the new generation to survive in the particular environment for which it is destined. It is clear that to a strictly antarctic species of penguin the outcrop of a mutation determining a change in the annual date-range of the breeding season, or bringing about a multiple breeding season within a year, would be, in effect, lethal to the new strain. The same would doubtless be true for most species living under the climatic conditions that prevail in the Fuegian region. In short, a prolonged or doubled breeding season would be of no value to *Spheniscus magellanicus* in its present range. But within the ranges occupied by either *Spheniscus humboldti* or *Spheniscus demersus*, on the other hand, such a type of breeding season would confer upon a penguin an enormous advantage. For example, it would enable *Spheniscus humboldti* to compete effectively with *Spheniscus magellanicus* in milder parts of the west coast of South America, to outbreed its rival, and thus to tend to bar *magellanicus* from the whole temperate and tropical stretch of the Humboldt Current. In the early stages of such competition, the development of strong recognition marks in the two forms would be a familiar evolutionary corollary.

It is not likely, of course, that the present ranges of the two South American species can be fully explained by such a simple type of control; many other factors may also be at work. For instance, it is noteworthy that examples of the South African Penguin (*Spheniscus demersus*) in the New York Aquarium are reluctant to go into their pool when the water temperature falls below 55° F. (12.8° C.). When it drops to 50° F. (10° C.), they avoid the water practically altogether. Now thermal responses of this sort are known from very wide laboratory experience also to have a genetic basis. As to the reactions to temperature of the two South American species of *Spheniscus* we can as yet only speculate, but it is worth noting that throughout the breeding range of *magellanicus* the average temperature of the ocean water is decidedly below 12.8° C., while throughout the range of *humboldti* it is well above that figure.

Such peculiarities of *Spheniscus humboldti* as an accelerated reproductive capacity, free from the restraints of the calendar, and a probable selective preference as regards water temperature, may be justly understood as genetic preadaptations. They did not necessarily originate in the surroundings now occupied by the species; they were not caused by any action of the environment. Although we may speak of them in retrospect as "adaptive" characters, they doubtless appeared as chance mutations, without reference to their subsequent survival value. They have permitted the species, however, to move up from the south and to occupy a new environment into which it fits on the basis of its preadaptations. We distinguish the species from its nearest relative because of a difference in a striking external mark, such as the presence or absence of a dark band on the throat; but in reality it is the physiological mutations, rather than the visible mutations, that fix the gulf between the two (Goldschmidt, 1933, 539).

The member of the genus *Spheniscus* about which most has been learned through direct observation in the field is neither of the two South American species, nor yet that of the Galápagos, but rather the form peculiar to the coasts of South Africa (*Spheniscus demersus*). Kearton, for example, dwelt among the African Penguins for several months, on an island off the southerly part of the west coast. In a book devoted to the birds (1930) he sheds light upon their behavior which, no doubt, pertains equally to one or more of the American species. This applies especially to such matters as courtship, choice of nesting site, excavation of the burrow, the shares of the sexes in incubation, the relief reactions of mates, the feeding of the young, moult, the purpose of swallowing pebbles, etc. Not all of Kearton's observations are critical, or even quite clear. Nevertheless they are for the most part crammed with valuable information, and the following summary is offered for its bearing upon the life histories of the far less adequately studied New World relatives.

The discordant braying of the penguins continues all night long. An earthquake one evening, however, led to an instant cessation of their calls, and for nearly ten minutes every bird on the island remained silent. During sand storms they are also inclined to keep quiet as they huddle into uncomfortable looking groups, back to the wind.

Rainfall appears to amuse the penguins. Even the incubating birds will clamber forth from their burrows, to stand in the open and shake their flippers in obvious enjoyment of the shower.

The mating season comes twice a year, in February and again in September. One female, marked with a ring, laid her eggs in the same burrow twice each year for three successive years. [Kearton's observations on this matter are supported by the testimony of Levick (1914, 47), who states that in the London Zoölogical Garden the African black-footed penguins breed several times a year.]

The earthy ground of the island is first used for burrows, but late-comers tunnel as well as they can into stony places, or merely lay their eggs under ledges of rock. Although the penguins are quick to suffer from the direct rays of the sun while they are ashore, some of the pairs dig only very shallow and inadequate burrows in the flat and hot terrain.

In excavating, the penguins lie flat and scrape with all four of their limbs until they have accumulated a little loose soil. Then they move forward and kick out the pile with the feet alone. Sometimes the dirt can be seen flying to a height of a yard from the mouth of a burrow. As a rule mated birds alternate in the digging for a few hours during the morning, after which they take to the sea to wash themselves and to fish.

Practically all of the birds make the most of whatever little vegetation can be found, to use as nest lining. Rootlets, twigs from shrubs, wisps of grass, and clumps of seaweed are all employed. Sometimes a penguin will labor for hours twisting and wrenching a small branch from a bush. The desire to collect stones is also apparent, and certain birds show a penchant for carrying home great numbers of them for half a mile or more. They are chiefly pebbles as big as a hen's egg—too large to be swallowed. The mere act of lugging sticks and stones about evidently gives satisfaction, for many penguins carry such objects to the water's edge and drop them before wading in.

During courtship, a posturing performance by the male is reciprocated by the female, both birds finally rubbing their beaks together with a clicking noise. [Levick (1914, 47) states, however, that the African penguins never assume the "ecstatic" attitude which is so characteristic of penguins of the genus *Pygoscelis* and also of the king penguin. Kearton's excellent and abundant photographs would seem to verify this.]

Thievery is universal among the African jackass penguins and nest material is promptly pilfered whenever the rightful owners of a burrow make the mistake of being absent together. Combat over the possession of burrows is also common between two or more pairs, the fighting sometimes going on until all the participants are blood-smeared.

The sitting period for each parent averages about twelve hours. The ceremony of exchange or relief comprises a peculiar shivering performance, intermingled with demonstrations of affection, all of which take place in the open, at the rim of the burrow.

Two or three days after the first egg is laid, a second appears. In rare instances there is a third. Incubation requires four weeks. Gulls and ibises succeed in devouring at least 40 per cent of the eggs before they hatch.

Very young chicks sometimes go through a scratching and digging reaction which is exactly like the burrowing behavior of adults. During their early life the chicks are fed very frequently—as often as three times an hour.

Moult of the down begins at an age of from four to five weeks, but for some time after its completion the chicks remain dependent. They are probably fully three months old before they break entirely loose from parental ties. They appear to be coaxed or even driven into the water by the adults, and the behavior of the latter during the early swimming stages strongly resembles "instruction."

The majority of the adult penguins begin their moult in December. Moulting at other seasons is sporadic, and is disastrous to the dependent young of such irregular individuals. The period of moulting and fasting normally occupies about six weeks, during which life becomes a process of slow wasting. Moulters stand stock still so long in one spot that rings of feathers form around them. Their skins acquire a loose and baggy appearance as the birds lose weight. So many feathers accumulate on the ground of the colony that during strong winds it looks as though snow-storms were raging to leeward.

The small proportion of the penguin population that moults "out of season" represents in the aggregate thousands of birds. When this misfortune happens to an adult that has not finished rearing its chicks, the latter can hardly escape destruction. Even though only one parent becomes thus incapacitated, the handicap to the offspring is nearly always fatal. [The fact makes it easy to comprehend how rigidly natural selection would tend to limit the date of the moulting season among species of penguins living in a subpolar climatic environment.]

After completion of the moult, the penguins swallow many pebbles along the shore before they once more enter the ocean.

African penguins that have lost their mates through death usually remain at least six days within the ordinary meeting area around the burrow before their home-guarding reactions are overcome by the desire to go down to the sea to feed.

In their progress to and from the ocean, the penguins follow definite, well worn paths which, in muddy places, become covered with transverse ridges and furrows from their footsteps. It is next to impossible to force the birds to turn aside from their accustomed route. The pathways may be said, indeed, to have a traditional or hereditary significance, for they do not trace by any means the easiest course over the present terrain. On the contrary, they often lead through the most awkward and difficult places, with better routes on either side. Boulders blocking the appointed paths are marked with grooves made by the beaks and claws of penguins that have scrambled over them for centuries.

Kearton pegged a cord across one of the rock pathways of the penguins but, instead of detouring, the birds attacked it in force and tugged until they had loosened the pegs. When Kearton himself sat down in a narrow part of the avenue, a column of birds several hundred strong halted when the vanguard was a few yards away. Those in the rear, without knowledge of the source of delay, likewise halted. Then, with neither crowding nor confusion, a waiting game began. After half an hour Kearton arose, retreated ten yards, and sat down again. The army of penguins immediately occupied the evacuated territory and then settled down as patiently as before.

When two birds meet at a place too narrow for passing, such as on the top of a small boulder in the path, they chin-wag for a short time, and then one pushes the other off and calmly strides ahead. They also seem to enjoy climbing on to exposed rocks in the water, and shoving one another off, or still more to bustle out of the way cormorants, oystercatchers, or other birds.

When the penguins take to the water from a beach, they may remain beneath the surface for a distance of 200 yards. They are not graceful divers, and they usually leap in feet first if they enter from a ledge above the water. An oily secretion exudes from their ears, soaking the adjacent feathers and perhaps making a protective dressing for the whole plumage. Before submerging, each bird fills "a little bag in the side of his throat with water." [This is worth investigating.] The penguins can often be seen at night sleeping on the surface of the water. After bathing and feeding in the daytime, they sometimes sleep through the warmer hours on the sand close to the edge of the sea. When coming ashore through surf, on rugged parts of the coast, they grasp the rocks with their beaks as the swell casts them high, and cling to their vantage until the next wave floods in.

Their food consists mostly of a small, sardine-like fish.

Freakish penguins in the colony are friendless, shunned, or generally abused creatures. Kearton noted and photographed three aberrant individuals, one of which had an entirely black head, the second a white head, while the third was a complete albino. All three were nestlings. When any one of them, but particularly the albino, wandered away from the mouth of its respective burrow, it was treated more or less like a leper by all the strange adults it came near. The complete albino had a normal nest-mate, and their one parent (the other adult had died or disappeared) showed no discrimination. Among the rest of the penguin population, however, the albino suffered correspondingly more than either of the two chicks with only a partially abnormal pattern. The more the albino wandered from its home site after it had grown up, the more it seemed to become the butt of scornful, one might almost say derisive, penguins, and it was snapped at by every other with which it came into close contact. The brood of two chicks which included the complete albino was one of those that starved to death because of the too early onset of the moult in the single surviving parent. Receiving no further food, both youngsters rapidly declined. Kearton once saw the wasted albino chasing a butterfly Later he observed it dying on the shore, where it was abused by every passing penguin in its last extremity.

No sea bird, apparently, surpasses the Peruvian Penguin in exclusive attachment to the Humboldt Current region. It is a perfect example of endemism and of ecologic fitness. Its range is substantially the length of coast line along which the Current is in contact with the continent. It is confined to a narrow belt of coastal water that is kept all but unvaryingly cool by the phenomenon of upwelling. It is protected by its peculiar environment from most of the marked physical and biotic changes in ocean water due to season and latitude, for uniformity, spatial as well as temporal, is the outstanding characteristic of the Humboldt Current. Doubtless the primitive northern limit of the penguin's occurrence on the coast, in the days of its abundance, was in the neighborhood of Point Aguja and Sechura Bay, where the Current begins to turn away from the continent. It would not be surprising, however, to find the penguins migrating at certain seasons northward to the latitude of the Gulf of Guayaquil or beyond.

Concerning the southern limit of the breeding range we know less. Paessler (1922, 438), an ornithological sea captain, was perhaps in error regarding the identity of a penguin egg brought to him from Santa María Island, off Coronel, Chile, for we now know that the Magellanic species is the nesting bird of that island. In all his personal observations, however, Paessler distinguished carefully between the Peruvian and Magellanic forms. At Coronel, he found that both species would often gather about his ship during the season between May and September, the Peruvian Penguin being far more abundant than the other. Sometimes the birds would scour the hull of his vessel, which was foul, in a hunt for small fish hiding among the weed and barnacles. Swift as an arrow, the penguins would dart about under water, making lightning turns by braking with one wing while beating with the other. Every now and then a penguin could be seen snatching and devouring a fish. The birds remained beneath the surface for from 50 to 70 seconds at a time, and when they came up for air it was only a moment before they were beginning their submarine hunt again.

During July, 1914, Paessler saw many flocks of the Peruvian Penguins, numbering fifty or sixty birds in each, in the harbor of Antofagasta. This is at the tropic of Capricorn, and here there were no Magellanic Penguins among the northern birds. Fishermen brought Captain Paessler more than a score of living penguins, taken in their nets, among which he found a large proportion of fledglings or other immature birds.

One of the early accounts of the nesting of this penguin in Chile is that of Landbeck, as quoted by Philippi (1873, 126). The observations were made in April, 1860, on an islet off Algarrobo, which is about 45 kilometers south of Valparaiso. According to Hellmayr (1932, 423), this is the southernmost known breeding site for *Spheniscus humboldti*, but some of Paessler's records seem to refer to points still farther southward.

Landbeck states that one slope of the islet off Algarrobo was honeycombed with penguin habitations, recalling a Bank Swallow colony on a large scale. All the resident penguins returned from sea toward evening of each day, and spent the night in their diggings, which swarmed with fleas. Upon entering the water again, the first care of the birds was always to clean themselves of mud and stains.

At the Chincha Islands, in Pisco Bay, Peru, I found during October and November, 1919, several burrows, each containing a pair of adult penguins or one bird covering eggs. All such holes had been dug with difficulty in the sand, pebbles, and fine talus at the junction of a narrow strand and the base of a granitic cliff. Every site of the sort, I judge, was subject to occasional flooding by the sea. The burrows were shallow—not more than an arm's reach to the nest proper—and they all sloped so steeply downward that in most cases one could see the eggs without stooping over the entrance. The possible sites for burrowed penguin nests of any sort were so few, in the absence of deep guano beds, that it was easy to understand why the bulk of the small remaining population had clung more to the natural caverns under the precipices.

At the Chinchas, too, I had one brief glimpse of what was apparently part of this penguin's courtship performance, which has never been described. On October 14, 1919, two of the birds were so busy bowing to each other, and exchanging mutual glances now with the right eye, now with the left, that they paid almost no attention until my boat touched the rock upon which they were standing. Ordinarily they proved far more shy.

On October 27, I visited some of the penguin caves of the north Chincha Island. Indian boatmen rowed me into heaving waters between the sheer cliff and an outlying fringe of fallen blocks, and whenever we came abreast of a cave mouth we could see the white fronts of penguins as blurred gleams in the darkness. In one cave about fifteen such spots were visible. We backed in, but I saw no trace of nests. A few days later, however, the Indians brought me both eggs and well-grown chicks from a similar cavern.

Coker's visit to the breeding grounds of the penguins at the north island of the neighboring Ballestas group was made in May, 1907, or at exactly the opposite calendar season from mine. He writes:

> Rowing around this island we could see a number of penguins in couples or small groups in numerous hollows and small caves or "cuevacitas." Far back in one of the large caves a considerable number of these birds were conspicuous, even in the obscurity of that deep vault, for their glossy white breasts and lateral stripes. The stripes of the sides and backs were generally better marks than the breasts, since the latter, though naturally white, were often quite dark with the mud and manure of the nests. Directing our boat into one of these caverns we rowed up well under one of the great arches forming the double entrance, but were obliged to put back as the boatmen were afraid of being unable to handle their craft in the swell and among the rocks. Another cavern proved more feasible of approach; after being rowed back to where the water was quite shallow near the beach at the inner end, I could step into the water and wade ashore. Some of the penguins ran hurriedly into the water along the sides, while about a dozen retreated to the very back of the cave. As soon as the eye became accustomed to the darkness, fully a dozen nests could be seen, each with two large eggs. The nests were simply hollows in the larger rocks and covered with bones, evidently those of penguins (Coker, 1919, 456).

At Vieja Island, Independencia Bay, during the middle of November, 1919, I found the Peruvian Penguins nesting in burrows, but of a very different type from those in either the narrow strands or the guano beds of the Chinchas. A high and steep bank behind a shingle beach along the western shore of Independencia Bay was riddled with two horizontal and parallel rows of burrows. The first-floor apartments, so to speak, were underneath a well-marked stratum, half a meter or less in thickness, and about seven meters above the present mean level of the bay. This stratum was a former sea bottom, made up of a well-cemented consolidation of small scallop and univalve shells. Thirteen meters higher up the bank was a second, similar layer of dark shells forming, in the same manner as the one below, the roof or ceiling of another tier of penguin burrows. In front of each row of black holes a worn, level promenade, like a porch, had been formed along the face of the silty bank. A very few additional burrows were scattered irregularly over this bank, but the great majority was arranged as indicated just beneath the strata of firm conglomerate.

It would be interesting to know what had determined the penguins' choice of location. Had they learned by experience that their roofs were likely to collapse in most parts of the unstable bank, or had the traces of natural, weathered terraces below the hard layers merely made it easier for them to begin digging there?

Eggs and young in practically every stage of development were to be found at this date among the penguin settlements of Vieja Island. Inca Terns (*Larosterna inca*) were at the same time nesting in such close proximity as to form almost a single community with the penguins. In some instances, indeed, the nests of these two species had a common entrance; evidently some of the terns had excavated their homes in the very walls of the penguin burrows.

Many of the highest and steepest banks along the shore were covered to their tops with the footprints of penguins. Here was evidence of laborious climbing, and for what purpose it would be hard to say, for the tracks led up many times as far as the highest nest. A few of them, in fact, topped a ridge at least 150 meters above the bay. At the Pescadores Islands, on a later occasion, I saw a lone penguin standing close to the brink of a tall cliff, among a cluster of boobies. If the penguin had worked as hard as I to reach the spot, I fail to understand the stimulus behind its efforts.

The downy young and the fledglings of the Peruvian Penguin, so far as I can tell from rather limited material, resemble very closely those of the Magellanic. In juvenal birds the chin, throat, and cheeks are gray, with an intermingling of white feathers; the U-shaped pectoral and lateral band is wanting; the feet are mottled and prevailingly light colored. The irides of such as I examined in life were clear dark gray rather than brown. I know of no certain means of distinguishing between first-year examples of *humboldti* and *magellanicus*, although the former have the longer and heavier bills. An adequate series of the young of each species would doubtless reveal diagnostic characters that could always be relied upon.

During November, 1919, at the Chinchas, the Indian guano laborers domesticated a number of penguin chicks, including at least one in the down and a number that had completed their moult. Two captives in the latter stage, both rather heavily speckled with black feathers on the breast, were swimming on long tethers off the dock of the central Chincha Island one day, when a free adult penguin came to the surface and remained with them for some time.

A half-grown chick in the down became thoroughly tame, followed us about like a puppy, and throve for several weeks. It died immediately after being brought to Callao, however, and the Indians attributed its end to the abrupt transition from seawater to fresh water for drinking. This change is regularly made in nature by certain antarctic penguins, such as *Pygoscelis adeliae*, which eats copiously of snow at the nesting ground after coming up from the ocean for the courtship season. But the Peruvian Penguins live on snowless, streamless, and pondless islands in a rainless region, and know only the taste of seawater. Nevertheless, the adults can survive as captives in fresh water pools.

At Independencia Bay a chick that had shed nearly all its down was much petted, and stuffed with food, on board our trawler for two days, and was then put into the water so that it might swim back to its native shore. Instead of doing so, however, it rolled on its flank and stroked itself with its feet, and then swam back and forth alongside, trying to climb back on board. After some time the ship's boy was sent down a rope ladder; the young penguin immediately swam into his hands, and showed complete contentment when brought on deck again.

Paessler (1922, 438) writes of a fledgling which he caught on the Chilean coast, and which, for the first few days of its confinement, he had to feed forcibly with fish and raw meat. He would take the penguin between his knees, hold its mouth open, and ram down the food, the bird all the while beating so violently with its flippers that its human foster parent's legs would smart for hours afterwards. Within a surprisingly short period, however, this captive became reconciled, and began to seek its new source of subsistence. Next, without a struggle, it would allow itself to be tied by the leg, carried down the landing stage, and tossed overboard to catch its own fish. Even when tethered by an eight-meter length of cord, it took plenty of prey, and grew fat. Twice it slipped the line completely, but came back to the steps, nevertheless, and called until it was hauled out of water. It followed its master around the decks, and demonstrated that it distinguished between familiar and strange persons.

Penguins in general have no native recognition of food unless it is alive and in its own element. I mean that they would probably starve to death in the presence of a heap of their normal food on the ground beside them. In the gardens of the Zoölogical Society of London, however, a Peruvian Penguin learned the transition from natural to artificial feeding.

> At first it required to be fed by hand; for if its food was placed on the ground the bird took no notice of it, although hungry. After a few days, if living fishes were thrown to it and the bird saw them jumping about on the floor, it began to pick up the fishes and swallow them (Bartlett, 1879, 6).

The moult of the Peruvian Penguin is perhaps as variable as its breeding season. Adults captured at Independencia Bay in the middle of November were in extremely worn and faded plumage, which was obviously soon to be replaced.

An example which reached the London Zoölogical Garden on January 24, 1878, entered the period of moping, ill-temper, and avoidance of the water one month later. Within a few days thereafter the feathers began to slough off, and by March 7 the process had been completed. The short scale-like feathering of the flippers flaked off in a sheet, like the shedding skin of a serpent. The actual change of plumage, after the first patch of old feathers fell away, required less than ten days (Bartlett, 1879, 6).

The Peruvian Penguins often join unwittingly with many other kinds of birds, and with such creatures as bonitos and sea-lions, in pursuing the great shoals of small fish that are so characteristic of the Humboldt Current region. On November 14, 1919, I saw many penguins and sea-lions foraging about together when the Bay of Pisco was filled with herrings, silversides, and anchovies, the cohorts of which showed as luminous spots or as patches of ruffled surface. Paessler (1922, 438) also describes how these penguins combine with the gulls and terns in raiding the schooling fish along the Chilean coast. He often saw the feeding penguins leaping a half-meter out of water, like porpoises, as they took up the chase. The stomach and gullet of one of the penguins I collected at the Chincha Islands were crammed with remains of anchovies (*Engraulis ringens*) to the number of at least several score. Among the fishes were also two parasitic isopods (*Anilocra plebia*). The stomach of another specimen contained several of the same isopods and a number of crystalline lenses, which are usually the last parts of fishes to remain undigested.

While I was residing in the guano administration house at Pescadores Island, during December, 1919, I frequently watched penguins shooting out of water within a certain small area to westward of the island where there always seemed to be an abundance of food. Six or eight of the birds roosted much of the time upon a rock in the cove, almost below my door. In moving from one part of the rock to another, they would progress by little jumps, in the manner of the Rockhopper Penguins. They could also surmount ledges by making standing high-jumps about equal to their own height, an extraordinary feat considering the weight and proportions of the body. When walking into the water they would bend their heads down, just as *Pygoscelis papua* does. When they disappeared from the surface of the water, it was not in a manner that could be called diving; at least the penguins made no spring forward but, rather, seemed merely to sink. In sallying forth from their rock on a fishing excursion, they always began with a long submergence. But later, when they returned well filled, they invariably entered the cove swimming at the surface, and they usually advertised their coming by loud cries.

Coker (1919, 457) describes the surface call as "a slightly prolonged hoarse note of a single pitch, much like the sound of a toy trumpet." The full bray, which they more often utter ashore, particularly at night, is a double or triple note. At the Chinchas we had a vociferous water-carrying burro, called Pancho, and there were nocturnal moments when I was uncertain whether a mournful and despondent braying in the distance issued from a bird or from this quadruped.

GALÁPAGOS PENGUIN

Spheniscus mendiculus

Spheniscus mendiculus Sundevall, 1871, Proc. Zoöl. Soc. London, pp. 126, 129 (James Island, Galápagos).

Names: This latest of the New World penguins to be discovered has been listed by no other than the generic and specific names given by the original describer.

Characters: Much smaller than either of the preceding species of *Spheniscus*, with a total length of 48–50 cm., a flipper of 15 cm., and a weight equal to about one-half that of *humboldti*. The bill is slender and relatively long, the mandible proximally light-colored. The plumage-pattern represents a degeneration of the ordinary *Spheniscus* type, as exemplified by the species *demersus*, *magellanicus*, and *humboldti;* it recalls, in fact, features of the immature stage in these three species, the several white areas and bands on head and neck being reduced and relatively obscure. Chin whitish, as in *humboldti*, but sometimes mottled rather than clear; white stripe outlining the face, narrow and interrupted—in some specimens practically obsolescent—beginning above and behind the eye; U-shaped band of breast and sides usually irregular, and relatively ill-defined in the pectoral region because of the invasion of its transverse section by white feathers; fore neck crossed by a very broad, smoky brown band, continuous with the dorsal plumage, not clearly defined as in *Spheniscus magellanicus*, but more or less intermingling with the whitish areas at both edges; external surface of flipper uniform slaty black, showing no white at the anterior, and little if any at the posterior, margin; under surface of flipper prevailingly black, with an irregular whitish median area; under tail coverts and crissum blackish, recalling the condition in very young examples of the two preceding species; 18 rectrices. Iris, "reddish brown" or "claret-brown"; bill mainly black, the maxilla narrowly yellowish or flesh-colored at its base, and usually with a light lateral blotch in front of the nostril, the mandible yellowish, flesh-colored, or pinkish on the proximal two-thirds of its length; sparsely feathered skin about base of bill, pinkish purple; legs and feet black, more or less mottled on the toes and webs with pinkish buff.

The seven specimens measured in the American Museum show the following dimensions:

1 male: wing, 140; tail, 21; culmen, 60; bill from gape, 71; nostril to tip of bill, 35; foot, 95; middle toe and claw, 60.2 mm.

6 females: wing, 128–145 (135.4); tail, 25–26 (25.5); culmen, 54–60 (56.2); bill from gape, 63–67 (65.2); nostril to tip of bill, 32–36 (34); foot, 86–90 (88); middle toe and claw, 56–59 (58) mm.

Measurements based upon 7 males and 9 females in the California Academy collection are as follows:

Males: flipper, 149–166 (156); tail, 23–39 (27); culmen, 57.4–61.1 (60.2); tarsus, 26–31.6 (29); middle toe and claw, 56.8–62.5 (60.2) mm.

Females: flipper, 140–155 (149); tail, 19–30 (26); culmen, 56–57.4 (56.7); tarsus, 25.7–29 (27.2); middle toe and claw, 56.3–60.7 (59.1) mm. (Gifford, 1926, 18).

Comparison of the dimensions of the three New World species of *Spheniscus* shows that while *humboldti* has the bill of greatest absolute length, *mendiculus* has a bill that is longer between nostril and tip than either of its congeners.

Distribution: Known chiefly from the central and westerly members of the Galápagos Archipelago, including the large islands of James, Charles, Albemarle, and Narborough, and the smaller islets, or outliers, of Jervis, the Seymours, Duncan, Brattle and Onslow. Tagus and Iguana Coves, Albemarle Island, are probable nesting localities.

Probably no penguin is so little known as the only equatorial member of the family, which is confined to the Galápagos Islands. The type specimen of the species was collected at James Island on May 10, 1852, by Dr. Kinberg, surgeon of the Swedish frigate 'Eugenie.' It found its way to the Royal Natural History Museum at Stockholm where, nineteen years later, it was described by Sundevall. Since that date, examples of the Galápagos Penguin have been obtained by numerous expeditions, and living birds have been kept for months in captivity at the New York and San Francisco Aquariums and elsewhere.

But most of the normal behavior and life history of this penguin in its native haunts have thus far escaped observation.

In its small size, long bill, and the somewhat disintegrated or "immature" facies of its plumage, the Galápagos Penguin stands well apart from the other members of the genus *Spheniscus*. As to its origin and geographic status, we are safe in assuming that it has reached its present home from the south, and that its restricted habitat marks the outpost of the same extraordinary environment that enables *Spheniscus humboldti* to dwell along the tropical west coast of South America to a point within six degrees of the equator. In short, the ranges of both Peruvian and Galápagos Penguins are correlated with, and probably more or less coeval with, the Humboldt Current. The result, as exemplified by *Spheniscus mendiculus*, is most striking. The species is, indeed, a monument among vertebrates to the directive or selective power of an environment, and to the fact that the filling of ecologic niches is another warrant for the old saw that nature abhors a vacuum.

The Galápagos Islands were not included within the scope of the Brewster-Sanford Expedition, but three specimens of the resident penguin, collected by Beck and his associates during the famous cruise of the schooner 'Academy,' have come, by exchange, to the American Museum of Natural History. In addition we have received as gifts from the New York Zoölogical Society five examples originally brought to New York alive by the expeditions of Dr. William Beebe and Mr. Vincent Astor.

For an understanding of the relationships of the Galápagos Penguin with other members of the genus, a certain recapitulation of the geographic and morphological data will be useful. The four species of *Spheniscus*, and their respective ranges, are as follows:

- *S. demersus*, the southern tip of Africa, and the cool-current region of southern West Africa.
- *S. magellanicus*, southern South America.
- *S. humboldti*, the temperate, and southern tropical, west coast of South America, all of which, however, is a cool-current region.
- *S. mendiculus*, the Galápagos Islands.

It is interesting, with respect to what has been said heretofore about the recognition marks of penguins, that *mendiculus* superficially resembles *magellanicus* rather than *humboldti*, the range of which intervenes between the ranges of the two former. In like manner, *humboldti* superficially resembles *demersus* of Africa, with the different-looking *magellanicus* occupying an intervening region. Such obvious likenesses between the alternating species have usually been taken at face value for taxonomic use. Examination of the four forms shows, however, that the resemblances commonly stressed are due entirely to the presence or absence of a single mark, namely, the dark, transverse throat band. In other words the resemblances are truly superficial, depending upon a character which, as we know from experimental analogy, might become changed by a relatively slight genetic recombination. In certain more fundamental respects *mendiculus* and *humboldti* on the one hand, and *demersus* and *magellanicus* on the other, show hitherto overlooked affinities, a grouping of the species which, by the way, is also in harmony with their geographic relationships.

For example, the neighboring species, *humboldti* and *mendiculus*, have in common relatively long bills and a white chin; *magellanicus* and *demersus* share shorter bills, that of *demersus* being the shortest in the genus as that of *mendiculus*, at the other end of the distributional sequence, is relatively the longest. The lengthening, in the latter instance, has taken place in the distal portion of the bill, between nostril and tip.

Although *demersus* and *humboldti* have in common white fore necks, owing to the absence of the median dark band present in both *magellanicus* and *mendiculus*, the following table will bring out more important criteria of relationships within the whole generic group.

Conditions in Adult, Breeding Examples of *Spheniscus*

	demersus	*magellanicus*	*humboldti*	*mendiculus*
Bill	Shortest	Slightly longer	Still longer	Relatively the longest
White head stripe	Very broad; beginning at the bill and encompassing the eye	Narrower; beginning in the lores and only rarely encompassing the eye	Still narrower; entirely above the eye	Narrowest, almost obsolescent; entirely above and behind the eye
Face	Completely but sparsely feathered; no bare skin at base of mandible	More sparsely feathered, with bare skin showing at base of maxilla and mandible	Lores, region around eyes, and a broad area adjoining the proximal end of the mandible, of naked, papillate, and brightly colored skin, covered only with filoplumes	Sparsely feathered, especially on lores and base of mandible, with papillate, brightly colored skin showing through
Chin	Black	Black	White	White or mottled whitish
External surface of flipper	White on posterior edge	White on posterior edge	White on both posterior and anterior edges	Entirely black, or sometimes narrowly white on posterior edge
Crissum	Mostly white	Mostly white	Mostly white	Black
Size	Largest	Slightly smaller	About equal to *magellanicus*	Smallest

The end species in the series, namely *demersus* and *mendiculus*, are the two that best show exclusive marks. The Galápagos Penguin, for example, has a conspicuous, pinkish mandible; the African Penguin has a light-colored, subterminal band or ring on the bill, and a small white patch over the base of the tail, the last being reminiscent of a similar patch in *Eudyptes chrysolophus*. But these are the two peripheral species, neither of which ever comes into contact with any penguin but its own kind. The two species that meet and mingle in parts of rhe west coast of South America have fewer readily visible differences, but one outstanding difference, namely rhe pattern of rhe throat markings, and this doubtless serves as a fundamental recognition sign.

A characteristic of all three large species of *Spheniscus* that crops out again in the Galápagos Penguin is the tendency to have scattered black feathers on the white ventral surface. Gifford (1926, 18) reports that in a series of 17 specimens not one lacked a trace of this spotting, the pattern being made up of from 2 to 33 dusky feathers in the plumage of breast and belly.

The Galápagos Penguin has been observed in the field chiefly about the southerly and westerly islands of the archipelago. It has been doubtfully reported from Wenman Island, which is isolated and lies in latitude 1° 20′ N. Apparently there are more records from the long westerly coast of Albemarle Island than from elsewhere. Fisher and Wetmore (1931, 25) state: "Although the penguin was kept in mind, as we visited the various islands of the Galápagos group, we did not find it until we reached the narrow stretches of water between Narborough Island and Tagus Cove, Albemarle Island, late in August," 1929.

More than twenty years earlier, the members of the Galápagos Expedition of the California Academy of Sciences found Iguana Cove, at the southwesterly tip of Albemarle, to be a favorite rendezvous of the penguins. Here 30 to 40 were sometimes seen at one time. At other islands the birds appeared to be widely distributed along the beaches only during periods of tranquil weather. At Iguana Cove as many as 8 to 10 could sometimes be seen resting on one rock. They were unsophisticated and curious, and would usually allow a man to approach them closely. In scrambling about over rough places they used both feet and flippers, but when on a smooth surface, such as a flat rock or the deck of a ship, they progressed by small jumps, bending the head and neck forward so that they had a very stooped posture. When climbing an obstacle, they employed their flippers as arms, placing them on top and hoisting up the feet. If a bird was seized, it turned on its captor with a snarl and tried to bite. The sexes did not show in life the discrepancy in size reported by Rothschild and Hartert, and were usually impossible to tell apart (Gifford, 1926, 16).

Snodgrass and Heller (1904, 235) report that the penguins sit on the rocks with a characteristic crook in their backs, or lie flat like sea-lions, with flippers outspread, and simply drop into the water when they are disturbed. Ashore, or floating at the surface, they tend to keep their bills tilted up slightly.

Apparently they never dive from a take-off in the manner of the antarctic penguins, but either flop into the water or jump feet-first (Townsend, 1927, 509). From a position of lying half on their flanks at the surface, they can disappear so rapidly that the eye fails to take in the stages. They swim with the feet stretched straight back and the soles turned upward, travel with great speed when they are below, and sometimes leap out of water like breaching porpoises (Snodgrass and Heller, 1904, 236). One pursued in a launch by the Pinchot party kept well ahead without difficulty, and its manner of swimming reminded the observers of a muskrat (Fisher and Wetmore, 1931, 25).

Beebe (1924, 175) found that the penguins spend part of their resting time in the dark interiors of caverns, and drew the conclusion that they breed in such places. By analogy with the habits of *Spheniscus humboldti*, this seems probable, most Galápagos shores not offering favorable terrain for burrowing. Furthermore, members of the California Academy Expedition saw three penguins enter a cave at Iguana Cove, Albemarle Island, and found in a similar situation a nest of sticks laid loosely together on the floor. This was attributed to the penguins. Two females killed on March 21, 1906, contained well-developed yolks in their ovaries (Gifford, 1926, 16). In two females taken at Tagus Cove, of the same island, on August 25, 1929, the ovaries were dormant (Fisher and Wetmore, 1931, 25).

Bronson (1931) has written a circumstantial account of the nesting of the Galápagos Penguin, and the rearing of the chicks. This, however, is not intended to represent more rhan plausible fiction, for apparently neither eggs nor downy young have ever been observed. Birds in juvenal plumage differ from adults in the same manner as do the young of the Peruvian and Magellanic Penguins. There is no white superciliary line, and the face and throat are white.

Small fish, up to 4 inches in length, made up the only food of the species noted by the California Academy party. While fishing, the penguins would often be closely followed by a flock of noddies, so that the position of the submerged penguins could be told by the swarm of fellow fishermen fluttering excitedly overhead. Nearly all the birds taken by the California naturalists were very fat. A captive adult "in good condition" was found by Townsend (1927, 509) to weigh exactly 6 pounds (2721 grams). Several of the California Academy specimens had had the webs of their feet slit during life, as though from a bite. It is possible rhat the sea-lions sometimes attack them in the water, as they are known, in very rare instances, to attack pelicans and other guano birds along the coast of Peru.

Snodgrass and Heller (1904, 235) say that the Galápagos Penguins utter a sort of grunt, and also an elongate, braying call resembling *hä-ä-ä-äh*, the stress gradually declining toward the end. Townsend (1927, 509) describes the recognition call of rwo captive birds as a soft, throaty *whoo*.

The first act of Galápagos Penguins when released in a tank at the New York Aquarium, as described by Townsend, was to drink copiously of seawater. They darted after minnows with which the tank had been provided, and continued hunting ar high speed until all had been captured. Sometimes the penguins floated at the surface with their eyes submerged, looking for fish that might have escaped them. Minnows thrown on the water were immediately seized and swallowed, and the birds became adept at catching in mid-air bits of fresh fish tossed to them. When placed beside a glass tank containing living fish, one of the penguins made repeated attempts to capture those that swam nearest. Sumner (1934, 559) has found by carefully controlled experiments, using mosquito-fishes (*Gambusia patruelis*) as prey and Galápagos Penguins as predators, that fishes which harmonize in color with their immediate surroundings are less likely to be eaten by these birds than fishes of the same species which do not so harmonize. In other words, the value of so-called protective coloration is to a considerable degree effective in protection from the penguin.

All the New York Aquarium Galápagos Penguins grew completely tame very rapidly, a trait not shared to the same degree by South African Penguins which have been kept there at other times. Each of the birds was decidedly interested in its own reflection in a mirror, and one of them took to looking behind the glass when it failed to make a satisfactory *rapprochement* with its image.

The moult of one of the captive adults occupied three weeks.

THE PROCELLARIIFORMES

The structure of the external nostrils sets the Procellariiformes or Tubinares sharply apart from all other members of the class Aves. This feature, in combination with less striking characters, marks the petrels and albatrosses as among the most distinctive of modern birds, although their affinities with the Ciconiiformes, Pelecaniformes, and perhaps with the penguins, have long been recognized. So pronounced is the morphological gap separating the Tubinares from their relatives that they are justly treated in the taxonomic system as an "order," but in an evolutionary sense, they might be regarded rather as one family of an ancient, more inclusive order, which has left no other survivors.

The archaic position of the Tubinares is indicated by the joint evidence of their structural isolation, ontogeny, psychobiologic reactions, distribution, and fossil record. The last is exceedingly fragmentary, but Quaternary and Upper Tertiary remains of petrel-like birds are known from several widely separated localities, while the oldest fossils of birds certainly belonging to this group go back to Oligocene times (Lambrecht, 1933, 274). With a few exceptions, the described fossils are referable to genera still extant, lending support to the opinion that the Tubinares had reached the climax of their radiation not later than the Middle Tertiary. Moreover, since the palaeontological record of their relatives, the Pelecaniformes, extends back into the Eocene, we have corroborative evidence for the early rise and dispersal of petrel-like forms, the more so because the oceanic environment, to which these birds are preëminently adapted, apparently underwent few changes between late Mesozoic time and the general lowering of sea level during the Ice Age.

Classification

Although no linear classification can satisfactorily express phylogenetic relationship, the following, in which the generic names are used comprehensively, may serve as a basis for the subsequent discussion:

- Pelecanoididae . . . . Pelecanoides
- Procellariidae . . . . . .
  - Hydrobatinae . . . .
    - Hydrobates
    - Halocyptena
    - Oceanodroma
    - Garrodia
    - Oceanites
    - Fregetta
    - Nesofregetta
    - Pelagodroma
  - Puffininae . . . . . .
    - Macronectes
    - Fulmarus
    - Priocella
    - Pachyptila
    - Daption
    - Thalassoica
    - Pagodroma
    - Bulweria
    - Halobaena
    - Pterodroma
    - Procellaria
    - Adamastor
    - Puffinus
- Diomedeidae . . . .
  - Phoebetria
  - Diomedea

This arrangement differs from most current classifications in the suppression of the subfamily Fulmarinae, within which the first six or seven genera in the list of Puffininae are commonly segregated. The end members of the subfamily Puffininae, as here extended, are undoubtedly far apart, but so gradual is the transition from fulmars to shearwaters through the intermediate genera *Thalassoica*, *Bulweria*, *Halobaena*, *Pterodroma*, and *Procellaria*, that it is impossible to delimit within the family Hydrobatidae a third subfamily of equal rank with the other two. Admittedly the Puffininae fall into three natural, even if not clearly defined, aggregations, which group respectively about the genera *Fulmarus*, *Pterodroma*, and *Puffinus*.

The Puffininae make up the bulk of the family Hydrobatidae and comprise chiefly moderate-sized Tubinares popularly known as fulmars, Cape pigeons, prions, whale-birds, mutton-birds, haglets, shearwaters, etc. One of the fulmars (*Macronectes*) is as large as some of the albatrosses. All of the latter are included within the very definite family Diomedeidae. The Pelecanoididae, or diving petrels, are the most aberrant and, at the same time, most homogeneous family of the order. They have a different facies from any other tubinarine bird, and, while confined to the southern hemisphere, they parallel the auklets (Alcidae) of the Holarctic Region.

Representatives of the small, swallow-like petrels, generally known as "Mother Carey's chickens," are sometimes placed in two different subfamilies on the ground that the resemblance between *Oceanites* and *Oceanodroma*, for example, is due to convergence rather than to close kinship. Lowe (1926, 1433) has presented evidence, however, to show that all of these small genera share many primitive, "non-adaptive" characters, and that they are more closely allied than had been formerly held.

Stomach Oil

Scarcely less distinctive than the tube-nostrils of the Procellariiform birds is the oily fluid, often of a bright orange or reddish color, which they eject when stimulated. This oil has a curious musky odor which clings for decades to museum specimens of petrels and albatrosses, even though the skins have been washed in both water and benzene during the taxidermic process. The same smell taints the breeding grounds, and may sometimes be detected in petrel burrows that have not been occupied for the space of a year or more.

The function of this oil is not known, beyond the fact that it is discharged as if in defensive reaction when the birds are approached. Many guesses have been hazarded, one being that the oil serves as food for the offspring, and another that it enables the petrels to calm the troubled surface of the sea about them during severe storms (Green, 1887, 4). The latter idea is not more probable than the first, and yet it is by no means ridiculous, as anyone knows who has seen, as I have, the almost miraculous effect of a few drops of fish or seal oil upon raging waters of the open ocean.

But still more remarkable is the fact that not even the source of the oil has yet been learned. It has been variously called a secretion of the proventriculus, a secretion of a gland (still to be located!) in the nasal region, and a secretion of the external preen-gland subsequently swallowed by the bird. Hagerup (1926, 139) goes so far as to say that in the Arctic Fulmar this oil is merely an undifferentiated product derived from the bodies of minute surface crustaceans. He states that if the latter organisms are crushed in water or alcohol, the reddish droplets of oil, with the same appearance and pungent odor as the Fulmar's stomach contents, will collect upon the surface. This explanation is, however, too simple, for petrels and albatrosses which have not eaten crustaceans, and young birds which have fasted for long periods, are also capable of freely discharging the oil.

The oil proves to be readily digestible by man and other mammals, and it has been regularly used in the preparation of food by at least one human group, namely the Maoris of New Zealand. Recently several biochemists have made studies of the oil, upon which the following summary is based (Rosenheim and Webster, 1927, 111; Carter and Malcolm, 1927, 484; Leigh-Clare, 1927, 725).

The stomach oil of the Northern Fulmar (*Fulmarus*) and of the Australasian Mutton-bird (*Pterodroma lessoni*) is rich in vitamin A and contains vitamin D in amounts equal to about one-fifth of that in good cod-liver oil. It is effective in the treatment of bronchitic conditions. Its purpose as food for young birds is considered very unlikely because the oil does not contain the quantity of protein that would be expected. Whatever the source of the substance within the bird may be, it is evidently a true secretion rather than a product of the digestion of fish, crustaceans, or other marine organisms. This is indicated by the uniformity in the chemical composition of the oil, and by its high component of cetyl esters and low concentration of cholesterol. The latter is the chief unsaponifiable alcohol in fish fats of all sorts.

Chemical analysis shows that the stomach oil is not a glyceride, but a "liquid wax" containing nearly 40 per cent of matter not easily emulsified and comprising unsaturated higher alcohols of the same type as those in spermaceti. Indeed, the resemblance between petrel stomach oil and the famous substance in the head of the sperm whale is so striking as to suggest similarity in origin and function, a train of thought, however, which is difficult to pursue.

The resemblance of this fluid wax to that produced by the preen-glands of the tail makes it appear reasonable that the stomach oil fulfils a similar function. Owing to their environmental conditions the petrels and their allies doubtless require a larger supply of feather-dressing than any terrestrial birds. The preen-glands of ducks contain about 40 per cent of alcohols, the same proportion as the tubinarine stomach oil. The idea of such use of the oil is strengthened by the highly distinctive structural features of the tubular nostrils possessed by all the petrel-like birds. Since they commonly discharge the substance through the nostrils, as well as sometimes through the mouth, it is suggested by Rosenheim and Webster that the grooves of the beak, another pronounced tubinarine character, may facilitate the distribution of the oil during preening operations while the birds are resting upon the water. The low viscosity of the oil, which is shared by sperm oil, distinguishes it from ordinary animal fats, and renders easy its transference from beak to feathers. The presence of unsaturated fatty acids and alcohols would tend to keep it fluid at relatively low temperatures such as many of the petrels and albatrosses encounter.

Distribution

Although the order is cosmopolitan, fully two-thirds of the hundred or so species of Tubinares breed only in the southern hemisphere. Ten or twelve species, all included within the family Hydrobatidae, have breeding grounds both north and south of the equator. The fulmar group is bipolar, the nesting range of the arctic *Fulmarus* extending northward to Franz Josef Land, and its flight range to within five degrees of the pole, while *Daption*, *Thalassoica*, *Priocella*, and *Macronectes*, which are limited mostly to seas well south of the equator, all breed on antarctic islands or the polar continent. *Oceanites* and *Pagodroma* likewise nest inside the antarctic circle, but while the entire range of the latter is confined to the polar zone, *Oceanites* migrates northward after its reproductive season, crossing the tropics into north-temperate or even subarctic oceans.

Among Tubinares restricted for the most part to the circumpolar southern oceans are the albatrosses of the genus *Phoebetria* and several of the genus *Diomedea*, the species of *Pachyptila*, *Halobaena*, *Procellaria*, *Adamastor*, and all of the Pelecanoididae. The genera *Diomedea*, *Pterodroma*, *Bulweria*, *Puffinus*, and *Oceanodroma* are represented by typical species in each hemisphere. The only exclusively northern genus is *Fulmarus*, unless *Halocyptena* deserves similar rank.

The distribution of the Tubinares is fraught with many contrasts and uncertainties. While some forms, as has already been pointed out, make enormously extensive migrations, others are known only from the immediate vicinity of very restricted breeding grounds. Still others, such as *Bulweria bulweri*, *Oceanodroma castro*, *Pelagodroma marina*, and *Puffinus assimilis*, offer remarkable illustrations of discontinuous distribution. While several authors have not neglected to link up this fact with the division and reconnection of continental masses, such as North and South America, during the Tertiary (Loomis, 1918, 13; Bannerman, 1914, 442), it is well to remember that discontinuous range may arise at any time and for a number of reasons. Moreover, degree of subspecific differentiation offers little clue to the date of separation.

Evolution

The most notable physical characteristic of the Tubinares is their great range in size, which finds no parallel in other ordinal groups of birds. Nichols (1914, 315) has attributed this condition to the evolutionary factor of intraordinal competition among many species in the absence of competition with birds of other orders. The idea is an old one, at least as applied to other and more comprehensive groups of animals, and it has much to recommend it. The range of size and the varying style of flight and feeding shown by albatrosses, petrels, and diving petrels, recalls in a somewhat limited sense Osborn's principle of adaptive radiation, which "expresses the differentiation of animal form radiating in every direction in response to the necessities of the quest for nourishment and the development of new forms of motion."

Because of a certain uniformity of habitat, and the possession of incomparable specializations for pelagic life, the Tubinares are almost without rivals in an enormous geographic field. Their range in size, therefore, tends directly to relieve the pressure of competition among their own kind. In the words of Nichols, the small "Mother Carey's chicken, the medium-sized Cape pigeon, and the large albatross collect at one time" at favorable centers of food supply, "and the smaller birds are satisfied with crumbs left by the larger ones. Resorting from vast stretches of sea to nest on islands, as the different species must, the smaller ones seek the protection of necessarily limited holes and crevices; the larger, not needing protection, nest in the open. If all were approximarely the same size, each would tend to crowd the other."

With these circumstances as a premise, it will be of interest to inquire into the extent of intraordinal radiation among the Tubinares, not only with reference to their structure, but also as expressed in their nidification, locomotion, and feeding habits. I wish to avoid pitfalls concerning the relation of habit and environment to evolutionary change. Whether selection has worked its effect upon a certain structure or upon the use to which it is put, needs no consideration here. An effort will be made, however, to keep constantly in view the interdependence of form and function.

Birds which are wholly pelagic, obtaining their food from the surface of the sea, would seem to have a relatively uniform environment, especially when the features of this environment are contrasted with such continental characters as altitude, aridity, nature of ground, vegetation, availability of cover, interordinal pressure, etc., all of which bear so strongly upon terrestrial animals. Homogeneity of the sea birds' environment, due to an oceanic range common to all, might be expected to limit rather than to increase opportunities for adaptive evolution. Yet the extraordinary difference in habitus between a swallow-like stormy petrel and an albatross, which is the largest flying creature of the modern world, is in itself a commentary upon the evolutionary importance of concentrated rivalry among closely related birds. If such rivalry originally began the process of selecting out different size-types, it follows that as soon as the members of the group had attained even slight discrepancies in size and power, their varying relation to food supply and to common enemies could not fail to introduce new influences which would accelerate trends already under way.

Formerly the Tubinares were associated in systems of classification with a more modern assemblage of water birds, the gulls, terns, and skuas, which share many superficial likenesses with them but which by no means have equivalent systematic rank. Gull-like birds are the dominant aërial sea fowl of the northern hemisphere, but, as most of them are littoral rather than pelagic, they have come into sharp competition with birds of other orders. Their adaptability has been exercised to such an extent that some of them have secondarily become almost terrestrial. For the same reason, perhaps, their range in size does not approach that of the Tubinares. Nevertheless, a broad analogy is evident between the smaller terns and the Mother Carey's chickens, the medium-sized gulls and the fulmars, the great skuas and the Giant Fulmar (*Macronectes*), the largest of the gulls and the albatrosses. Only the skimmers (*Rynchops*) on the one hand, and the diving petrels on the other, fail to fit into the scheme. It may prove profitable to compare certain aspects of the two mainly parallel groups.

Nidification and Growth

With the exception of a very few species, such as the sooty albatrosses (*Phoebetria*), which are hermits, the Tubinares are called colonial in their nesting habits. This may not be quite the correct term to apply, for, although the pairs nest close together, they still appear to live independent, socially isolated existences. Only the albatrosses of the genus *Diomedea* have habits at home which resemble those of penguins in taking cognizance of their neighbors, and which have developed as a limited form of community behavior. Possibly the nocturnal whistling and sobbing and yowling of petrels and shearwaters at their nests is also a kind of community expression, but nothing has yet been learned about this.

Excepting the albatrosses and the larger fulmars, all Tubinares seek to conceal their single egg, either at the end of an excavation made by the parents, or within the recesses of a natural cleft, or in the midst of vegetation on the surface of the ground. The shearwaters, many species of the genus *Pterodroma*, the smaller fulmarine petrels such as *Halobaena*, the members of the genus *Oceanodroma*, and the diving petrels, to name but a few, are burrowers. Some of the shearwaters (*Puffinus* and its subdivisions) that breed on arid tropical islands dig their crooked tunnels through sandy soil to a length of several meters. Obviously the burrowing custom can be followed only in zones where the soil is not solidly frozen during the breeding season. Therefore we encounter it particularly in tropical and temperate regions, and southward to the low antarctic islands, beyond which it is replaced by cleft dwelling. The typically sub-antarctic and low antarctic petrels of the genus *Pachyptila* are soil-burrowers, while the allied antarctic *Daption*, the breeding range of which barely overlaps that of *Pachyptila*, is exclusively a cleft-dweller. At certain arid, rocky, tropical islands, too, where there is a paucity of soil, the native petrels are of necessity cleft-dwellers or surface-dwellers rather than burrowers. Thus at Trinidad Islet, in the South Atlantic, the endemic form of the genus *Pterodroma* lays its egg on ledges or in niches of the volcanic rock, nesting sites similar to those selected by *Fulmarus*, *Priocella*, *Thalassoica*, and *Pagodroma* on arctic or antarctic cliffs. Concealment of the nest in dense vegetation, with no burrow, is a rarer habit, but it is followed by several species of *Pterodroma* and by *Garrodia nereis*.

Aside from the protective significance of burrows, an important incidental end is served by them, namely the multiple use of the same breeding area by two or more species of very different sizes. In the Antarctic Zone Wandering Albatrosses sometimes crowd all the available space on grassy islets; yet the same areas offer ideal sites for the burrows of whale-birds (*Pachyptila*). Thus the two species—one large, one small, one diurnal and overt in its activities, the other nocturnal and secretive—occupy the same territory, and the numbers of one species are not limited by the abundance of the other. Rothschild (1912, 1) has called attention to a fortuitous time economy which in some instances supplements the space economy among breeding Tubinares and associated sea birds. Thus at Laysan Island, in the North Pacific, certain burrowing petrels arrive to nest in August, undermining the whole surface of the island. In October the resident albatrosses follow, and still later the Sooty Terns and other species appear.

In rare instances certain gull-like birds, such as the Inca Tern of Peru, scratch out burrows or utilize crevices in order to shield their offspring from vultures; but in general the Laridae and Stercorariidae nest in the open, relying for protection upon their own aggressiveness and the obliterative coloration of their eggs and young. Neither of these factors comes very much to the aid of the smaller Tubinares, and the only representatives of the order that nest upon the surface of open ground are the larger fulmars and albatrosses, birds too powerful to be endangered by their normal enemies. Nests of the albatrosses and Giant Fulmar are often in the form of mounds of soil and humus which support the incubating birds well above the surrounding mud. Giant Fulmars breeding in arid or sandy situations, however, sometimes incubate directly upon the ground.

As stated above, nearly all Tubinares are gregarious during the breeding season, associating not only with members of their own species and others of the order, but also with birds such as penguins and cormorants. Nevertheless, examples of specific segregation are not unknown. At the island of Laysan, for example, a colony of *Diomedea immutabilis* occupies the whole flat interior, while another albatross, *Diomedea nigripes*, breeds mainly in a fringing zone along the beaches. In general the position of the nest, its altitude and distance from the ocean, vary regionally as well as upon specific and individual grounds. Albatrosses of one species may nest from sea level to a high altitude. One kind is said to breed within the old crater of Tristan da Cunha, approximately 2300 meters above the sea. Sooty albatrosses and diving petrels often nest far back in the mountain valleys of pan-antarctic islands. Hornby's Petrel breeds in deserts of the Andes. Certain tropical petrels make their burrows near the summits of wooded mountains. Some species of *Oceanodroma* nest in the floor of island forests. Despite these exceptions, however, the breeding grounds of the bulk of the order are characterized by sparse vegetation and proximity to the sea.

All Tubinares lay annually but one egg, which is pure white or faintly speckled. The task of incubation and of caring for the thoroughly helpless nestling is shared equally by the parents. The incubation period is long, although we have exact data covering only a few species. That of *Hydrobates pelagica* is about 35 days, as compared with 11 days for *Sterna minuta*, a tern of approximately the same size. The term of the albatross *Diomedea melanophris* is more than 60 days; that of *Larus glaucus*, one of the largest of the gulls, 28 days. The young Storm Petrel (*Hydrobates*) remains in its nest 8 to 9 weeks after hatching. In these lengthy periods of embryonic life and infancy we see additional evidence for the primitive position of the Tubinares, while the fact that their divergent lines of evolution have been carried so far, in spite of their slow reproduction and single offspring, also bespeaks a long ordinal history. The Stercorariidae and most, though not all, of the gulls and terns lay more than one egg. In the responses of the ptilopaedic nestlings the Tubinares and gull-like birds present certain contrasts and certain less significant agreements, which may be expressed as follows:

Altricial	*Nidicolous*	*Precocial*	*Nidifugous*
Tubinares	Tubinares	Laridae	Laridae
	Stercorariidae	Stercorariidae	

The fact that young skuas agree with the Tubinares rather than with their own kin, in clinging to the nest during growth has perhaps a secondary correlation with their raptorial habits. But young Tubinares are nidicolous for the more compelling reason that they are typically altricial.

Before the egg has been deposited the mated male and female tubinarine birds remain together at the nesting site, whether the latter be on the surface of the ground or within a hidden chamber. Upon the appearance of the egg.

one parent or the other begins sitting, and after a period ranging from a few hours to ten days, or perhaps even longer in certain species, it is relieved by its mate.

From the full coöperation of the sexes in rearing the young, one might expect an identity in appearance of males and females among Tubinares as among the gulls. This is, in fact, true among all members of the order excepting the great albatrosses of the *Diomedea exulans* group in which the sexes are dissimilar as regards both size and plumage. A possible explanation of the exceptional case may be found in the sphere of sexual selection. The subject is discussed further in the biographies.

Young Tubinares resemble penguins in having two successive coats of down, which usually differ in color and texture but which both grow continuously from the same axis as the definitive feathers or teleoptyles. The mesoptyle down develops luxuriantly about the time that the parents cease to brood their offspring, and affords an effective insulation against temperature changes whether in the tropics or the polar regions.

A juvenal contour plumage differing from that of the adult bird is rare, but exists in the Wandering Albatross (but not the Royal Albatross), the Giant Fulmar, and to a lesser extent in *Oceanites oceanicus.* Fledglings of the latter species are characterized by white feather-edgings not present to the same extent in the adult, and similar conditions will doubtless be found when other small petrels are closely studied. *Macronectes* presents plumage problems not yet fully understood or even fully described. The natal down of this bird is straight and white, the mesoptyle curly and gray. The latter down is succeeded by a black juvenal plumage, which seems to be followed ultimately by a variable grayish coat, or in some cases replaced by a plumage almost wholly white. White birds are far less common than dark birds, but the ratio of the former increases with latitude, being highest along the coast of the antarctic continent. Dichromatism of a somewhat different sort is a common phenomenon among many other species of Tubinares. In some instances the phases seem quite capricious, while in others they have acquired a definite association with locality, but in neither case has any survival value been discovered.

Some of the albatrosses require a term of several years for the assumption of their complete adult plumage. *Diomedea exulans*, for example, passes from the secondary down to a suit of brownish black feathering with a white face and white wing-lining. It apparently experiences no early post-juvenal moult, but at the period of the first annual moult the worn blackish plumage gives place to a mottled garb, and only after a term of perhaps four or more years does the bird don the finely vermiculated white plumage of maturity. A similar delay in the appearance of the adult feathering obtains among the larger gulls.

The young of Tubinares grow slowly, but those of most species are ready to leave the nest before the close of their first autumn. This applies even to such large representatives as the Giant Fulmar and the smaller species of albatrosses, the offspring of which take wing at an age of from fifteen to twenty weeks. But the development of the largest albatrosses, such as *Diomedea exulans*, is much slower; the chick remains in the nest, entirely dependent upon its parents, during the summer, autumn, and winter after hatching.

Many observers have commented upon the fact that relatively few of the Wandering Albatrosses noted on the high sea are mature birds in the resplendent white plumage. Dark yearlings are common enough, as are also mottled albatrosses of the second and third year, but fully adult birds are disappointingly scarce. Skins of mature specimens in museums have been collected in most instances not on the ocean but at the breeding ground. No such preponderance of young over adults is apparent among the smaller albatrosses, such as *Diomedea melanophris* and *Phoebetria*, doubtless owing to the fact that these birds complete their breeding season and migrate to sea before the end of the antarctic autumn, when the old ones would actually outnumber the first-year young. The mature Wandering Albatross is, however, confined longer to its nesting ground. The young doubtless lead a pelagic life for two or more years before returning to the land to breed. For such reasons immature birds mighr generally be expected to outnumber the adults observed at sea.

Enemies

Burrowed nests and nocturnal habits may well represent the primitive customs among Tubinares. Nevertheless, a comparison of a tropical islet like South Trinidad, where small petrels fly about in the open all day, with an island in the Antarctic Zone like South Georgia, where most of the petrels remain strictly under cover except after nightfall, suggests that the enemies of these birds have had much to do with the preservation, if not with the development, of many of their present traits.

Chief among petrel enemies, at least in higher latitudes of the southern hemisphere, where Tubinares are most abundant both as species and as individuals, is the largest member of the family Stercorariidae, the skua (*Catharacta*). This is a genus of aggressive, bird-eating gulls of thoroughly hawk-like habitus. Its evolution, doubtless through a long period, seems to have been counteractive to that of the Tubinares and penguins, which furnish the greater part of its prey. South of the tropic of Capricorn, the genus *Catharacta* has become distributed over every land area upon which Tubinares breed, quite to the southernmost limit of vertebrate life upon the antarctic continent. In spite of its efficient adaptations, it has preserved a generalized character which equips it to function as a diurnal and crepuscular, terrestrial bird of prey during the long breeding season, and as a pelagic scavenger, bird-robber, and plankton-feeder during its extensive oceanic migrations. All in all, the skua has attained immense physical superiority over the less intelligent and more narrowly specialized Tubinares. At the pan-antarctic islands, most of the smaller kinds of petrels could on no account depart from rheir burrowing and nocturnal habits during the coexistence of the skua, which contrives, even under what might be called unfavorable circumstances, to destroy incredible numbers of such forms as whale-birds (*Pachyptila*, *Halobaena*) and divers (*Pelecanoides*).

The relative helplessness of the Tubinares, especially when contrasted with the effective pugnacity of such small-sized Laridae as some of the terns, is very marked. Doubtless it has been continuously accentuated by the age-long though purely defensive competition with their ubiquitous foe, which keeps them not only underground but also out of the daylight. The skua may, indeed, be one of the agencies which force the small pan-antarctic petrels away from the vicinity of their breeding grounds for the greater part of each year, thus emphasizing the traits which make the Tubinares the most pelagic of birds. Falkland Island petrels, for example, go to sea permanently as soon as the nesting season is over, whereas petrels at certain sub-tropical and tropical islands, where there are no skuas, often remain near their nesting stations throughout the year. Climate probably does not altogether explain this difference.

Not only skuas, but also many members of the widespread gull family, may likewise be classed as enemies of the smaller petrels, and it is safe to assume that, were it not for the custom of concealing the nest, the egg or young would fall a prey to any predatory bird that sought it. In a few localities adult petrels are eaten by owls or hawks; fortunately, they have almost no native quadrupedal enemies, although domestic animals and rats have wrought havoc at numberless breeding colonies. Doubtless the absence of carnivorous mammals and reptiles in land areas of the far south has enabled the Tubinares to take advantage of that field for their great expansion.

The extirpation of Tubinares at a number of island breeding grounds by introduced rats has surely never been appreciated. A vast reduction in the population of petrels at Tristan da Cunha, for example, has been attributed chiefly to the killing of rhe birds for human food. In view of the size and heighr of the island, the myriad sea birds that formerly nested there, and the mere handful of resident human beings, this explanation is quite incredible, whereas the rats are sufficient to account for the whole lamentable change. Below is the gist of the story of the rats of Tristan, as told to Captain du Baty by the former chaplain of the island, Mr. Dodson, a brother of the author of "Alice in Wonderland."

They came to Tristan on a schooner called the 'Henry B. Paul,' which was run ashore on the far side of the island, four miles away from cultivated ground. The islanders ignored the clergyman's plea that these ship rats should be at once exterminated, believing that they would not give trouble, as they were so far away.

In the course of a few months, during which they bred tremendously, the vanguard of an army of rats appeared among the potato fields and devoured everything on their march. Then with reinforcements they turned to the wheat-fields and devoured the corn. With relentless ferocity they next attacked the rabbits, which were also prolific in the island, and waxed fat upon their prey. Now rhey invaded the settlement itself, and seemed to have no fear of the human inhabitants, who on their side had become panic-stricken.

It reminds one of the Pied Piper of Hamelin. Gray rats, brown rats, fathers and mothers, uncles and cousins, fat old fellows, and frisky youngsters came in battalions to the houses of the Tristan folk, scrambling over the stone walls, into the tussock gardens and the cattle-pens, getting into the lumber sheds, and invading the front parlours and the back bedrooms of the stone-built cottages. . . . Cats were imported into the island to exterminate this plague, but the rats exterminated the cats!

At the present day there are still a great number of rats on Tristan da Cunha, but the inhabitants say that they have dwindled in numbers, and are no longer such a dangerous pest. . . . Even now, however, the islanders are unable to grow grain on this account (du Baty, 1912, 95).

Locomotion

1. Walking.

The disinclination or inability of most of the lesser and medium-sized petrels to walk, or even to stand straight upon their legs, is in strong contrast with the fine balance and general terrestrial capabilities of the gulls; but has the connection between this well-known characteristic of many Tubinares and their mode of life been heretofore pointed out? The evolutionary process has made good walkers, even runners, of a few species within the order. These, quite logically, are species that nest on the surface of flat and open ground.

Whether or not the absence of walking ability is the primitive condition, it is now correlated with burrowing and cliff-dwelling habits, as represented by many divergent types of Tubinares, from Mother Carey's chickens to sooty albatrosses. Such birds as these spend all their active life at sea, where they descend upon nothing more substantial than the surface of the water. When they repair to land in the breeding season, they no more than alight at the entrance of a tunnel, cranny, or ledge and crawl to the nest-chamber. Some species, such as the Cape Pigeon, are quite incapable of standing on straight tarsi or of springing into flight from a level surface. I have experimented with living examples of *Daption*, and have observed, moreover, that in nature this species always alights upon ledges or hillsides or steeply sloping snowbanks, so that launching into the air will be facilitated.

Whale-birds, diving petrels, many species of *Pterodroma*, the storm petrels such as *Hydrobates* and *Oceanodroma*, are equally helpless on *terra firma*, always squatting on flat tarsi and if stimulated, progressing by means of fluttering and crawling motions or by using the bill as a walking stick. Although *Oceanites* "stands" on the water with the aid of its wings, it cannot stand on land.

Most if not all of the typical shearwaters (*Puffinus*) and also *Procellaria*, can walk fairly well, though they do so awkwardly. On the other hand, the albatrosses, which nest in the open, all walk freely except *Phoebetria*. The latter nests on restricted ledges of cliffs and, while it is capable of standing on straight legs, it has all but given up the habit, if it ever possessed it. The Wandering Albatross requires powerful running legs to carry its heavy body rapidly along the ground when it undertakes the labor of launching into flight; but the slender legs of *Phoebetria* need to furnish only a single slight impetus, for the bird merely has to release the energy of its weight by falling into the air. In this respect *Phoebetria* resembles the cliff-nesting Tropic-bird (*Phaëthon aethereus*).

The best equipped of all the Tubinares for terrestrial locomotion is the Giant Fulmar, the largest relative of such notoriously helpless genera as *Daption* and *Priocella*. The adaptive significance of the difference is at once apparent, for *Macronectes* nests in the open and chiefly upon level ground. No less important is the fact that it obtains a good proportion of its food ashore, a trait in which it is unique in the entire order.

In view of the foregoing, there is hardly need of adding that no downy nestlings of Tubinares, excepting the young of some albatrosses in late stages of growth, forsake their nests in the manner of young gulls and terns. The first signal of approach of active life among the petrels is the loss of the secondary down, which is invariably shed from the head, back, and wings before it is lost from the ventral surface, so that the nestlings have a dense mattress to sit upon until they are almost ready to leave the nest. In the case of the smallest species, this moult may be undergone within a period of ten weeks after hatching, and its completion is soon followed by an exodus from the breeding ground. For among all the smaller species ability to fly is thoroughly coördinated with general development, and is practically synchronized with the loss of the last vestiges of the mesoptyles. These birds make no practice flights; they have no need to learn the fundamentals of their aërial progression; when the appointed hour arrives they simply burst from their burrows or ledges and are gone. Young whale-birds and diving petrels, for instance, lie hidden in their subterranean cradles all through the austral summer, sitting steadfastly in the darkness, for to issue forth, even after they had grown enough to be capable of flight, would mean speedy destruction by the skua. Nightly they are visited and fed, and ultimately they are abandoned, by their parents. Gradually they slough off their down and absorb a good proportion of their fat until they come to be nearly indistinguishable from the old birds. Then suddenly they vanish. One evening a quiet, semi-starved chick will occupy a burrow which next morning will be deserted forever. I have examined sites from which the first flight of fledgling petrels could not have been shorter than 10 kilometers —down a rocky valley, through a long fiord to the sea and, finally, a sufficient distance offshore to be beyond the range of foraging skuas at daybreak.

2. *Flight.*

As regards the beginnings of flight by young birds, the Tubinares exhibit the widest possible range of behavior. Among burrowing species, such as have just been described, the muscular and nervous coördination necessary to produce flight is inhibited until it bursts forth in final and perfect form, like Minerva from the head of Jove. But how sharply such spontaneous reactions contrast with the prolonged efforts to fly made by the fledgling Wandering Albatross, before success crowns its attempts! Here we have a large, heavy-bodied bird, for which instinct supplies the impulse of flight while the power is still lacking. The young bird must slowly learn the art in which it is destined to surpass all living vertebrates. The learning process is described in detail in the biography of the species.

The incipient flight reactions of *Phoebetria*, which nests on precipices, are probably similar to those of the small petrels rather than of the Wandering Albatross, for the fledglings must at least glide successfully from their high ledge to the surface of the sea before they can make any further trials.

The Tubinares have developed the most remarkable powers of sustained, swift, and energy-economizing flight of any large group of birds. The style is no more uniform throughout the order than is the shape of the flying organs, which properly include the tail and webbed feet as well as the wings; but all Tubinares except the diving petrels agree at least in possessing proportionately long wings with very short secondary quills. Such a type of wing gives the maximum of efficiency in the gliding or scaling flight which is fundamentally characteristic of all Tubinares save the Pelecanoididae.

Without going into the technicalities of flight mechanism, we may be able to distinguish six or seven styles of aërial progression among the Tubinares. Let us assume that the least specialized action of the wings in the flight of modern birds is a measured beating which pulls them through the atmosphere. This is, of course, quite apart from the question as to whether avian flight originated in gliding or in flapping.

Beating flight is well illustrated by some of the more generalized Tubinares, such as the typical fulmars, the Snow Petrel, and many species of *Pterodroma*. The wing stroke of *Fulmarus* has been described as owl-like in its regularity, the tip of the wing being passed through a rather short arc, and the beating being interrupted by periods of gliding which increase in length with increasing force of the wind. In calm weather, and more especially during the season of the moult of the primaries, these birds adopt an almost dove-like, pulsating wing stroke which is less sparing of muscular energy. I have observed the latter type of flight in several species of *Pterodroma*, and have even obtained photographic records showing the exceptional length of the stroke.

The "whirr-flight" of the diving petrels is unique in the order. It is the reverse of economical, for it relies upon converting a great expenditure of muscular energy into rapid vibrations of the wings. It closely resembles the flight of such gallinaceous birds as quails, but in *Pelecanoides* it is correlated with diving and subaquatic feeding.

The Mother Carey's chickens or storm petrels, especially *Oceanites* and its near relatives, exhibit more variety in flight than other Tubinares. Their wings, though long for such small creatures, are proportionately broad when compared with those of larger species. During calm weather, the wing strokes are even and deliberate, especially when the birds are coursing straightaway without stopping to feed. When they rise in a brisk wind, the flight is erratic and bat-like. Their normal peregrinations, however, are carried on with alternate flutterings and glidings that are highly characteristic. Owing to their light weight, they have no ballast. They are as feathers in the wind, and they must consume a great amount of energy to fly against it.

The scaling flight, for which most of the larger Tubinares are noted, differs from typical soaring, as exemplified by the buteonine hawks, in that the forward motion is seldom in an orbit. From the sailing flight of the American vultures it differs in that the angle of incidence of the wings is low, *i. e.*, the wings of Tubinares are held straight out from the body, or slightly downward, instead of at an upward angle as in *Cathartes*.

The differentiation of flighr inro "stiff planing" and "erratic planing" is well marked among the several groups, and seems to depend upon two factors, namely, the proportion of wing and tail area to body weight, and the shape of the expanded tail. Most of the fulmars, such as *Priocella*, *Fulmarus*, and *Macronectes*, are relatively heavy-bodied birds with abbreviated, rounded tails.

Their flight is rigid, with a minimum of rocking and of wing flexure, even in a gale of wind. *Macronectes*, in particular, flies so stiffly that its style is diagnostic as far away as the bird can be seen. In a strong breeze this bird is like a well-ballasted ship, for it easily carries the wings at their fullest extent, whereas the longer-winged albatrosses under the same conditions appear to flex their planes, as though "shortening sail." For the same reason, however, the Giant Fulmar must labor more energetically than the small albatrosses during a calm.

Diomedea exulans, the flight of which is smoother and less rigid than that of *Macronectes*, has one of the smallest tails among the gliding Tubinares, but it apparently uses its huge webbed feet, which project beyond the tail, as accessory steering organs. Its wings are longer than those of any other living creature, but they are proportionately less narrow than those of the smaller and more graceful albatrosses, such as *Diomedea melanophris* and *Phoebetria*. The latter especially, with its exceedingly narrow wings and long, cuneate tail, reaches the pinnacle of perfection in flight. It gives the subtle impression, which is exceedingly difficult to describe meaningly, of marvelous flexibility in the air. It never appears stiff, as the Giant Fulmar and even the Wandering Albatross do; its wings are forever in slight motion, as though being adjusted to imperceptible cat's-paws, but it beats or flaps far less than any of the other large birds.

Certain of the shearwaters (*Puffinus*) are miniatures of the albatrosses, particularly of the great albatross, in their style of flight, but the Wedge-tailed Shearwaters (*Puffinus pacificus*, etc.) resemble rather the whale-birds (*Pachyptila*) which likewise have cuneate tails. The erratic gliding of these petrels is the most wild and airy type of flight among all birds; it might best be described by the term "oestrelatous"—goaded on by a gadfly. When the air is filled with a flock of whale-birds careening in the breeze, rising, falling, volplaning, twisting, sideslipping above the sea, now flashing their white breasts, now turning their almost invisible backs—they resemble the motes in a windy sunbeam.

The importance of the shape of the tail, doubtless in combination with other characters, becomes apparent when one discovers a certain parallel tendency toward erratic flight among several natural groups of Tubinares, and notes that the end members in each group have cuneate tails. The following series are examples of this progression which, of course, does not necessarily coincide with the evolutionary sequences:

1. Fulmars. . . . . .*Macronectes—Priocella—Pachyptila.*
2. Shearwaters. . . .*Procellaria—Puffinus gravis—P. lherminieri—P. pacificus.*
3. Albatrosses . . . .*Diomedea exulans—D. chrysostoma*, etc.—*Phoebetria.*

It remains only to speak of "hydroplaning," an extremely specialized type of locomotion illustrated in an incipient stage by *Daption*, but further developed by *Pachyptila*. This will be described in connection with the feeding habits of the whale-birds.

Feeding

The feeding habits of the Tubinares are, of course, correlated with their styles of flight and swimming. Their food includes cephalopods, pteropods, fishes, swimming crustaceans, ctenophores, and almost any sort of animal refuse, particularly fatty substances. Most of them also swallow floating cinders and the like, which lodge in the ventriculus. Much of the foraging takes place at night, or just before the dawn of day, when squids and cuttlefish are near the surface in greatest numbers. As stated above, the Giant Fulmar is the only species of the order which feeds to a considerable extent upon the land, where it sometimes gorges with carrion until it can no longer rise into flight. It is also the most truly carnivorous or cannibalistic of the Tubinares and has been described as a scourge to certain penguin colonies, in which it feasts upon both eggs and helpless young. Its predatory propensities, moreover, seem to increase in direct ratio to the latitude in which it is found. At the Falkland Islands and the northerly antarctic islands, *Macronectes* is chiefly a harmless scavenger; at the South Orkneys and in West Antarctica it is reputed to be no less destructive to bird life than the skua itself.

The gulls, and more especially the man-o'-war birds (*Fregata*), can descend upon beating wings to a position over the water, and there poise while they pick up floating food or even catch fish. It is curious that no tubinarine bird has evolved similar powers of feeding from the air. The closest approach to this type of feeding is found among the Hydrobatinae, petrels which habitually "stand" upon the water, facing the wind which supports them, and strike downward with their bills in much the same manner that *Fregata* strikes from the wing. All Tubinares dive, and some of the shearwaters (*Puffinus*) even dive from flight and "fly" under water, though the latter customs have been developed to their fullest extent only by the family of diving petrels (Pelecanoididae). These birds plunge into the sea from the air, and obtain their food entirely beneath the surface, propelling themselves through the water with their short, quick-moving wings. Their mode of feeding is therefore like that of the auklets rather than that of the plunging terns. It is perhaps not generally appreciated that all forms of Tubinares submerge themselves at least from the surface of the water, that is from a swimming position. I have seen *Oceanites* descend to a depth of several times its length in pursuit of food. Also I have seen the Giant Fulmar, and albatrosses of four or five species, dive so far that only the tips of their long and upraised wings projected above the surface.

The least specialized type of feeding among the Tubinares is probably that of the larger fulmars and the albatrosses, birds which immediately take to swimming when they have located their food. When the Giant Fulmars, for example, approach floating refuse in large masses, they do not alight in the midst of it, but invariably drop into the water a little distance away, and then swim toward the food. I have had opportunities to watch these birds regaling themselves at rafts of whale carcasses near southern whaling stations. The Cape Pigeon feeds in much the same manner. Even though it is a relatively small and agile bird, it nevertheless encounters more difficulty in rising from the water, especially when the wind is light, than the shearwaters, whale-birds, or Mother Carey's chickens. Still more are the larger fulmars and the albatrosses limited by the considerable exertion of launching into flight, with the result that *Macronectes*, and the species of *Diomedea* and *Phoebetria*, usually prefer to remain on the water for a considerable period after they have once alighted. In this respect they differ strongly from the nimble and restless gulls. The Wandering Albatross swims about amid the schools of its prey, and fishes in the manner of the White Pelican (*Pelecanus erythrorhynchos*), taking full advantage of a long, hooked beak and an extensible neck. Squids with bodies half a meter in length are none too large for it to manipulate. In calm weather it is so loath to undertake the effort of flying that it will sometimes allow itself to be run down by a steamer if it cannot escape the danger by swimming alone. In times of high winds, on the other hand, even this largest and heaviest of the Tubinares sometimes "stoops" for food and quickly resumes flight.

"Stooping" refers to the customary method of feeding among many petrels of the genus *Pterodroma*, as well as the shearwaters and their kin. These birds scour about in the air, generally very close to the water, and when they perceive food they drop down, seize it, and then take wing again. Shearwaters sometimes give chase to schools of fish by alternately flapping along the surface and diving quite out of sight, but they rise as soon as the immediate quest is ended. Both the shearwaters and the *Pterodroma* petrels occasionally "stand" on the water, sustained by rapidly beating wings, while they feed upon large and heavy objects such as the bodies of squids or fish.

Nearly three decades of whaling in antarctic waters have resulted in a curious unbalance in the feeding habits of many southern-hemisphere Tubinares and quite possibly in changes of distribution and population as well. That the influence is not negligible, even in the vast territory of the southern oceans, is shown by the fact that more than ten thousand whales have been slain in these circumpolar waters during a single year. Each of the carcasses, it is safe to assume, became in its turn a center of interest to birds. Lester (1923, 186) has written as follows of conditions at the South Shetlands:

> The whaling industry has undoubtedly become a great factor in the settlement of the food question for millions of Antarctic birds. Immediately after whaling had commenced and the carcases were brought into Whalers Bay, there appeared to arrive from nowhere a vast multitude of birds. Never have I seen such numbers as there were in this harbour. There were Giant, Silver, and Antarctic petrels, Black-backed gulls and Wilson's petrels, but these counted for little when compared with the thousands upon thousands of Cape pigeons; the water and air were filled with their bodies, and all had but one object in view, that of feeding upon whale. I have often witnessed the comical sight of two Cape pigeons fighting for the possession of one whale carcase. So great was the number of birds, and so taken up were they with feeding. that it was quite possible by leaning out of the boat to lift a Cape pigeon out of the water. By frightening a few, a roar as of a great storm could be created, because to frighten a few was to scare the million, and the noise from twice that number of wings was terrific. It was light all night long when we first arrived, and the screech from countless throats seldom abated while the light lasted; it was a din which once heard could never be forgotten.

The surface dancing of the Mother Carey's chickens is an extraordinary mode of feeding, and may be considered as an outgrowth of stooping. The stilt-legged *Oceanites* and *Fregetta* are better exemplars of this method than the petrels of the genus *Oceanodroma*. *Oceanites*, like other Tubinares, hunts on the wing, and when it has found its food it drops and, with legs straight, strikes its webs against the surface. Sometimes it flops down so impetuously that it also strikes its breast, but adult birds rarely swim while feeding. Instead they dance, supporting their weight partly by means of the impact and rebound of the feet, or by treading water, and partly by "leaning on the wind" with the wings set stiffly as planes. In the absence of air currents sufficient to maintain equilibrium, the birds accomplish the same purpose by holding the wings high and beating them rapidly. In this attitude they progress by skipping with both feet together, and they pick up the small particles of their food just as a sandpiper might pick up its food ashore.

The "scooping" of the blue whale-birds (*Pachyptila*) is the characteristic method of feeding that has given one species of these petrels the name "scooper," by which it is more or less widely known to seafarers in the southern hemisphere. Such whale-birds feed largely upon free-swimming crustacea, and when they find an area filled with these creatures, the birds descend to the water in flocks and progress with the odd, crawling motion referred to above as "hydroplaning," resting the breast upon the surface, but holding the outstretched wings slightly above it, the feet furnishing most of the motive power. Then while they scurry along rapidly, their heads are thrust under the water and their lamellated bills "scoop" for food.

The submerged feeding of the diving petrels has been described above, as has also the carrion feeding of *Macronectes* on the land. At such times the Giant Fulmars act precisely like vultures, thrusting their heads and necks into the interior of a seal carcass, for instance, until they are smeared with blood. They will also dig up and devour deposits of blubber that sealers have buried in the sand. The sea-elephant hunters of South Georgia and Kerguelen Island assert that the Giant Fulmars discover such caches through their sense of smell, but no well-checked experiments have yet decided this point. Strong (1911, 619) has shown that the olfactory lobes of the common Fulmar are relatively huge, and the folds of the turbinals complicated. This would seem significant, and in the biographies that follow further data are given concerning the olfactory sense. However well developed this may prove to be, the Tubinares, like the vultures, all rely much upon sight and a keen observation of the actions of one another. Nichols (1912, 46) has this to say about recognition marks in the group:

> The sailing flight characteristic of petrels and albatrosses, in which the bird glides inclined first to one side, then to the other, displays particularly well the patterns of both upper and lower surfaces. The white rump of the Mother Carey's Chickens is not noticeable among the white-caps when the birds flit aimlessly hither and thither, but when they fly steadily in one direction, their unchanging position makes them conspicuous from the rear. At times one sees streams of Mother Carey's Chickens flying swiftly and steadily in one direction, quite unlike their usual custom. I fancy that if any delectable food becomes available, birds at a distance see others go

to it and fly towards them, and we presently have streams of birds flying towards it from all the surrounding sea. When *Fregetta grallaria* gather to feed, the white rumps and lower surfaces of the high-held wings make a twinkling white effect conspicuous at considerable distance.

An interesting feature of the feeding of Tubinares is the intimate association of birds of various sizes and various sub-groups. In the southern hemisphere one rarely sees bands comprising only one species, or even half a dozen species, because, as before stated, the large and small birds interdigitate. Within a period of a few minutes, in the South Atlantic, I have seen 14 species, and almost as many genera (Murphy, 1914, 317). During a calm on December 2, 1890, in latitude 39° 51′ S., longitude 8° 49′ E., or southwest of the Cape of Good Hope, Parkin (1900, 675) shot examples of 13 species of Tubinares. Even in the northern oceans the bands of wandering and migrating shearwaters usually include 2 or 3 species, not counting the smaller petrels, such as *Oceanites* and *Oceanodroma*, which often mingle with them. There are few parts of the world where an observer might hope to see as many as 6 to 8 species of Laridae during one day, and several of these would surely be represented only by scattered individuals.

Certain species of Tubinares are at times enormously abundant over great tracts of the sea. The flocks of arctic Fulmars, mentioned by Darwin, have so overwhelmed the imaginations of witnesses that this bird has sometimes been singled out as the most numerous feathered creature in the world. If the breeding grounds of a species are greatly restricted and thoroughly known, it may be possible to compute a census with a reasonable approach to accuracy. Gurney, for example, estimated the world's population of Gannets (*Sula bassana*) at not more than 101,000 birds. The breeding grounds of many Tubinares are not well known, either as to locality or extent, but an observer who has seen the flights of such southern forms as *Pachyptila* filling the air like the flakes of a snowstorm, and stretching in all directions toward the circle of the horizon from daybreak until dark—yet never to the complete exclusion of other species—might be pardoned for extravagant assertions. The streaming rivers of the now-extinct Passenger Pigeons were doubtless composed of more densely packed birds; but this species travelled in concentrated formation, and was confined to the relatively small area of the North American continent. The whale-birds, as represented by several species, apparently range through an almost unbroken belt of ocean, which is some thirty degrees of latitude in width and encircles the earth.

THE ALBATROSSES

FAMILY DIOMEDEIDAE

At one time or another the albatrosses have apparently been of cosmopolitan distribution for, although no species now inhabits the tropical and north Atlantic area, the genus *Diomedea* is reported from Lower Pliocene formations of Europe. Older fossil genera bearing a resemblance to albatrosses include *Plotornis*, of the European Miocene, a bird apparently as close to the fulmars as to the albatrosses; and *Gigantornis*, of the Eocene of Nigeria, an enormous creature with a sternum showing twice the linear dimensions of that of the largest extant albatross. The characters of *Gigantornis*, however, merely approach those of the albatrosses. The remains indicate relationships with the Pelecaniformes as well as with the Procellariiformes.

Of the 13 existing species of albatrosses, several of which break up into two or more geographic races, 9 are confined to temperate and sub-antarctic regions of the southern oceans, 1 is technically equatorial although it feeds mostly in temperate waters, and 3 belong to the fauna of the North Pacific. Attempts to associate albatrosses, because of their peculiar style of flight, with belts of specific atmospheric densities, and hence with certain restricted latitudes of the northern and southern hemispheres, respectively, run into difficulties because of the presence of an equatorial species at the Galápagos Islands. Nevertheless, it is perhaps significant that the Galápagos Albatross migrates only in a southerly direction from its breeding ground, penetrating the belt of the southeast trade winds instead of travelling northward toward the doldrums of the thermal equator. Moreover, we do find more or less parallel types of certain albatrosses in about the same latitudes north and south of the geographic equator. The matter is discussed further in the biography of the Galápagos species.

The southern-hemisphere albatrosses illustrate a zonal type of distribution, with representative species or races of each group occupying distinct climatic areas. The most southerly albatrosses, like other antarctic marine organisms, are of circumpolar distribution, while the more northerly forms tend to be confined to definite ocean areas. Thus *Phoebetria palpebrata*, *Diomedea exulans exulans*, *D. melanophris* and *D. chrysostoma*, all of which are antarctic birds in the sense that they breed south of the Antarctic Convergence, enter ice-filled seas, and approach or cross the polar circle, are likewise of circumpolar distribution. *P. fusca* and *D. chlororhynchos*, on the other hand, belong to the temperate sub-antarctic belt and are characteristic of the South Atlantic-Indian Ocean area, which forms a natural zoögeographic unit because of the low latitude of the southern tip of Africa as contrasted with the high-latitude barriers of both South America and New Zealand. Similarly, *D. bulleri* is definitely characteristic of a Pacific temperate area. *D. cauta* may likewise be called a temperate-zone bird, but it appears to be represenred by one or more of its subspecies in each of the southern oceans.

D. epomophora, one of the two largest albatrosses, bears a much less definitely antarctic stamp than *D. exulans exulans*, but the range and the possible subspecies of the former are still very imperfectly known. The typical form of the Wandering Albatross (*exulans*) breeds for the most part at glacial islands such as South Georgia and Kerguelen which, as has been shown above, are either hydrologically antarctic or else lie very close to the Antarctic Convergence. The Royal Albatross (*epomophora*) attains its southernmost breeding stations at such localities as Campbell Island, and, presumably, Tierra del Fuego. These lie definitely in the Sub-Antarctic Zone of surface water. The climatic difference between South Georgia and Campbell Island can be expressed in terms of sheep, which thrive at Campbell but which soon succumb at South Georgia, despite an equal abundance of rich pasture.

Systematic knowledge regarding the subspecies of albatrosses is still very imperfect. Names galore have been applied, but the facts have rarely been worked out from series of specimens that can be definitely associated with known breeding grounds. This is particularly true of the forms of the Wandering Albatross, of which more than one subspecies possibly occur as breeding birds in the eastern hemisphere, as is true in the South Atlantic.

The existing albatrosses fall within two natural groups, of which the sooty albatrosses (*Phoebetria*) comprise one, and all the remaining species the other. Of the second group, called in this book by the comprehensive generic name *Diomedea*, the two species of great albatrosses, *exulans* and *epomophora*, stand apart from the remainder because of their size; but in bill characters, which have been used so much in the differentiation of genera, they are more unlike each other than either one is from certain of the lesser species. After comparing all the known albatrosses, and considering the several generic names which have been bestowed upon the smaller southern-hemisphere species and the birds of the North Pacific group, I am inclined to agree with Hartert (1926, 345) and with Peters (1931, 41) in concluding that these all belong within a common genus, *Diomedea*.

Phoebetria, the genus of Sooty Albatrosses, stands well apart from the others because of the great length of the tail, its cuneate form, and the persistence in the bill of a well-known primitive Tubinarine character, namely, the sulcus which divides the lateral plates of the lower mandible. All other members of the family have lost this groove, though its obsolescent traces show in most very young albatrosses and even in the adults of several species. The long tail and long slender wings of *Phoebetria* are associated with a type of flight which also distinguishes the two species of this genus from all other albatrosses. The mandibular sulcus and the dark plumage (a youthful character of certain other albatrosses) might lead to the conclusion that *Phoebetria* is a structurally primitive member of the family. Doubtless, however, it is at the same time highly specialized in certain respects.

The southern-hemisphere mollymauks, a group of albatrosses of uniform proportions though of varying bill structure, comprise the birds that have been called by the generic names *Thalassogeron*, *Thalassarche*, *Nealbatrus*, and *Diomedella*. Their tails, which are never pointed, average about 40 per cent of the length of the distal element of the wing. In the two great albatrosses (*exulans* and *epomophora*) the tail is still shorter, while in the Galápagos and North Pacific species it reaches its smallest relative size, being in some instances shorter than the bill. The Galápagos Albatross has, however, proportionately the largest bill of any member of the family.

The relationships of the southern mollymauks with the North Pacific albatrosses sometimes called by the generic name *Phoebastria*, have never been adequately studied. Certain forms in each hemisphere bear a close superficial resemblance to distant species in the other hemisphere. Andersen (1895, 91) has gone so far as to suggest that *D. melanophris* and *D. immutabilis* are genetically very closely related, and that one of these two has been derived directly from the other.

The South American coasts as a whole are richer in species of albatrosses than any other part of the world. The elongate continent not only shares with Australasia every one of the southern species, but has in addition the Galápagos Albatross, which seems to be a bird of highly restricted range. Eleven or perhaps twelve forms are treated in the succeeding biographies.

Our information about the habits of albatrosses is fragmentary and sketchy. To an extraordinary extent similar patterns of behavior seem to obtain through all the species of the family, which makes it the more important that we should gain exact and detailed descriptions of the courtship habits and other reactions of each species, in order that the distinctive features may be dissected out from the general mass of resemblance. Birds in general seem to be more dependent than mammals upon a fixed order of reactions leading toward any essential physiological function; if even a single stage in the series is disarranged, the whole process is nullified. This is eminently true of albatross courtship, which is quite different from mammalian courtship, perhaps because we may say that mammals woo more or less with the cortex of their brains while the courtship of birds functions rather through the corpus striatum. But much of what is called courtship among albatrosses proves upon investigation not to be courtship at all. This behavior is discussed hereafter in the light of existing information; much more is needed in the way of precise and objective accounts of just what the performing birds do. How many individuals take part, for example, at the different and successive stages of albatross dances? Do the sexes in any instance play a different rôle? What is the exact manner and sequence in the posture of the participants, the movements of the whole body and of the head, bill, wings, and feet? It is surprising how rarely such simple questions have been answered by descriptions in the literature.

Similar patterns are observable in other aspects of the reproductive behavior of albatrosses, and some of them have a clear survival import. Most species, for instance, build up a cone-shaped nest, yet one or two, such as the Galápagos Albatross, make no nest at all. It is interesting that the loss of nest-building, if such it be, has occurred in environments where there are no floods from melting snow or torrential rains during the breeding season.

Of the 13 known forms of albatrosses, including all their subspecies, 12 lay their egg during the months between September and January, that is, in the spring season of the southern hemisphere. Curiously enough, this applies to the northern-hemisphere species as well as to those of the farthest south. In the case of the North Pacific birds it would seem clear that stimulation of the pituitary gland, and a consequent beginning of the annual reproductive cycle, cannot be due to the effect of daily increasing light. Several of the southern-hemisphere albatrosses have a very long season of egg-laying at any one locality. At South Georgia, for example, the Wandering Albatrosses begin to lay soon after the middle of December, but other and in the main younger birds of the

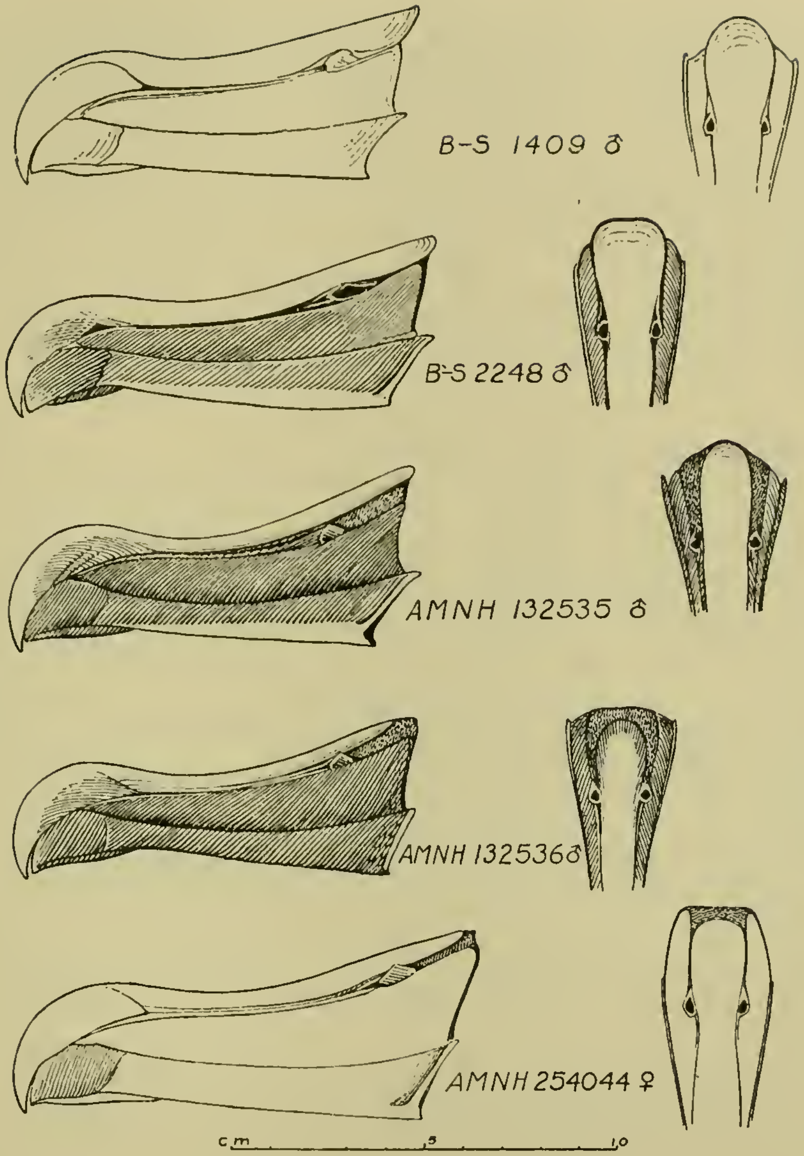


Fig. 52. Bills of Mollymauks. Lateral and dorsal aspects of the bills of five species, based upon specimens in the Brewster-Sanford and American Museum collections, to illustrate the form of the plates and of the integument in the commissures, and the distribution of color. Reading from the top downward: 1, *Diomedea melanophris* (Corral, Chile); 2, *D. bulleri* (Valparaiso, Chile); 3, *D. chrysostoma* (South Georgia); 4, *D. chlororhynchos* (South Atlantic); 5, *D. cauta salvini* (South Pacific).

same species carry on egg-deposition until the middle of February. The latest of the southern-hemisphere albatrosses to begin its reproductive cycle is the sub-antarctic *Diomedea bulleri*, which is said to produce its earliest eggs at the Snares, south of the southern tip of New Zealand, rather late in January.

The single exception to the rule of southern-springtime nesting is furnished by the Galápagos Albatross, which lays its eggs during May and June.

Brief descriptions of the eleven forms of South American albatrosses precede the respective biographies. It should be stated, however, that specimens of each of these species can be readily distinguished by bill characters alone. Therefore the accompanying figures are offered in lieu of further text.

SOOTY ALBATROSS

Phoebetria fusca

Diomedea fusca Hilsenberg, 1822, Froriep's Notiz., 3, p. 74 (Mozambique Channel).

Names: Brown Albatross; Pio or Peho (at Tristan da Cunha); "Albatros Obscuro" (in South America). A synonym of the specific name is *fuliginosa*.

Characters: Distinguishable from albatrosses of other genera by the rather uniform dark coloration, the long cuneate tail, the exceedingly narrow wings, the incomplete white eye-ring, and the broad yellow sulcus on the dark mandible, a feature visible only at close range. The peculiarly easy, graceful style of flight is diagnostic after it is once recognized. General color sooty brown, slightly paler on back and belly, and darker on head and face, the sides of the latter being blackish; a ring of white feathers, broken in front, around the eye; wing and tail quills blackish brown, the shafts white or whitish except at their distal ends. Iris olive-brown; bill black, the lower mandible divided by a long and broad sulcus filled with yellow or orange skin, the hue of which is persistent after death; legs and feet pale grayish flesh color.

Immature birds differ from adults in having a buffy collar, whitish nape, and brownish shafts to the quills.

In addition to the few specimens of this albatross in the American Museum of Natural History, I have examined all available material in the Rothschild Collection and the British and Berlin Museums. The following summaries of dimensions are based upon 13 specimens from the Atlantic and Indian Oceans, including two taken not far from the Australian coast.

9 skins (5 males, 4 doubtful males): wing, 481–516 (502); tail, 241–265 (255); exposed culmen, 111–116 (113.4); width of maxilla at base, 22.5–23 (22.8); depth of closed bill at base, 41–43 (41.7); least depth of closed bill, 22.5–25.5 (24.2); tarsus, 75.5–85 (81.2); middle toe with claw, 119–125 (120) mm.

3 females and 1 doubtful female: wing, 497–515 (503); tail, 237–253 (245); exposed culmen, 110–114 (112); tarsus, 76–83 (79.5); middle toe with claw, 112–120 (116.8) mm.

Mathews (1932, 39) reports that the eggs of *Phoebetria fusca* at Tristan da Cunha are relatively wider than those of other albatrosses; but among ten obtained by Comer at Gough Island the form varied from elongate ovate to very short and round. The ground color is white, with a slight grayish tint, the whole egg being covered with minute specks of grayish brown. In most specimens these specks become larger and denser about the large end, occasionally forming a slight zone (Verrill, 1895, 446). Verrill records the dimensions of these ten eggs as follows:

Average, 101.7 x 66.5 mm.

Average cubic contents, 220 cc.

Smallest egg, 94 x 66.8 mm.

Longest and narrowest egg, 107.4 x 64 mm.

Largest egg, 101.6 x 69.6 mm. (226 cc.).

Mathews (1932, 42) says that among a series from Tristan da Cunha some are almost unmarked, while others are speckled or ringed with reddish. The average measurements of eight eggs are 100 x 67 mm.

Distribution: The South Atlantic and Indian Oceans, eastward to Australia; confined chiefly to temperate sub-antarctic latitudes, though recorded from as far south as latitude 55° S. Breeds at Gough Island and the islands of the Tristan da Cunha group in the South Atlantic, and perhaps at St. Paul Island in the Indian Ocean (Pelzeln, 1869, 149; Studer, 1879, 107).

The two species of Sooty Albatrosses, which are readily distinguishable in life, illustrate a type of distribution made familiar by certain other closely related sea birds of the southern hemisphere. The brown species (*Phoebetria fusca*) belongs to relatively low latitudes and is confined, so far as known, to the Atlantic-Indian Ocean region. The second, or light-mantled species (*palpebrata*) is antarctic and circumpolar, neither Cape Horn nor New Zealand offering a barrier to its spread around the globe. The two species mingle in parts of their pelagic range, but each returns to its own breeding zone, which is separated by not less than ten degrees of latitude from that of its congener. Among other albatrosses, the Yellow-nosed (*Diomedea chlororhynchos*) and the Gray-headed (*D. chrysostoma*) have an exactly parallel relationship, the former belonging to the milder Indian-Atlantic region, the latter to the icy circumpolar belt.

Only within recent times have the two Sooty Albatrosses been recognized as distinct species, originating in different climatic regions. Therefore many older observations in the literature are stamped with more or less uncertainty. In the case of birds studied at their nesting grounds, however, we can always be sure of the species referred to.

In a family of supreme fliers, the Sooty Albatrosses occupy a special pinnacle of excellence. Of the present species Gould (1865, 441) has written:

> The cuneated form of the tail, which is peculiar to this species, together with its slight and small legs and more delicate structure, clearly indicate that it is the most aërial species . . . ; and accordingly we find that in its actions and mode of flight it differs very considerably from all the other species of albatrosses, its aërial evolutions being far more easy, its flight much higher, and its stoops more rapid; it is moreover the only species that passes directly over the ship, which it frequently does in blowing weather, often poising itself over the masthead, as if inquisitively viewing the scene below.

Green (1887, 14), too, remarks that its special object at sea "seems to be to study the trucks of masts, especially if vanes are carried. Round these it circles in the most marvellous manner."

In the same strain, Hutton (1865, 294) has recorded the following:

> The unrivalled flight of the Albatros has been the admiration of voyagers from the earliest time. Day after day, with unabated interest, I have watched them, and I quite agree with Mr. Gould that the Sooty Albatros (*D. fuliginosa*) carries off the palm from all competitors. Never have I seen anything to equal the ease and grace of this bird as he sweeps past, often within a few yards, every part of his body perfectly motionless except the head and eye, which turn slowly, and seem to take notice of everything. I have sometimes watched narrowly one of these birds sailing and wheeling about in all directions for more than an hour, without seeing the slightest movement of the wings. This, however, is longer than usual.

During the southward cruise of the brig 'Daisy,' in November, 1912, I did not see the Brown Sooty Albatross, at least at close enough range to recognize it. But, returning from South Georgia after the antarctic summer, we picked up three at about 50° S., on March 17, and thereafter had the species with us every day until March 27, in latitude 37° 40′ S., longitude 30° 58′ W. The largest numbers were noted between the 42d and 38th parallels, whereas the Light-mantled or Antarctic Sooty Albatross (*Phoebetria palpebrata*) had disappeared in the neighborhood of 47° S. A male and a female of the brown species were collected near latitude 39° S., on March 26. An example in immature plumage, conspicuous because of its buffy, mottled collar, joined the 'Daisy' on March 23, in latitude 42° S., and was seen frequently during the next four days. Buller (1893, 195) quotes a Captain Kempson to the effect that a marked bird had followed his ship for 3000 miles.

The two species of Sooty Albatrosses are of about the same size and form and are equally gifted and beautiful as regards aërial performance, but the color of back and breast is different enough to distinguish them, even at long range. Moreover, when they closely approach a vessel, the yellow fleshy sulcus on the lower bill of the temperate species is easily visible to the naked eye. The blue sulcus of the antarctic species is rather more difficult to make out when the bird is in air. The distinctness of the two species in life has been noted by many other observers, some of whom have recorded, moreover, their correct geographic relationship, despite the fact that the birds mingle and overlap at sea (Hutton, 1867, 186; Wilton, Pirie and Brown, 1908, 75; Wilkins, 1923, 503; Lowe and Kinnear, 1930, 183).

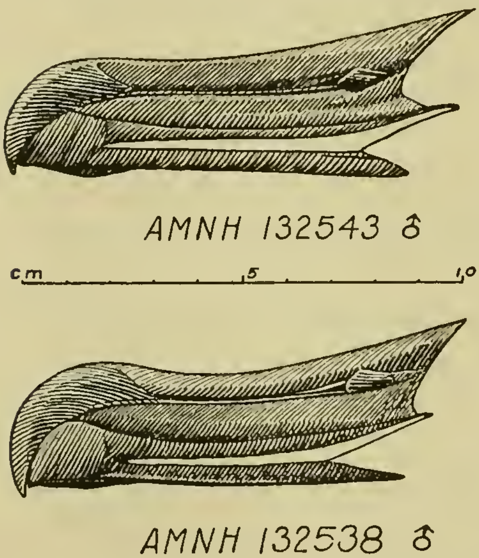


Fig. 53. Bills of the two species of Sooty Albatrosses. Above, *Phoebetria fusca*, with a yellow sulcus (latitude 39° S., longitude 31° W., South Atlantic); below, *P. palpebrata*, with a blue sulcus (collected on the nest at South Georgia).

During the voyage of the 'Scotia,' both kinds of Sooty Albatrosses were seen not far from Bouvet Island, several being shot and one taken on hook and line. Both species are likewise common in the waters about Gough Island during the southern winter, as reported by Wilkins and others, but the latitude of Tristan da Cunha seems to be just a little north of the normal range of *palpebrata:* all the discriminating records for this vicinity refer to *fusca* alone.

At Tristan, the Sooty Albatross returns from its pelagic wanderings in August, and departs again in April (Barrow, 1910, 275). Breeding activities are under way by September. By most recorders the nests are said to be scattered rather than colonial, and to be built in lonely and dangerous sites, such as the shelves and brinks of cliffs. This would make the habits of the bird agree with those of the Antarctic Sooty Albatross, but there are early accounts which indicate that before the era of human settlement *Phoebetria fusca* was perhaps a somewhat gregarious species at Tristan da Cunha. Godman (1910, 365) notes that the species is recorded "as occasionally breeding in societies." It would be difficult to make any other interpretation of Carmichael's observations during December, 1816. He writes that on the higher slopes of Tristan da Cunha the "black albatrosses (*D. fuliginosa*)" were nesting so close together that he reckoned upwards of a hundred of their six-inch conical piles within half an acre. At this date the chicks were half-grown.

> There was something extremely grotesque in the appearance of these birds standing on their respective hillocks motionless like so many statues, until we approached close to them, when they set up the strangest clattering with their beaks, and, if we touched them, squirted on us a deluge of foetid oily fluid from the stomach (Carmichael, 1818, 489).

Captain Comer states that at Gough Island the Sooty Albatrosses do not form rookeries, but build their low nests of grass and mud on the cliffs. "They commence laying by the middle of September and lay one egg, but when killed have a number of small eggs inside. While sitting on their nests they keep up a continual cry similar to that of a young goat" (Verrill, 1895, 445).

While the 'Scotia,' of the Scottish National Antarctic Expedition, lay off Gough Island, during April, 1904, the cook caught six Sooty Albatrosses on fishhooks. One of the birds spewed up a cuttlefish, the only specific evidence I can find regarding the staple food.

We are even more ignorant concerning the appearance of the down and first plumage in this species. Reference to the buffy or whitish collar of immature examples has been made above, but I suspect that light-tipped feathers are still more conspicuous on juvenals in, or recently out of, the nest. The skin of a young female in the British Museum, which was collected by a member of the 'Quest' expedition off Nightingale Island, Tristan group, May 25, 1922, has many buffy feather-terminations.

LIGHT-MANTLED SOOTY ALBATROSS

Phoebetria palpebrata

Diomedea palpebrata Forster, 1785, Mém. Math. Phys. Paris, 10, p. 571, pl. 15 (Latitudes 47° to 71° 10′ S. = 64° S., 38° E.).

Names: Antarctic Sooty Albatross; Pio, Piew, Pee-arr, Peole (sailors' names at various islands); Blue Bird; Stinkpot. A synonym of the specific name is *cornicoides*, besides which the name *fuliginosa* includes this species in the older literature.

Characters: In form similar to *Phoebetria fusca*, but differing in that the feathers of the back and ventral surface are decidedly paler than the remainder of the plumage. The culmen of the bill, moreover, is concave rather than nearly straight, and the sulcus of the mandible, which is narrower than in the other species, is filled with integument of a bluish hue in life. Wing-spread 2 meters or thereabouts. Head dusky grayish brown, nearly black on lores; a white ring, broken in front and on the anterior half of the lower lid, encircling the eye, as in *P. fusca;* mantle pale ashy gray, blending on the nape with the dark shade of the head, and lightest in center of back; rump and scapulars dark gray; wings dark brownish gray, the quills blackish with white shafts, as are also the rectrices. Iris dark olive-brown; bill black, with the mandibular sulcus varying from very pale blue to purplish or violet, but quickly discoloring after death; skin of mentum blue under the feathers; legs and feet pale flesh color with a vinaceous wash over the scales; claws white.

The immature plumage resembles that of adults, except that the shafts of the long quills are brownish or horny, rather than white.

For the purpose of comparing birds from several parts of the circumpolar range, the measurements are presented in tabular form. Since most of the Indian Ocean specimens lacked sex determination, I have not discriminated among the ten birds from this region. They come from Kerguelen, the Crozet and Prince Edward Islands, and the intervening waters. The 15 New Zealand specimens are chiefly from waters near the Antipodes, Macquarie, and Auckland Islands, together with several from nesting sites on these islands.

		Wing	Tail	Exposed culmen	Tarsus	Middle toe with claw
South Georgia	12♂	503–552 (524)	249–294 (271)	103–117 (111.4)	80–87 (83.2)	120–128 (124.3)
	8♀	490–526 (511)	236–276 (267)	98–117 (109)	78–84 (80.9)	116–125 (121)
New Zealand region	9♂	511–548 (526)	257–278 (274)	101–115 (107)	80–86 (81.7)	121–130 (123.7)
	6♀	511–543 (525)	265–290 (273)	101–107 (104.3)	78–82 (80.2)	115–124 (119.4)
Indian Ocean	10♂ and ♀	507–545 (528)	236–274 (262)	99–110 (103.1)	77–86 (80.3)	115–131 (121.3)

Additional measurements of 9 males are: width of maxilla at base, 23–25 (23.6); depth of closed bill, 38–45 (41.5) mm.

The wing-spread of a specimen measured at Kerguelen Island was 210 cm. (Werth, 1925, 583). Scouler (1826, 203) found that several of the largest among forty captured west of Tierra del Fuego measured 213 cm. across the wings, and weighed up to 2268 grams.

To judge by published data, the eggs of this species are highly variable in size. Two from Kerguelen Island are of broadly ovoidal form, marked by a collection of reddish specks about the larger end. The shell is compact, rather thin, and superficially smooth, although with many microscopic pits and linear depressions, being in this respect quite unlike the loose granular texture and mammilated surface of the eggs of *Diomedea exulans*. The two measure 100.3 x 67 and 100.3 x 66 mm. (Kidder and Coues, 1876, 12).

An egg from South Georgia differs only in size from eggs of *Phoebetria fusca* collected at Gough Island. It measures 106.7 x 69 mm., and has a cubic capacity of 250 cc. (Verrill, 1895, 446). One that I collected at Cumberland Bay, December 1, 1912, measures 103 x 68.5 mm.

Oliver (1930, 165) records an egg from Auckland Island measuring 118 x 74.5 mm., and Mathews and Iredale (1921, 49) give 103 x 66 mm. as average dimensions of certain eggs from the New Zealand region.

Distribution: Circumpolar in the pan-antarctic belt, ranging from about the 35th parallel, or somewhat farther northward in cold-current regions, southward into the zone of pack-ice and beyond the antarctic circle. Breeds at Antipodes, Campbell, Auckland, Macquarie, Kerguelen, Crozet, Prince Edward, and South Georgia Islands, and, in all probability, at Heard, Bouvet (Vanhöffen, 1901, 310; Reichenow, 1904, 347), and the South Sandwich Islands.

The Antarctic Sooty Albatross, with its pearly body contrasting with the dark cap and wings—giving it the fanciful appearance of a cowled monk—was the first of the two species to receive notice in the literature of exploration, and the first to be described and named. In Captain James Cook's journal of circumnavigation, the bird is referred to as being shot by Dr. Forster in latitude 64° 12′ S., longitude 38° 13′ E., close to the border line of the southern Indian and Atlantic Oceans. This position, therefore, makes a satisfactory restriction of type locality from the wide range given by the describer (Mathews, 1912, 302).

Most of the bird's vernacular names, such as "Piew" and "Pee-arr," are taken from its peculiar call at the breeding grounds. "Blue Bird" is a sealers' name from islands in the Indian Ocean, and it emphasizes very fairly the difference between the Antarctic and the South Temperate Sooty Albatrosses. The latter could be called only a "brown bird," whereas the former actually does look blue in the strongly actinic light of the far south. "Stinkpot" is a name I have heard used by sailors and have read in log books of the sea-elephant hunters. Green (1887, 14) refers to the disagreeable smell of the species, but I have never noticed it among either living or dead examples. Ainsworth (1915, 190) says that the egg has a peculiar and disagreeable odor.

I became acquainted with this albatross during the southward cruise of the brig 'Daisy,' in the high thirties of the South Atlantic, during November, 1912. The Sooties were the premier fliers among the host of petrels and albatrosses that followed in our wake, but they differed from all the others in their apparent lack of interest in bait trailed on lines. In some respects they seemed the wariest of all the Tubinares, and yet on occasion they would sail across the quarterdeck, or even between the masts. Free offerings, *i. e.* food not tied to a hook, would bring them to the water, where they usually quarreled among themselves with hollow, ghostly trumpetings, as weird a sound as I have ever heard from the throat of a bird. They did not dive after sinking objects, as the mollymauks do, but at the surface they would seize floating oakum, paper, shavings, etc., and shake them in the water so that the foam flew. Once I saw three of them alight successively astern, each solemnly to pick up, shake, and discard the same chip of wood.

On November 18, in latitude 48° 39′ S., longitude 36° 40′ W., we lay to all day under fore-staysail and trisail, in the teeth of a southwesterly gale—a pampero, I suppose it should be called. Dark weather alternated with bright sunshine; the temperature averaged about 4.4° C.; there were several brief hailstorms; spray broke over us continually, but we shipped no heavy seas. During the morning four Sooty Albatrosses joined us and remained near-by for five hours, appearing to have no other purpose than to play in the howling wind for the admiration of us on board. Their ease and precision, and particularly their ability to vary their speed and to "stand still" in the air, put them in a class by themselves. To scratch their polls with the claws caused no hitch in their gyrations, and one of them was seen to turn down its head and preen the feathers of its belly without losing its place in the squad. Their white-ringed eyes, which gave them a sort of perpetually astonished expression, were conspicuous even at several ship's lengths. No doubt these queer orbital marks, together with the somber guise of the fowl, have been responsible both for the name *Phoebetria*, "the prophet," and for the legendary place that the Sooty Albatross seems to hold among seafarers.

For several days thereafter, when the 'Daisy' had resumed her southward way, the group of four Sooty Albatrosses from time to time made up a unit about the brig, even though unassociated individuals might also be sighted here and there. The quartet was with us mostly during late afternoon each day, and for the reasons which follow I believe that it was composed of the four identical birds which had first joined us during the great gale. On the evening of November 20, I shot one of these Sooties as the four of them crossed our deck amidships. The victim tumbled into the arms of a sailor, nearly knocking him down. Shortly after noon next day, in latitude 51° S., a group of *three* Sooty Albatrosses overtook us and drilled in the usual formation. The same was again true on November 22; and in late afternoon of the 23d, just after we had made out the white highlands of South Georgia, the familiar trio again appeared, encircling the brig and poising successively on the tip of the bowsprit and over the gilded truck of the fore-topgallant mast. To one who has watched the clumsy landings of Wandering Albatrosses and mollymauks, wonderful fliers though they be, the grace of a Sooty Albatross while raising its wings and planting its dainty feet upon the moving tip of a spar, seems inimitable. And yet, despite its exquisite skill, the bird has been known to collide with the upper stays of a ship during stormy weather, and to come crashing to the deck (Menegaux, 1907, 67).

November 24, when the 'Daisy' anchored in Cumberland Bay, South Georgia, was clear and tranquil, and during the forenoon I saw a score or so of Sooty Albatrosses, along with other sea birds, wheeling so far up into the heavens that they quite disappeared from our view. This phenomenon is more fully described in the biography of the Wandering Albatross.

During the course of the Brewster-Sanford Expedition, Mr. Beck saw Light-mantled Sooty Albatrosses near the Falkland Islands and Staten Island, in September, 1915, but he secured no specimens and discovered no breeding stations. In this connection I would point out that the breeding records for this species reported by Bent (1922, 25) from "Cape Horn" are, at best, very dubious. In all probability the eggs to which Bent referred were those of some species of mollymauk.

Our American Museum examples of Light-mantled Sooty Albatrosses comprise chiefly a series of breeding birds obtained by J. G. Correia and myself at South Georgia, and a series from New Zealand waters collected by Beck during the Whitney South Sea Expedition. Examples from the southern Indian Ocean and elsewhere, examined in other museums of the United States and Europe, bring the total number of skins which have passed through my hands up to 55.

In 1914 Mr. J. T. Nichols and I published a review of the genus *Phoebetria* (Nichols and Murphy, 1914, 526) in which we admitted four subspecies of *Phoebetria palpebrata*, one breeding at the Indian Ocean islands, one at the New Zealand sub-antarctic islands, one at South Georgia, and a fourth based upon two birds of unknown nativity collected in the Pacific. Our only fully adequate data lay in an excellent series from South Georgia, but the measurements of five scattered specimens from other localities seemed to confirm the classification of Mathews (1912, 303).

Comparison of large numbers of specimens from breeding stations has since compelled me to change my opinion altogether. The color differences pointed out by Mathews do not hold; they can all be matched in a series of breeding birds from any part of the range. Measurements offer no better ground for discrimination, as will be seen from the tables presented above. Differences in dimensions relate to the sexual discrepancy, to age, or to the ordinary amplitude of individual variation.

In the last category belong, no doubt, the alleged characters of the bird which Nichols and I described as *Phoebetria palpebrata auduboni*, and which is so given in the "Check-List of North American Birds." At the time of our publication the Light-mantled Sooty Albatross was supposed to be an uncommon bird in the South Pacific, but the converse is now apparent. For instance, on the homeward voyage of the British Antarctic Expedition vessel, 'Terra Nova,' from New Zealand *via* Cape Horn, this albatross was recorded continually to a point northeast of the Falkland Islands (Lowe and Kinnear, 1930, 182). Furthermore, a number of overlooked early records prove that it is an abundant bird to westward of southern South America. Thus Scouler captured forty specimens during a calm on November 8, 1824, four days after rounding Cape Horn into the Pacific. He writes:

Some of these birds measured seven feet between the tips of the wings. Their weight did not correspond well with their size, as they generally weighed about five pounds. This was owing to the very thick plumage with which they were provided. The physiognomy of this albatross is very remarkable; its flat head and crooked bill give it some resemblance to the owl, which is much heightened by its large eyes and very convex cornea,—a structure which renders it probable that this animal seeks its food chiefly during twilight. The oesophagus of this bird is furnished at its upper part with an apparatus similar to what we find in the gullets of the marine turtles, and probably for a similar use, as the albatross lives principally on molluscous animals of the genus *Sepia*.

As we advanced to the north, the *D. fuliginosa* became more scarce, while the larger species, the *D. exulans*, appeared more abundant (Scouler, 1826, 203).

The "apparatus" in the esophagus is doubtless a reference to the spines which line both gullet and mouth, providing for the free passage of solid objects chiefly in one direction.

In its pelagic range the Light-mantled Sooty Albatross is the most southerly member of the whole family. Moreover, it breeds at a larger proportion of the colder antarctic islands than any other albatross. Since in nesting habits it is a hermit and a cliff-dweller, it requires neither grassy plateaus nor snow-free slopes, and various references in the literature make it seem probable that Bouvet Island and certain islands of the South Sandwich group belong within its breeding range.

Although South Georgia is the closest known breeding station to South America, this albatross is at times abundant along both the Atlantic and Pacific coasts of the continent. Paessler observed it during the southern winter season from 40° S. in the Atlantic to the Falkland Islands, thence through the Magellanic waterways and up the west coast of South America to northern Chile. In spring it was abundant off the Chonos Archipelago, and a specimen was collected at Iquique, or well within tropical latitudes (Paessler, 1909, 100; 1913, 42; 1914, 272, 274). These observations, and the somewhat dubious records from farther north in the Pacific (Nichols and Murphy, 1914, 532) make it seem likely that *Phoebetria palpebrata*, like so many other antarctic Tubinares, should be looked for as a regular member of the Humboldt Current fauna, at least in the southerly parts of that distinctive littoral belt.

Eastward and southward from the Magellanic region the Light-mantled Sooty Albatross is an equally common bird (Andersson, 1908, 48). Bennett (1920, 34) reports a large number over ice-filled waters close to the coast of West Antarctica, latitudes 64° 50′ to 66° S., on March 6. In January the members of Dr. Charcot's Expedition also observed many of the birds near Graham Land and the Palmer Archipelago, during stormy weather which had broken up icebergs and freed a great number of dead fish (Menegaux, 1907, 67). The 'Scotia' party logged the species as far south as latitude 67° S., the same parallel at which Ross had reported an example in Weddell Sea on March 1, 1843 (Clarke, 1913, 266). Gain (1914, 158) notes repeated observation of from one to six birds of the species along a course extending from Bransfield Strait southward and westward to latitude 70° 15′ S., longitude 121° west of Paris; and Bernacchi's (1901, 316) records go still farther southward into the pack-ice of Ross Sea, on the opposite side of Antarctica. The 'Challenger' expedition collected at least one specimen of this albatross at the edge of pack-ice on February 10 (Saunders, 1901, 230). The southernmost records all relate, as might be expected, to the season of antarctic summer.

There can be little doubt that the antarctic observations all, or practically all, relate to *Phoebetria palpebrata*, even though many were published under the old inclusive name, *fuliginosa*. There is no evidence that the temperate zone species, *P. fusca*, approaches the polar circle or inhabits ice-filled seas. Midway between South Georgia and Tristan da Cunha, which are 2500 kilometers apart, Wilkins (1923, 495) saw both species together. Within two days' journey northward from this point, however, *palpebrata* had been left behind and *fusca* was the only one seen thereafter. Chun (1900, 167) reports that the 'Valdivia' encountered *fusca* about halfway between the Cape of Good Hope and Bouvet Island during November, and that *palpebrata* was seen almost daily from Bouvet Island southwards. Both species were observed off Gough Island by the 'Scotia' party during April, *palpebrata* being in lesser numbers than *fusca* (Clarke, 1913, 289). I saw the two in company between latitudes 47° and 50° S., in the Atlantic, during March. The detailed observations of Wilson and other observers show that the geographic relation between the two species is substantially the same in the Indian Ocean (Lowe and Kinnear, 1930, 180, 183).

The breeding of the Light-mantled Sooty Albatross at many islands in the eastern hemisphere has been described by Hutton (1865, 284), Kidder (1875, 21), Moseley (1879, 180), Studer (1879, 107), Hall (1900, 18), Vanhöffen (1901, 314; 1905, 505), Ainsworth (1915, 189), Loranchet (1916, 256), and Werth (1925, 583). The accounts show that the habits of the bird agree at all breeding stations from the New Zealand and Indian Ocean regions to South Georgia.

The species is common at sea off South Georgia throughout the year, and flocks of a dozen or so birds may sometimes be found sitting on the water at the mouths of the fiords (Matthews, 1929, 570). The first appearance of Sooty Albatrosses in the neighborhood of their nesting sites on the cliffs was noted by members of the German International Polar Expedition at Royal Bay on October 16 (Will, 1884, 38; Pagenstecher, 1885, 23). The method of selecting territory, and the preliminary stages of mating, are unknown. Possibly courtship is begun at sea, or in the bays, for the birds appear to be mated when they occupy rhe ledges of cliffs, which may be at various altitudes above the sea or above the floors of inland valleys.

While the pairs of Sooty Albatrosses have no gregarious interest in others of their kind during the breeding season, neither do they exhibit any territorial jealousy against the close proximity of another nest. I found nests on ledges only a few meters apart, and the same phenomenon has been reported by others (von den Steinen, 1890, 256; Matthews, 1929, 570). At Prince Olaf Harbor, South Georgia, I also saw an occupied Sooty Albatross nest in a niche just above a ledge full of cormorant nests.

During construction of the nest, mated birds sit side by side, entwining their necks, rubbing beaks, and uttering their peculiar cry (Ainsworth, 1915, 189). The nests vary greatly in size, according to the amount of earth or humus available upon the ledge. I saw several which were very slight and flattish. On the other hand, if mud is plentiful the mounds may be built up to a height of 30 centimeters, with a diameter somewhat greater. Sometimes the bowl is lined with a little grass; the sitting birds are forever tugging at any that grows within their reach.

Of the nesting habits at Kerguelen Island, Eaton (Sharpe, 1879, 148) writes:

> In dry nooks . . . *D. fuliginosa* constructs its nest of pieces of adjacent plants (especially *Festuca erecta*) disposed in the form of a low truncated cone hollowed out at the top. The nests appear to be used many years in succession, as the original materials of several that were examined seemed to have been reduced by age to vegetable mould. These old fabrics are relined with fresh dry grass when the birds return at the commencement of the breeding season. The position of her nest is liable to be betrayed to persons walking within sight of the female when she is sitting, for every now and then while she is observing their movements she will utter her cry. . . . If anyone goes near her she assumes a rather formidable attitude, and ruffling up the feathers of the neck snaps fiercely and loudly with her beak at the intruder, the noise resembling that made by a large dog in catching flies.

The lamentful note of the Light-mantled Sooty Albatross has been variously described as a screech (Hutton, 1865, 284), as resembling the *meow* of a cat (Kidder, 1875, 21; Hall, 1900, 18; Menegaux, 1907, 67), or the cry of an ass (Will, 1884, 138). It is heard most often before the egg appears, or during the early days of incubation when, by calling both upon the ledges and in air, the birds inevitably betray the nest. After the egg hatches, the adults tend to become silent. Matthews (1929, 571) thus describes the note:

> At the nesting season a loud shrill cry is produced. One pair was found at the nest before the egg was laid. The female sat on the nest while the male stood on the ledge near by, frequently uttering this cry. It consists of two notes, first a loud shrill one made with the beak open and the head thrown back, so that the bird is looking straight up into the sky. This is an expiratory note and is immediately followed by a much lower and quieter inspiratory note, made with the bill closed and held pointing down to the ground so that the under surface of the mandible rests against the breast. Every two or three times the male did this the female stood up on the nest and answered in the same way and then sat down again.

Members of the German Expedition found that at South Georgia a pair of birds which had occupied a nesting site on October 16 had produced an egg (which the birds immediately abandoned) by November 1 (von den Steinen, 1890, 256). I am unable to trace the source of South Georgia egg dates given by Bent (1922, 25) as "October 8 and 10." They are probably erroneous. Matthews reports that the last week of October and the first of November mark the height of the egg-laying period. I have, however, taken a freshly laid egg as late as December 1. The term of incubation is not precisely known but is not likely to be shorter than 60 days. I saw young in various stages of growth between January 6 and March 3. One collected by Correia on March 29 is in the midst of losing the down, being nearly bare of it on the dorsal surface. According to Hutton (1865, 284), the fledglings at Kerguelen Island go to sea during May.

On the stormiest days in the Bay of Isles, South Georgia, the Sooty Albatrosses, together with two species of mollymauks, would spend more or less time about our anchored brig. Wherever perilous headlands rose abruptly from the waves, we could find them at any hour and in all weathers. While one of a pair was sitting, we often saw the other sailing with inspiring, effortless motion back and forth, regardless of whirlwind snow flurries from the heights, always passing close to the nest and seeming to gaze at its quiet mate. During four months I saw plenty of nests crowded against the faces of sheer cliffs, as high as 200 meters above the beaches, but there were not more than three of them that a man could have reached. Two of these were at the Bay of Isles—one within 30 meters of the breaking waves, the other about 4 meters above the first—both sheltered by an overhanging rock wall. In each household the sitting birds apparently dreamed away the long weeks of incubation, for we could see them sleeping with bills tucked under their wing coverts.

On January 20, 1913, I clambered up to the lower of the two eyries with a camera. The nest proved to be a very slight accumulation of blackish soil, the platform being barely higher than the rocky shelf. The male parent, which was brooding a downy chick, grunted softly and snapped his beak with a hollow "chop." When I had backed away two meters (as far as the ledge would allow), he snuggled down and began to draw blades of grass through his bill, now and then glancing at me with the solemn, wide-eyed expression caused by the orbital ring. Presently the youngster also took an interest in the strange intruder, and stuck its head out from beneath its sire, snapping the bill just as the old bird had done. The chick looked like a nestling vulture because of the bent beak, and because the covering of the head was very short while long curly down covered the rest of its body.

When I hauled the young albatross out of the nest (after ejecting the father!), it immediately crawled back, in spite of its weak, almost helpless legs. The South Georgia sealers had already told me how closely the young Pee-arrs cling to their cradles. The instinct to lie in one particular spot from birth until flying time is strongly developed. After my visit to one such narrow, dizzy ledge, it was easy to understand that natural selection could hardly fail to weed out all the restless, fidgety chicks, leaving to perpetuate the race only those which are content to lie low and bide their time.

In the biography of the Wandering Albatross will be found an account of the experimental flights which the fledglings of that species make before they leave their islets. It is obvious from the nature of the nesting site that this reaction has no close parallel in the behavior of the young Sooty Albatrosses. Their first flight must be a capable and successful flight or they would be dashed to pieces. For the same reason the adult Sooty Albatrosses have little use for their legs ashore. They are capable of walking a few steps on their ledges, but they never need run to a take-off, and I very much doubt whether it would be possible for them to do so. On the rocks they certainly spend most of their time in a squatting attitude, and the process of taking wing involves no more effort than pitching forward into space. It is to be regretted that I have no specific notes on the manner in which the Sooty Albatross takes flight from the surface of the ocean.

Squid beaks were found in the stomachs of Sooty Albatrosses collected at South Georgia.

A well-grown nestling demonstrates the important fact that chicks moult directly from the gray down into a plumage practically indistinguishable from that of adults. *Phoebetria fusca* appears to have a distinctive juvenal plumage, but in the South Georgia nestling of *P. palpebrata* the new feathers of back, scapulars, and sides are of a pale hoary shade, quite as light as the pearly feathers of adults. The ventral surface of this chick is still covered with a mattress of down.

BLACK-BROWED ALBATROSS

Diomedea melanophris

Diomedea melanophris Temminck, 1828, Planch. Color. d'Ois., 4, livr. 77, pl. 456 and text (Cape of Good Hope).

Names: Mollymauk, Molliemawk, Mollymoke, Mallemuc, Mollyhawk (variously spelled and pronounced), or Molly; Spectacled Albatross; "Pájaro Carnero," "Pato Carnero," and "Lagartón" (Wace, 1921, 196) in Spanish-speaking South America; "Gaivotão" and "Albatroz" in Brazil. The specific name has often been spelled *melanophrys*, and various subspecies have been described.

Characters: The only white-headed mollymauk in which the adult has a wholly yellow bill. This and the dark line over and through the eye are diagnostic. Wing-spread approaching a maximum of 2.5 m.; length of body, 80–95 cm. Head, neck, rump, upper tail coverts, and ventral surface white; lores, and a streak above and through the eye black, more pronounced in front of than behind eye; scapulars, wings, and tail dark brown, the quills terminally blackish, becoming white on the shafts and webs toward their bases; wing-lining white, more or less shaded with gray, except at the edges of the wing, where the marginal feathers are dark brown. Iris brown; bill yellow (sometimes as bright as gamboge-yellow), becoming orange, pink, or even red on the hook of the maxilla; a narrow ring of black skin around the base of the maxilla; legs and feet usually bluish gray or grayish flesh color, darker blue or violet on the joints and webs (owing to wide individual variation the feet range from whitish to dark purplish red among birds in the same region); claws horn-color or whitish.

Young birds differ from adults in that the pileum and nape are strongly suffused with ashy or slaty gray; the bill is grayish black, and the under surface of the wing dark except for a rather narrow axial streak. In later stages preceding maturity, the head becomes white while the bill is horny or yellowish brown.

Birds taken at sea usually have long, heavy claws. The claws of those captured on or near the nesting ground show the effects of wear, being sometimes rather stumpy.

Measurements of 38 adult specimens from the South American region, *i. e.* South Georgia, the Falklands, Magellanica, and the Atlantic and Pacific coasts of the continent, show that one form of the Black-browed Mollymauk occurs throughout this range. Moreover, the figures are entirely comparable with those given by Lowe and Kinnear (1930, 170) for the eastern hemisphere. The sexes appear to differ little if any in size.

24 males: wing, 487–544 (503); tail, 172–201 (188.3); exposed culmen, 111–124 (119.1); width of maxilla at base, 25–30 (27.6); depth of closed bill at base, 45–52 (47.3); least depth of closed bill, 24–30 (26.8); tarsus, 82–92 (86.6); middle toe with claw, 117–133 (125.7) mm.

14 females: wing, 478–530 (503); tail, 176–201 (190); exposed culmen, 114–124 (118.2); tarsus, 81–89 (83.8); middle toe with claw, 116–131 (125.7) mm.

Wing-spreads of from 214 to 246 cm. have been recorded for the Black-browed Mollymauk. The last figure, which is approximately 8 feet, 1 inch, represents the expanse of the largest of many examples caught and measured by Green (1887, 13). Dixon (1933, 128) found that the average wing-spread was 221 cm., and the average weight 3515 grams, among 10 examples captured at sea.

A young nestling of this species, taken by Beck at Ildefonso Island, Chile, on December 18, 1914, is covered with straight, smoky white down. The bill is black and the feet whitish. Older chicks have dense curly and woolly down, short on the face. "The feet and legs are white with a pink tinge, . . . the inside of the mouth is bright pink" (Matthews, 1929, 569). Immature flying birds have at first black bills, which gradually change to horn-color. The unguis, which ultimately becomes pinkish, retains its black coloration much longer than the other horny plates. The yellow bills of some adults have, in life, a definite pinkish suffusion.

In juvenal plumage, the forehead, crown, and nape are washed with brownish gray, which also forms an incomplete collar. The dark tone is lost through abrasion, the first whiteness of head and neck coming, therefore, as a result of wear. The interscapular region of juvenals lacks the ashy gray tinge shown by adults in fresh plumage. Several of our immature birds have much abraded primaries, indicating long retention of the first generation of quills. This is confirmed by a British Museum specimen, a yearling female undergoing its first complete moult. In this bird, which was collected by M. J. Nicoll, at Valparaiso, Chile, on February 17, 1903, the quills of wings and tail are literally worn to shreds, and replacement is under way.

The eggs of this species are rather elongate as a rule, dull white with a sprinkling of red spots at the larger end, or rarely with reddish splashes scattered over the whole surface. Usually they are more or less stained with mud. A Falkland specimen measured 67 x 110 mm., and weighed about three quarters of a pound, or 340 grams (Vallentin, 1924, 299).

8 other Falkland eggs average 66 x 105 mm., and the blotches are "more liver-colored than red" (Mathews, 1932, 39). An egg from West Point Island of the Falklands, regarded by Vallentin (1924, 300) as abnormal, measured 63 x 120 mm. One from Staten Island, collected on December 4, 1902, measured 66 x 103 mm. (Hartert and Venturi, 1909, 255). At South Georgia, according to Matthews (1929, 569), most of the eggs are laid during the third week of October.

Distribution: The southern oceans generally, from the tropic of Capricorn to latitude 60° S., and occasionally beyond. Breeds at Campbell and the Auckland Islands, and perhaps elsewhere in the New Zealand region; at Kerguelen and the Prince Edward Islands, South Georgia, the Falklands, Staten Island, and at the Ildefonso and Diego Ramirez Islets, near Cape Horn. Breeding records from Tristan da Cunha (Thomson, 1878, 162; Mathews, 1932, 39) are erroneous, as are probably the references to nesting localities in Tierra del Fuego. Data are needed for Bouvet Island in the Atlantic, and for Heard Island in the Indian Ocean.

The commonest albatross in the southern hemisphere, the most sociable and the most fearless of man while at sea, is the consensus of opinion regarding the Black-browed Mollymauk. Gould (1865, 438) says that it ordinarily approaches much nearer a vessel than any other species, a fact which I had abundant opportunity to confirm during the long cruise of the 'Daisy' in the South Atlantic.

Nevertheless, its fearlessness must be attributed in part to mere numbers. Other albatrosses sometimes sweep across a ship's stern or even between the masts, but the large pelagic population of the Black-browed Albatross offers the widest possible latitude for differences in the temperament or impulsive behavior of individual birds.

Mollymauk, according to a learned commentator (Newton, 1896, 530), is a sailors' corruption of an English word which was corrupted from a German word corrupted in turn from the Dutch! It was originally a name of the Arctic Fulmar, the vast flights of which reminded the Dutch whalemen of "mallemugge," the tiny midges that whirl around a lamp; but today it is applied by mariners of nearly all nations to the smaller albatrosses of the southern oceans. As I heard the word on the whaling brig 'Daisy' in the Roaring Forties, it would be rendered "Mollymoke."

With its white head and body, yellow bill, and the black-streaked eye which gives it a somewhat dour and beetling expression, the adults of this albatross are readily distinguishable from any other sea bird. The young, which have black bills and grayish napes, are less easy to tell at a distance from four or more other species of small albatrosses likely to be met within the same range.

On board the 'Daisy,' it was my custom to keep the legion of oceanic birds interested in the brig by trailing bits of fat pork or strips of loggerhead turtle meat from the stern, and the Mollymauks proved to be even more inquisitive than the smaller petrels. They would fly again and again across the quarter-deck, jerking up their heads like spirited steeds and showing curiosity and temptation in every action. Sometimes they wiggled their feet in air with an amusing running motion, or spread their translucent webs so that they looked blood-red against the sky. Sometimes they halted so abruptly in flight that it seemed they had struck an invisible barrier. During brisk breezes they zoomed across the stern close enough for me to see the color of their eyes and to hear the humming swish of their stiff quills. To anyone properly equipped, they would then have offered a splendid opportunity for studying the fundamentals of aëronautics. Every movement revealed the constant, delicate reactions of the mechanism of balance—the gentle, almost unnoticeable rocking and seesawing of the wings with the bird's body as a fulcrum, the gauging of the angle of wing-axis with horizon according to the sharpness of a turn, and the feat of "shortening sail" at a critical moment, the last capability being due to the structural advantage of jointed planes, which man has thus far been unable to build into his imitation aircraft.

After groups of the Mollymauks had followed the 'Daisy' southward for ten days or so, competition for food seemed to become more keen among them. They showed increased excitement when bait was trailed from lines, and would drop like falling pillows from the height of the masthead, spreading wide their legs, throwing their bulging breasts forward and their heads far back, thus assuming the most awkward and ridiculous attitudes on their way toward the water. Before alighting they stretched down the legs and turned the toes upward. Then the huge webs would strike the surface obliquely and the birds would skate forward several meters before they slowly settled into the buoyant swimming position, with their pinions held like those of angels high above their backs, to be folded later. But after alighting they often wasted time in a laughably solemn way, sidling round each other, croaking peevishly, and pecking in a half-hearted manner while the bait was relentlessly towed out of their reach. When, however, the coveted pieces of turtle meat were not attached to lines, the Mollymauks would dive for them until only the tips of their long open wings showed above the surface of the sea.

The evidence was convincing that the same individual Mollymauks followed our vessel for considerable periods, although the frequent presence of stray birds, singly or in small bands, altered the population about the brig from day to day. Birds with distinctive marks, such as a missing primary quill or a patch of immature or faded feathers on some part of the body, came to be well known to us on board. This agrees with the experience of Gould, who, as noted below, hooked, marked, and released a number of Black-browed Albatrosses, and found that certain birds followed his ship for many days.

Not infrequently flocks made up almost wholly of immature Mollymauks of this species may be encountered. Members of one of the British Antarctic Expeditions have noted this in low latitudes of the Atlantic and Indian Oceans (Godman, 1910, 342), and Paessler (1913, 48) records the same phenomenon in the Fuegian channels during the month of December.

At sea west of Cape Town, Dr. Wilson, of Scott's Expedition, once observed two Black-browed Albatrosses "billing one another exactly as though they were adult and young" (Lowe and Kinnear, 1930, 168). This is evidently another example of the year-round "dance" in which all albatrosses seem to indulge at sea as well as ashore. Further notes on the custom, which is still little known, will be found in the biography of the Wandering Albatross.

It goes without saying that the Black-browed Albatross is a strong flier, perhaps more so than certain other members of a family well nigh peerless in the air. Whitlock (1931, 264), whose experience in such matters is particularly full, says that it is very rarely driven ashore by the storms of western Australia. Gould (1865, 438) caught and marked examples which had been following a ship, and freed them at nightfall. At daybreak they were still in the wake, after a night's run of 150 kilometers. Hutton (1867, 190), however, observes that more frequently they tend to settle on the water toward evening, as though making ready to spend the night afloat, and that few are to be seen before eight o'clock next morning. From that hour they increase throughout the day, becoming most numerous in late afternoon. This agrees entirely with my own experience. Hutton also kept a note of air temperatures ranging between 7.8° and 22.8° C., and could detect no differences in the flight or other behavior of the albatrosses from this cause.

Coppinger (1884, 89) writes of this species:

> I have noticed that it sometimes uses its wings to raise or propel itself in such a manner that to a superficial observer it would then appear to be only soaring with wings stationary. It does not "flap" them, but depresses them rapidly toward the breast, so that it seems as if the body were

being raised at the expense of the wings, whereas, in reality, the entire bird is elevated. The movement does not resemble a flap, simply because the return of the wings to the horizontal position is accomplished by a comparatively slow movement. By resorting to this manoeuvre occasionally, it is able to maintain a soaring flight for periods which, without its aid, might be considered extraordinarily long. Of course, when it wants to gain a fresh stock of buoyancy and momentum, it gives three or four flaps like any other birds.

Idrac (1926, 38), who applied the same methods of studying the flight of this species as of the Wandering Albatross, found that its average speed is 19 meters per second.

The American Museum Collections contain a large number of specimens of the Black-browed Albatross from South America, the New Zealand region, and the intervening reaches of the Atlantic, Pacific, and Indian Oceans. Altogether, I have examined and measured more than a hundred skins, leading to the general conclusion that no bird is more widely distributed over the southern oceans, and that there are scant ponderable grounds for distinguishing two or more geographic races. Green (1887, 13) has called attention to the uniformity in appearance of adult Black-browed Albatrosses wherever observed at sea. The same applies to closer inspection in the hand for, except for variations in color due to the wear and fading of feathers, and the reasonably wide range in dimensions apparent among birds from any one nesting locality, they seem to be exactly alike the world over. I am aware that the figures of Lowe and Kinnear (1930, 170) indicate that specimens from the New Zealand region may have, on the average, slightly shorter bills than those from South American waters, but the data are too slight and irregular to be convincing.

Our South American specimens come from many points around the coast of the continent from Lobos de Tierra Island, northern Peru, where Forbes shot two in June (midwinter), southward along the west coast to Juan Fernández and Cape Horn, and thence eastward and northward to South Georgia, the Falkland Islands, and the mouth of the Río de la Plata. Still farther northward, on the east coast, it is known from Rio Grande do Sul and Santos, and has been captured in the harbor of Rio de Janeiro (Goeldi, 1894, 588; Ihering, 1907, 38), as well as in the same latitude offshore (Andersen, 1895, 91). To Brazilian fishermen it is sufficiently familiar to bear the native name of Gaivotão (Koenigswald, 1896). The Portuguese book-name is Albatroz.

Between the Río de la Plata and Tristan da Cunha, in May and early June, Loranchet (1916, 331) saw Black-browed Albatrosses constantly, as he did likewise thereafter on succeeding legs of his voyage to the Cape of Good Hope and to Kerguelen Island in the southern Indian Ocean. During the southward cruise of the 'Daisy' I noted them on every day but two between latitude 33° 28′ S., November 4, and South Georgia, November 24.

In the Humboldt Current, where this albatross normally penetrates farther into the tropics than anywhere else in the world, I found it not uncommon even during the southern-hemisphere summer. The observations of Beck and Jaques, of American Museum parties, confirm this for the west coast from Salaverry southward, while the published records of Paessler (1909, 100), Lönnberg

(1921, 16), and others testify to its still greater abundance in winter. Beck collected examples off Callao, Cerro Azúl, Pisco, and Mollendo, Peru, in June and July, and off Antofagasta, Talcaguano, Valparaiso, Mas Atierra Island, Corral, and Ancúd, Chile, between August and December and in February and March. On July 1, 1913, he saw forty or more in the Bay of Pisco, Peru.

Throughout the Magellanic-Falkland region Beck saw this albatross almost daily, his records being too numerous to cite except in the following bare summary:

July, 1914. Gulf of Peñas, common in the inland waterways; Magallanes.

August. Off the Río de la Plata, dozens in the steamer's wake; Montevideo, flying near the wharf and breakwater on a windy, rainy day.

September and October. Mar del Plata, common; many sitting on the water on October 9.

November. Cape Vírjenes; Strait of Magellan, common.

December. London Island; Thomas Island; Caroline Island; Hoste Island; Ildefonso Island, several thousand on the three islets, the nesting season just beginning; Cape Horn and Lort Bay; Nassau Bay, large numbers resting on the water, December 26; Hermite and Jerdan Islands, common in the channels.

January, 1915. Magallanes; Hacienda Grande, large flocks; Beagle Channel; O'Brien Island; Smoke Island; Brecknock Island.

February and March. Magallanes.

April. Ushuaia; Bertrand Island; Diego Ramirez Islets (common all the way out to these islets); False Cape Horn.

May. Good Success Bay, Strait of Le Maire, many; off Santa Cruz; off the Río Gallegos.

June. Cape Vírjenes; Strait of Magellan.

July. Ushuaia; Bertrand Island; False Cape Horn.

August. Near Staten Island, common; various points along the Patagonian coast, common.

September. Puerto Deseado; waters about the Falkland Islands, common.

October to January. Various islands of the Falklands, where nesting colonies were visited.

As a rule the Black-browed Albatross leaves the wake of vessels when pack-ice is encountered. Occasionally, however, it penetrates far southward, even beyond the antarctic circle. Reichenow (1904, 346) states that its southern limits are similar to those of the Wandering Albatross. A male in the British Museum was taken in latitude 58° S., between New Zealand and Ross Sea, in March, while in West Antarctica the French Expedition reports the species as far south as 69° 20′ S., 102° 9′ west of Paris (Gain, 1914, 157). There are many records from the vicinity of the Palmer Archipelago (Menegaux, 1907, 68). From the central South Atlantic, somewhere in the neighborhood of Bouvet Island, the southerly limits of the normal range appear to slant off poleward both to eastward and to westward (Vanhöffen, 1901).

A number of specimens have been taken in the northern hemisphere but, as in the case of the Wandering Albatross and many other Tubinares, the probability of transportation by sailors must always be kept in mind. The Black-browed Albatross takes a hook particularly freely, and by no means all the captured birds find their way to the sea-cook's pots. Some are designed to be kept as pets (!); others are released through sentiment or whim in all sorts of strange places. An extraordinary account of the freeing of many southern petrels in the North Atlantic is given in the biography of the Cape Pigeon

On June 15, 1878, a Black-browed Albatross which is now mounted in the Peterhead Museum, England, was shot northwest of Spitsbergen, in latitude 80° 11′ N., longitude 4° E. (Andersen, 1894, 241). The species has, therefore, gone far closer to the north than to the south pole, despite its antarctic affinities! Far more remarkable and, indeed, in the nature of a fairy tale, is the thoroughly substantiated story of an example of the species which dwelt among the Gannets of the Faeroe Islands for thirty-four years.

This bird was so well known that it became a tradition. Lord Rothschild not only saw it but once endeavored to shoot it, as he has related to me verbally. From 1860 until 1894 it lived with the breeding Gannets on Myggenaes Holm, an islet which forms the westernmost extension of the Faeroes, and which is separated by only 60 meters from Myggenaes. The Holm is occupied by the sole colony of Gannets in the Faeroes. The albatross was seen constantly among the Gannets, on the ledges of the island and feeding in the neighboring waters. Each year it left the region with the Gannets in the November emigration and returned with them in February. By the inhabitants of the islands it was naturally regarded as an aberrant sort of Gannet, and was called by them the "King of the Gannets." Finally, on May 11, 1894, the albatross was shot. It proved to be a female with fully developed ovaries. It is still preserved in the Copenhagen Museum. A description of the bird, with measurements, is given by Andersen (1895, 91).

What a pity that this lonely waif, which had associated itself with its nearest counterpart in the North Atlantic, might not have been watched at close range by an ornithologist who could record its reactions during the courtship and mating seasons of the Gannets. It is evident that the latter tolerated it, and not beyond the bounds of possibility that they took some other cognizance of its presence among them.

The nesting grounds at which the Black-browed Albatross has been longest known are at the Falkland Islands, where the early sealers became familiar with them, drawing upon their eggs, as well as those of penguins, for food. Captain Edmund Fanning, for example, found them nesting among the Rockhoppers at New Island during October, 1797, and states that the first eggs were laid about October 10 (Fanning, reprint, 1924, 55). At Keppel Island, West Falkland, in February, 1855, Snow visited a colony which he describes as follows:

> In this place, and quietly maintaining their dignity, were numerous penguins and mollimauks attending to and taking care of their young; the latter being squatted upon cup-like nests about a foot high. Those upon the nests were young mollimauks, with their feathers just beginning to take the change from a previous down. As I approached them they spouted at me, ejecting some oily substance from their beak, and babbled loudly; but otherwise they did not attempt to move. The parents were flying about in all directions, now one to sea, now another back to feed the young. These old ones made no noise; but calmly passed and repassed as if perfectly indifferent to me (Snow, 1857, 1, 140).

The species continues to thrive at the Falklands, despite the raids upon its eggs which have been made since the first days of discovery. According to Vallentin (1924, 297), a new egg is never laid in a robbed nest, but Wilkins

(1923, 484) reports just the opposite at South Georgia, saying that the egg is always replaced within a few days. At the large Falkland rookery on the banks of the north end of Saunders Island, and at the neighboring Pebble Island, the albatrosses

> . . . begin to arrive early in October and leave during March. The nests are built up of mud, plastered by the bills of the birds on the foundations of old nests. Sometimes tussock grass is mingled with the mud, which soon dries and becomes hard. They are frequently associated with the rockhopper penguins. But the mollymauks always keep themselves spotlessly clean in spite of the filth, whereas the penguins are usually very dirty while ashore. The nests are cylindrical and vary in height according to the slope on the ground. At the top they are about 16 inches in diameter and have a cavity about 3 inches in depth (Vallentin, 1894, 297).

Vallentin goes on to say that at the end of the breeding season (March or April) the parents abandon the young but that the latter soon follow them off to sea. Many, however, perish before they can get away, and others fly into the interiors of the large islands instead of out over the oceans, as is proved by the frequency with which dead or moribund fledglings are found in valleys far back from shore. The skua, which is such a foe of the penguins, never appears to molest young Mollymauks, perhaps because it finds them unpalatable.

During the Brewster-Sanford Expedition, Mr. Beck visited a number of colonies of the Black-browed Albatross. At the end of January, 1916, he found them nesting on steep seaward slopes of Pebble, Saunders, and West Point Islands, of the Falklands. Few had young, and many nests contained no egg, because of visits from near-by residents of West Point. The owner of the island told Beck that he had taken six eggs, known to have been laid within a few hours, and had put these in marked nests on October 14, 1915. All six had hatched on December 24, thus showing that the period of incubation is about 71 days, 10 or 11 days longer than recorded by Vallentin.

The nests were all strongly built, and ranged in height according to the incline. Thus some measured in excess of 60 centimeters on their lower sides, while some on flat ground were built up less than a handbreadth. The sites varied from high steep banks to gentle slopes or nearly level places close to the sea. On January 31, in a drizzling rain which softened the soil, incubating albatrosses were adding to their nests by pulling wisps of grass and by picking up bits of mud about the bases of the structures. They would then shake their bills to one side or the other, thus plastering little gobs of mud on the walls of the nests, near their tails.

Beck ate a number of the fresh eggs and found them preferable to those of penguins. At the South Georgia whaling stations I also enjoyed excellent Mollymauk eggs which were undoubtedly of this species. Even the adult birds are said by Layard formerly to have been sold as food in the market at Cape Town (Godman, 1910, 339).

At the Ildefonso Islets, which lie well out to sea southwest of Tierra del Fuego, Beck found several thousand breeding Black-browed Albatrosses on December 18, 1914. Here the nests, which his notes say reminded him of those of flamingoes, were not only among those of Rockhopper Penguins but were in some instances directly above the burrows of Magellanic Penguins. Most of the nests contained recently hatched young, and not a single egg was seen.

At South Georgia I saw this species constantly throughout my stay (November to March), and found it commonest in the fiords on windy days. Beck also noticed near Cape Horn that the Mollymauks, along with gulls and shags, would seek the shelter of the inter-island channels when squalls and williwaws raged hardest. During gales at the Bay of Isles, South Georgia, numbers of the birds often alighted astern of the anchored 'Daisy' in search of scraps of sea-elephant blubber. On the whaling banks it was by far the most numerous of all the albatrosses.

It is found throughout the year in the neighborhood of South Georgia, and is a common breeder. It nests earlier than *Diomedea exulans*, the egging season for the Norwegian whalemen being the first week of November, when boatloads are collected for food. Matthews's account of the species at South Georgia is as follows (1929, 568):

> In the nesting season they come ashore early in October in enormous numbers, breeding in rookeries on the cliffs, especially at the north-west end of the island. There are also rookeries at the south-east end near Cape Disappointment. The rookeries are on the steep slopes at the summits of the cliffs, and each contains several thousand nests. The nests are built of mud and peaty moss on ledges amongst the tussac. They are cylindrical, from one to one and a half feet in height, with vertical sides and a depression on the top. The materials for the nests are collected from the ledges in the immediate vicinity. When the nest is being built the female stands on it and the male collects the mud and brings it to his mate. He places this on the nest and then bows the head down to the ground and spreads the tail and makes a loud braying cry. The female bows and brays too, and then arranges the mud on the nest and treads it down. The birds then nibble each other's beaks and bow and bray again, after which the male fetches another load of mud. In between spells of nest-building, and after it is complete, they go through a further ceremony. Standing on or near the nest, facing each other, they touch the tips and sides of the bill, as though fencing with them. They then bow to each other, and each turns the head round so that it faces backwards, and touches the back between the shoulders with the tip of the bill. They stop in this attitude for a moment and make a low grunt and then face forward again and start braying with the beaks wide open, moving the head from side to side while the tail is spread. They then nibble the feathers of each other's heads before going through the same process again. The displays are not usually followed by pairing. When they bray the feathers of the side of the face are parted so that a furrow is formed running back from the gape; this exposes a ridge of pink skin The ridge is kept exposed for a few moments after the call and then the feathers are allowed to fall into place. When they arrive in the rookery after being away fishing at sea they bray loudly as soon as they have got on to their feet: they land very awkwardly and usually capsize on to the breast.

The "ridge of pink skin" referred to is the edge of the mouth, behind the bill. The inside of the mouth is, sometimes at least, of a pinkish violet color.

At South Georgia the heights of land are perpetually and deeply buried in snow. At the Falklands, the nesting grounds of the Black-browed Albatross are on small islands of no considerable altitude. There is therefore no locality within the South American region at which the species nests on the crowns of lofty hills, 300 to 400 meters above sea level, as it does on certain islands near New Zealand (Buller, 1888, 198).

Like its larger relatives, the Black-browed Albatross eats squids. Matthews states that the stomachs of South Georgia specimens were packed with beaks and spermatophores, some of which appeared to be remains of cephalopods over a meter in length. Euphausiid crustaceans have also been found in the gullets of birds taken at sea (Lowe and Kinnear, 1930, 168). In waters close to land, a good proportion of the Black-browed Albatross's diet seems to be made up of fish. In the Strait of Magellan, near Magallanes, on March 6, 1915, Beck watched fifty or more of them feeding with a large flock of Kelp Gulls. Both species were following a shoal of small fish which he calls sardines and, when the albatrosses were run down by a launch, they coughed up "dozens" of the fish before they took wing. The same sight was observed in San Francisco Bay, near Cape Horn, on December 24, 1914, and in Beagle Channel on April 30, 1915. Moreover, labels on Beck's specimens from a number of Magellanic localities are marked "stomach filled with sardines." Mr. Bullock reports that around the coast of Mocha Island, Chile, the "Lagartones" often filch fishes from the Blue-eyed Cormorants by giving chase to them as soon as they bring their catches to the surface. Nicoll (1904, 52) found a fairly large fish in the stomach of a male shot off Valparaiso, and Buller (1888, 198) found the bill and feathers of a diving petrel in the stomach of one cast ashore during a gale at the Auckland Islands. My experience with Tubinares in the field leads me to believe that many of the larger forms will attack and devour any bird encountered disabled on the water.

The young nestling Mollymauks, according to Matthews (1929, 569), make a soft piping cry in the nest. This becomes loud and shrill as they grow, and after they are half grown they attempt to imitate the braying call of the adults.

> They start right but the voice then breaks and they finish on a falsetto note. When approached they sit back in the nest and stretch up the neck, all the while shuffling round so as to face the visitor. They snap the bill at him, at each snap making a gulping sound. If closeiy approached the snapping becomes rapid and a quantity of dark orange-red oil is brought up into the throat and ejected. The oil is quite clear with a strong odour and sets solid on cooling.

GRAY-HEADED ALBATROSS

Diomedea chrysostoma

Diomedea chrysostoma Forster, 1785, Mém. Math. Phys. Paris, 10, p. 571, pl. 14 (No type locality; South Georgia is here proposed).

Names: Blue-headed or Yellow-nosed Albatross, or Mollymauk; Blue Mollyhawk (to distinguish it from the "White Mollyhawk," *Diomedea melanophris*). A synonym of the specific name is *culminata*.

Characters: Very similar, except in the color of the head, to *Diomedea melanophris*. Head and neck bluish gray, paler on the forehead, sides of face, throat, and hind neck, the concealed parts of all the feathers being white; a slaty black mark through the eye; mantle ashy gray, becoming dark brown or nearly black on the back, scapulars, and wings which, however, have a slaty gloss, especially on the secondary quills; primaries and rectrices blackish on outer webs, grayish on inner, and with white shafts and bases; lower back, rump, upper tail coverts, and ventral surface caudad from throat, white; axillaries and under wing coverts white, with a broad black band of small coverts along the edge of the wing. Iris brown; bill laterally black, the culminicorn bright yellow, changing to brownish orange on the hook, and becoming paler and yellowish again at its tip; a narrow line of black skin encircling the base of the maxilla; a ventro-lateral stripe along the ramus of the mandible, yellow, the color being continuous with the orange-yellow skin which crosses the base of the ramicorn and extends caudad along the gape; extreme tip of lower mandible pale yellowish; lining of mouth orange-yellow; feet light bluish or grayish, bluer on the joints, and pinkish or fleshy on the webs; claws whitish.

Immature birds have at first black bills and brownish heads, being difficult to distinguish except by bill characters from the young of certain other mollymauks.

Dimensions of 19 adult specimens from the South American region agree well with those of six birds from the Indian Ocean, as well as with those of 35 or more from many parts of the southern hemisphere as tabulated by Lowe and Kinnear (1930, 174). The following summary is based upon birds from South Georgia, Weddell Sea, the Falklands, Cape Horn waters, and the coast of southern Chile.

14 males: wing, 480–555 (510); tail, 175–205 (195); exposed culmen, 106–122 (114.3); width of maxilla at base, 25–30 (28.2); depth of closed bill at base, 41–50 (45.7); least depth of closed bill, 22–28 (25.6); tarsus, 79–91 (85.6); middle toe with claw, 117–138 (125.8) mm.

5 females: wing, 473–523 (504.3); tail, 175–199 (189.3); exposed culmen, 108–119 (114.7); tarsus, 79–89 (84.6); middle toe with claw, 111–131 (122.1) mm.

An egg from Diego Ramirez

. . . is of oblong form. . . . Both ends are quite blunt. The surface of the shell is in character like a common hen's egg. The color inclines to a light creamy white, with a ring of seemingly fine spattered burnt sienna specks . . . around the larger end. . . . The center of the ring runs together in the fine markings, making the color almost solid, and fades away from the outer edge (Bent, 1922, 18).

Six eggs collected at South Georgia on December 20 have average measurements of 74 x 101 mm. (Wilkins, 1923, 488).

Distribution: Similar to that of *Diomedea melanophris*; ranging from south temperate latitudes to the edge of pack-ice, and breeding at Campbell Island south of New Zealand, at Kerguelen, the Prince Edwards, Crozets, probably Bouvet, South Georgia, the Falklands, and the Diego Ramirez Islands southwest of Cape Horn.

The Gray-headed and Black-browed Mollymauks have practically the same breeding range. In fact, I can find no island certainly occupied by only one of these two species, although everywhere the Gray-head seems to occur in much the lesser numbers. Its most northerly, and climatically mildest, breeding stations are among the Falklands where, at West Point Island, for example, a few nest with the Black-browed species. At Ildefonso Island, near Cape Horn, Beck saw one sitting among Black-browed Albatrosses at the edge of a cliff, on December 18, 1914. A sealing captain who served him for many months in the Magellanic region, assured him that the species was abundant at the Diego Ramirez Islets during September, but Beck never found an opportunity to verify this. References to this albatross in his notes, some of which are substantiated by specimens, are as follows:

Cape Horn, December 29, 1914, one seen several times; 12 kilometers outside False Cape Horn, in heavy weather, April 6, 1915, several; Good Success Bay, Strait of Le Maire, May 6, two; same locality, August 4, several, on which occasion Beck writes rather ruefully, "the species which has kept me on this boat since February last"; east of the Falklands, September 20, four; off the Falklands, September 24–26, a few daily; 65 kilometers northeast of Staten Island, September 27, several.

For the Humboldt Current region of the west coast of South America, there are a number of records which, however, cannot be accepted conclusively since they are unsupported by specimens. Thus Paessler (1909, 100; 1913, 50) reports birds of this species off the Gulf of Guayaquil, off Paita, near Lobos de Afuera

Island, in the Bay of Pisco, and thence southward to the Strait of Magellan. There is no reason why the Gray-headed Albatross might not occur along the coast of Peru, especially since it has been reported from Panama (Godman, 1910, 355) and even from the west coast of North America (Bent, 1922, 17). But Paessler's records are not verified by specimens in the Berlin Museum (such as confirm many of his other excellent observations on sea birds), and we now know that other albatrosses which might readily be confused with *Diomedea chrysostoma* are of regular occurrence along the coast of Peru. Two such species, which had never been recorded off the west coast of South America at the date of Paessler's publications, are *D. bulleri* and one of the races of *D. cauta* (Murphy, 1930, 3 and 6). The former species, in particular, resembles *D. chrysostoma* so closely that differentiation in the field is almost impossible.

Mollymauks with gray heads are very common along the coast of Peru, as witnessed by Beck's notes on birds which he could not identify. He saw several such near Hormigas de Afuera Island, others off Huacho and Callao, and still others off Chilca, all during June, 1913. My own notebooks contain additional records, some of which were almost certainly *D. chrysostoma*, as follows: Independencia Bay, November 18 and 19, 1919, three; off Mollendo, January 10, 1925, two; off Pescadores Point and Doña María, January 12 and 13, 1925, three. Furthermore, in several European museums I have examined specimens from the ocean west of Cape Horn, and I confidently look for additional captures to northward in the Humboldt Current.

For West Antarctica there are many records; moreover, I suspect that others listed in literature under the name *D. chlororhynchos* refer, in reality, to this species, which is of far more polar proclivities than the Yellow-nosed Albatross. Members of the French Antarctic Expedition recorded examples of *chrysostoma* southward beyond the polar circle in the Graham Land region, as far south as latitude 68° 30′ S., longitude 73° west of Paris, in January, 1910 (Gain, 1914, 158).

The type locality of this species has usually been recorded incorrectly as "Cape Seas," meaning the Cape of Good Hope. Peters (1931, 45) gives, on the other hand, "vicinity of the antarctic circle and in the Pacific Ocean," which is equally erroneous. Forster's text is as follows:

> . . . se trouve dans les mêmes parages que la commune [*Diomedea albatrus* = *D. exulans*]: cependant nous observâmes qu'il n'y en avoit que très-peu dans le voisinage du cercle polaire antarctique et dans l'Océan pacifique.

There is nothing in the above to indicate the same type locality as that of the Wandering Albatross and, since the last clause would seem to call for an Atlantic locality, I suggest South Georgia, where Forster met the species during the voyage of the 'Resolution.'

During the southward cruise of the 'Daisy' in the Atlantic, I logged this species from latitude 42° 24′ S., longitude 42° 28′ W., on November 14, 1912, every day until we reached South Georgia on November 24. Four was the greatest number seen on any one day until on November 22, in latitude 53° S., "many" were noted.

Nichols (Bent, 1922, 18) writes that this albatross

> . . . is a common south temperate species coming about ships at sea for the scraps from the galley. It can be easily caught with fishhook and salt pork. The tip of the hook catches under its upper mandible, and if the line be held taut the bird may be hauled on deck along the surface of the water, or through the air like a kite. Except rarely when it catches in the soft parts of the mouth, the hook does not penetrate anything and if the line be slackened drops out by itself; but as a rule the bird foolishly braces back, sticking its feet out in front of it, or setting its wings, and is readily drawn inboard. On deck it is stupid, helpless, unable to rise, and after a few minutes seems to become dizzy from the vessel's motion. Its legs fail it so that it will often squat instead of trying to stand, and with every appearance of seasickness it regurgitates oily matter. Though generally silent, when being hauled aboard I have heard it give a goose-like honking or grunting note. It rises from the water with much awkward flapping, kicking, and splashing, especially in light breezes, and when fairly launched sails on stiff, motionless wings, occasionally giving them a few flaps, less frequently as the wind increases in force. In moderate breezes the wings are held quite widely extended; in high winds they are somewhat folded, exposing less surface. It sails straight away, swinging into the air and then down close to the water, leaning to one side or the other as it curves its course. Its flight is never high above the water, but about the ship it rises somewhat higher than the smaller birds. Attracted by food in the wake, it alights to seize it, but the wings are at such times often held half raised over the back. Though adults are readily distinguishable, young of this species and of the spectacled albatross, the other common small albatross of the south, can be differentiated with difficulty in life. The offshore habits of the two seem identical.

In the Bay of Isles, South Georgia, I saw the Gray-headed Mollymauks occasionally, sometimes in close association with the Black-browed which always outnumbered them by at least ten to one. Both species would come into the bay during stormy days, and would feed upon blubber and refuse from the brig. I noted the Gray-heads from our anchorage on eight days between January 14 and March 13, 1913

The species was not certainly known as a breeding bird of South Georgia until the first visit of the 'Quest' in December, 1921, when it was found to be a not uncommon resident of the northwesterly end of the island and of outlying islets. Wilkins reports that although it flies and feeds with the common Mollymauk, the two species do not mingle at a nesting site, though the respective colonies may be only a few hundred meters apart (Wilkins, 1923, 484). Matthews (1929, 570) adds the following regarding conditions at South Georgia: "The two species are not mixed in the rookeries but keep apart, though occasional pairs of each nest in the rookeries of the other." The same phenomenon has been observed at the Falklands and elsewhere.

Matthews reports, furthermore, that the habits and food of *Diomedea chrysostoma* are so similar to those of *D. melanophris* that one description answers for both.

At South Georgia the Gray-headed Mollymauk comes ashore to nest early in October, eggs beginning to appear by the middle of the month. "If the egg is taken a second one is laid" (Matthews, 1929, 570). The nest resembles that of the Black-browed Mollymauk. One at Diego Ramirez Islets, which contained a fresh egg on January 12, was composed of mud and clumps of tussock, and lined with fine grass and feathers. The diameter was 45 centimeters at the base and 30 at the top, with a bowl 25 centimeters across and 12 in depth (Bent, 1922, 17). According to Wilkins (1923, 488), the nests at South Georgia are used by the birds throughout the year as places of rest. He says that they are 30 to 35 centimeters high, 50 in diameter at the bottom and 30 at the top, and constructed of earth and moss.

Three young nestlings taken at Elsa Harbor, South Georgia, on January 30, 1921, have grayish white down, entirely black bills, and white egg-tooth. The feet are recorded as translucent white. Older young have darker curly down.

Juvenal specimens have black bills, brown rather than gray napes, and dark wing-linings. The culminicorn begins to turn horny and then yellow in advance of the stripe along the lower edge of the mandible. A British Museum specimen taken in the Pacific off Veragua, western Panama, illustrates this stage of immaturity. It is in fresh plumage and has a very dark gray head. Two adults in the Stockholm Museum, taken west of Cape Horn during the month of March, illustrate the extremely worn plumage and have nearly white heads.

The age-changes are described by Mathews and Iredale (1921, 52) as follows:

> When the young flies it has a dark grey head which extends on to the throat; the ocular patch distinctly blackish; the grey is a dirty-brown grey, while the bill is practically all black, but the lower edges of the under mandible show pale brownish. The grey head and neck lose their brownish tinge while the culmen takes on a light yellowish-brown shade, the strip on the lower edges of the lower mandible becoming paler. The fully-adult has a beautiful pearl-grey head, neck and throat, while the culmen is pale clear yellow and the lower edge of the lower mandible is also clear light horn or yellowish. Some birds, however, in the change, as shown by the coloration of the bill, have the head white and the back of the neck inclining to white.

Of several specimens taken during the 'Scotia' cruise on Burdwood Bank, 150 kilometers south of the Falkland Islands, December, 1903, the zoölogical log reads:

> They differ in colour especially about the head, some being much lighter than others. The bills also differ in colour, the three we secured yesterday showing this. Two of them have a yellow culmen and yellow under the mandible, while the third is almost entirely grey. The inside of the mouth is yellow. The legs are of a pale grey, almost white in parts, mottled with darker grey towards the outer end of the webs. The grey has a distinct lavender tinge, much the same as the feathers. Eyelid is black as well as the cere. At lower angle posteriorly is a patch of white feathers, which in flight looks like a white eyelid. The eye has a dark olive-green iris, while the pupil is greenish black (Ramsay, 1913, 215).

YELLOW-NOSED ALBATROSS

Diomedea chlororhynchos

Diomedea chlororhynchos Gmelin, 1789, Syst. Nat., 1, part 2, p. 568 (Cape of Good Hope).

Names: Yellow-nosed Mollymauk; Blue-headed or Pink-footed Albatross; synonyms of the specific name include *eximius*, *carteri*, *bassi*, *olivaceorhyncha*, *olivaceirostris*, and *profuga*.

Characters: The only member of the black-billed and "yellow-nosed" group of mollymauks which lacks a corresponding yellow stripe along the ramal border of the mandible; also the most slender-billed member of the group. Back slaty brown, the wings and scapulars darker, the mantle grayish; head and neck white, the occiput, nape, and cheeks tinged with pearly gray (in fresh plumage); a gray or blackish supra-orbital mark, most evident in the supra-loral region quite to the base of the bill; tail hoary brown, the shafts of the rectrices white; a patch on each side of the breast gray; rump, upper tail coverts, and ventral surface white, except for a narrow anterior blackish brown border on the under surface of the wings. Iris brown; bill black with a yellow culminicorn which passes into orange or pink on the unguis; gape and transverse stripe at base of mandible orange; feet and legs bluish, with flesh-colored webs and white nails.

Immature birds have wholly black bills.

For purposes of measurement, the examples of this species are in less satisfactory series than those of the other mollymauks I have studied. The localities, for instance, are more scattered, and a good proportion of the labels lack the sex mark. However, 13 specimens taken at the Tristan da Cunha group, or in neighboring parts of the South Atlantic, show no character of appearance or dimension to distinguish them from birds collected elsewhere. The sexes appear to be alike in size, as in plumage. The following summary is based upon 30 skins of both sexes collected between the North Atlantic and the coast of Australia.

Wing, 456–499 (480); tail, 177–199 (185); exposed culmen, 105–124 (115); width of maxilla at base, 22–27 5 (25.7); depth of closed bill at base, 37–43 (41); least depth of closed bill, 20–24 (21.8); tarsus, 74–84 (75.7); middle toe with claw, 103–116 (111) mm.

The wing-spread of four South Atlantic specimens ranged between 198 and 207 cm. This is about the expanse in *Diomedea bulleri*, and less than that in the other two closest relatives, *melanophris* and *chrysostoma*. A male in the British Museum, taken close to the West African coast at Great Fish Bay, weighed four pounds (1814 grams). The Yellow-nosed Albatross is probably the smallest and slenderest member of its genus in the southern hemisphere.

Twenty eggs of this albatross from Tristan da Cunha have average dimensions of 96.5 x 62.5 mm. (Mathews, 1932, 41). Seventy-five from Gough Island are characterized by Verrill (1895, 444, 445) as follows:

Average dimensions, 96.1 x 63.2 mm.

Average cubic contents, 180 cc.

Smallest egg, 86.1 x 58.4 (135 cc.).

Two largest eggs, 109.7 x 64.5 and 105.4 x 66 mm. (each 220 cc.).

The shape of the 75 eggs is comparatively pretty uniform, . . . most of them approaching an elliptical ovoid. Several are nearly perfect ellipsoids.

The texture and surface of the shell is much like that of *D. exulans*, but finer and smoother in proportion to their smaller size.

The ground-color is white, generally with a very slight grayish or dusky and sometimes reddish tinge, and the whole egg is covered with minute specks of a reddish brown, darker than in *D. exulans;* in some they are even dark brown.

These specks vary much in number and are, for the most part, in the small pits and depressions on the surface of the shell. About one-third of the eggs are otherwise unmarked, so that at a little distance they simply have a dusky appearance. In the other two-thirds the specks become larger and thicker toward the larger end, often forming a more or less perfect zone about it, in other cases they run together and form a blotch which is, in some, quite heavy and conspicuous.

As in *D. exulans*, the color is very superficial and many have larger spots or small blotches, unevenly distributed, that scale off when very dry.

Distribution: Lower latitudes of the sub-antarctic, ranging widely over the southern oceans, and breeding upon Gough Island and the islands of the Tristan da Cunha group in the Atlantic, and at St. Paul Island in the Indian Ocean. Peters's inclusion of the Crozet Islands within the breeding range (1931, 45) is a *lapsus calami*. The species is primarily a bird of the milder Atlantic and Indian Ocean regions.

During the visit of the 'Challenger' to the Tristan da Cunha group, in October, Lord Campbell made the following entry in his notebook on the Yellow-nosed Mollymauks, as he first encountered them at a certain large rock in the grassy plateau of Nightingale Island:

Two mollymawks quietly walked out from under the grass behind us, and stood unconcernedly by our side. They are beautiful birds, snow-white throat and breast, black wings and tail, back of the head and neck tinted a pearly grey, a black bill with an orange streak on the upper mandible, black eyes under a straight black eyebrow, which, with a soft dark edging around the eye, gives them an odd look of half fierceness, half gentleness. This rock appeared to be a starting-point from which, coming from their nests among the grass, they took their flight. They, as well as the penguins, were nesting; their nests consisting of a cylindrical column of earth mixed with grass, about a foot high, a slight depression on top. . . . It was the prettiest sight to see these handsome birds among the grass tunnels, which radiated in all directions, looking quietly dignified as they walked or sat on their high nests among the squatting, screaming penguins (Campbell, 1877, 66).

More than a half century earlier, Carmichael (1818, 490) had become acquainted with the species at the main island of Tristan, and had noted that when these albatrosses are irritated the feathers of the cheek are separated so as to display a beautiful stripe of naked orange skin running from the corner of the mouth toward the back of the head. The stripe is, of course, only the cleft of the mouth itself, which fairly divides the head in twain, and the baring of it is the well-known albatross gesture of "spreading the whiskers" before expressing displeasure by deliberately throwing up. All of the mollymauks can apparently open their mouths almost to a right angle.

Although this albatross migrates into oceans somewhat south of its breeding grounds, it belongs definitely to lower and more temperate latitudes than either of the preceding members of its genus. Beck observed it a number of times near the Falkland Islands in September, and it has been reported from as far south as latitude 64° 14′ S., in the Indian Ocean (Vanhöffen, 1901, 313), and from the Palmer Archipelago to the antarctic circle (Menegaux, 1907, 68) in American Antarctica. But I am suspicious of all such extremely southerly records, due to the likelihood of confusion between this species and *Diomedea chrysostoma* or one of the other gray-headed albatrosses. The error has been made a number of times, even when specimens were collected. For example, Fristedt (1894, 331) reports shooting two examples of "*Diomedea chlororhynchos*" west of Cape Horn, at the end of March. I have examined these two birds in the Royal Natural History Museum at Stockholm, and they both prove to be *Diomedea chrysostoma*. Dabbene (1926, 347) has wisely disregarded all such questionable records in his clear and useful distributional chart. Certainly all the nesting records for the Yellow-nosed Albatross at ice-covered southern islands, such as Kerguelen and the Crozets, are erroneous. So far as we know, the distinctly temperate islands of the Tristan group, Gough, and St. Paul, are the only breeding grounds.

There are many records for this species from Australian waters, a fact which has puzzled several writers because no breeding grounds are known anywhere within the Notogeal region (Lowe and Kinnear, 1932, 180). It seems to me, however, that St. Paul Island, in the central Indian Ocean, would be the natural source of Australian specimens. The species appears to be the best-known albatross in lower latitudes of the Indian Ocean, between the Cape of Good Hope and West Australia. Alexander (1928, 19) remarks that "its range is more northern than that of its congeners, so that it is the dark-backed albatross . . . most frequently met with on the routes of passenger steamers in the southern hemisphere." Gould observed it almost daily along the west-wind route from the South Atlantic to New South Wales (Godman, 1910, 358). Wilson, too, notes that it is the common Indian Ocean species in temperate latitudes, and close to the African coast, while farther southward it is replaced by *Diomedea chrysostoma* (Godman, 1910, 358). The easternmost record for the Yellow-nosed Albatross in the Indian Ocean-Pacific region appears to be the west coast of Auckland, New Zealand, where a specimen was cast ashore on the beach (Oliver, 1930, 164).

Lowe and Kinnear (1930, 178) are inclined to recognize two subspecies of this mollymauk, one being the Atlantic, the other the Australian (*i. e.* Indian Ocean?) bird. In the latter form, according to their notes, the head and neck are white, instead of gray, and the ocular streak and loral smudge are fainter than in examples from Tristan da Cunha.

I can only point out that the described paleness of Australian specimens is exactly the condition of all Yellow-nosed Albatrosses in worn plumage. It is matched by several Atlantic birds in the American Museum Collection. Furthermore, Lowe and Kinnear state that in freshly moulted Australian specimens a slight tinge of bluish gray suffuses the head, nape, and hind neck, which vitiates the remainder of their argument. It is, of course, possible that two subspecies of the Yellow-nosed Albatross exist, but no such fact has yet been established.

Of forty-five skins which I have examined, two represent stray birds from the northern hemisphere, and the remainder were taken in the central South Atlantic, near the west coast of Africa, and along the east, west, and south coasts of Australia. The species evidently bears the same geographic relation to *Diomedea chrysostoma* that the Brown Sooty Albatross (*Phoebetria fusca*) does to the Light-mantled Sooty Albatross (*P. palpebrata*). Among penguins, we find a parallel relationship in the two crested species, *Eudyptes crestatus* and *E. chrysolophus*, the former being prevailingly temperate in its range, the latter prevailingly antarctic.

From its pan-antarctic congeners, the Yellow-nosed Albatross appears to differ also in another way, namely in a tendency toward solitary rather than gregarious nesting habits, although it is as tolerant of the penguins which build their nests all around its own as the Black-browed Albatross is at the Falklands and elsewhere. Pelzeln (1869, 149) speaks of the Yellow-nosed Mollymauks gathering by hundreds atop the cliffs of St. Paul Island, in the Indian Ocean, during November, but I infer that such brinks represent the places from which the birds take flight rather than those in which they nest.

On the west coast of South America, or elsewhere in the eastern Pacific, this species seems to be as yet unreported, but on the east coast it is known from the mouth of the Río de la Plata (Loranchet, 1916, 331) and neighboring latitudes. One was taken in the estuary of the river after a heavy October storm which washed many sea birds on adjacent Argentine shores (Dabbene, 1922, 272). Whitlock (1931, 264), by the way, says that this species is the commonest albatross to be found dead on Australian beaches after gales, which may mean that its flight is less powerful than that of its congeners, or merely that it is the most abundant albatross in the cool-current region of western Australia.

During the cruise of the 'Daisy' I saw the bird on nine different days of November and March in the thirties and forties of south latitude, some hundreds of kilometers east of the South American coast. Loranchet (1916, 331) records it from Tristan da Cunha to the Cape of Good Hope, and thence southeastward into the Indian Ocean, between June and September. Vanhöffen (1905, 503) found it along a similar course during December, and the members of the 'Quest' expedition saw it, together with other species of mollymauks, near Gough Island in late May and early June. The naturalists of the South Atlantic Expedition of the Cleveland Museum of Natural History collected many in the Atlantic between latitudes 27° and 30° S., longitudes 5° and 10° W., toward the end of August, 1925. During the cruise of the 'Valdivia,' flocks of as many as three hundred of these albatrosses were observed sitting on the water during quiet weather, along the African coast, in latitudes 16° to 17° S. (Reichenow, 1904, 346).

The Yellow-nosed Albatross comes to the islands of Tristan da Cunha to nest in August, and leaves the breeding grounds in April (Barrow, 1910, 275; Wilkins, 1923, 495). The breeding season is not, however, as much earlier than that of related species at South Georgia as might appear, for few eggs are laid at Tristan until about the first of October. Six months, or thereabouts, elapse between the time the egg is laid and the flying of the young.

During courtship, according to Moseley (1879, 129), the male stretches out the neck, raises the wings, erects the feathers, and utters high-pitched and rapidly repeated calls, not unlike a shrill laugh. It then puts its head against that of the female, and the two rub bills. The female then takes her turn in going through the identical ritual, which ends in the same way. Mrs. Barrow recorded the following at Tristan on February 6: "While sitting on the cliffs at Sandy Point, a pair perched within a few feet of us. . . . They have the most graceful movements, and this pair bowed, and clicked their bills together, and made love to each other in the most charming way. They cannot rise off flat ground unless there is wind, only from a hill or cliff edge" (Mathews, 1932, 41).

Carmichael (1818, 490) stresses the solitary habits of the Yellow-nosed Mollymauk at Tristan, saying that it builds its nest in some sheltered corner, such as a gulch draining into a larger ravine. Rogers, however, wrote from Nightingale Island, on January 31, 1924: "The Mollymawks thrive here, both in the tussac and in the open valleys, as well as on the cliffs. I saw one rookery in a beautiful but swampy valley, containing over 500 of these handsome birds, right in the middle of the island" (Mathews, 1932, 41).

At Nightingale Island the 'Challenger' naturalists found the albatrosses nesting on October 17. Most of their homes were among the nests of Rock-hopper Penguins, but others were more or less hidden away among tussock grass, ferns, and clumps of *Phylica* or other brush. In such cases it was necessary for the birds to have access to a high or open place, such as the rock mentioned by Campbell, before they could take flight from the nesting ground (Moseley, 1879, 129; Thomson, 1878, 162; Salvin, 1881, 149). The cylindrical nests were 25 to 30 centimeters in height by 50 or less in diameter. They were made of earth mingled with grass, sedge, and peaty fibers, and the upper edge in many cases overhung the sides, which the sitting birds had more or less undermined with their bills. Many nests contained eggs. The adults were characteristically fearless of man, and could not be driven into taking flight.

In another part of Nightingale, the albatrosses were nesting in the open where a large dirty puddle had formed around several nests. A sitting bird occupied each nest and others, presumed to be the mates, were wading about in the water, and showing no interest in flying off to sea during their relief periods. Sometimes these free birds would stroll up to their mates and squat down beside them, whereupon the pair would bill together. At the approach of men the sitters would clatter their beaks and shake their heads gravely. At a closer approach, they might stand, though without evidence of fear, and when doing so they would cover the egg with their broad webbed feet. The birds seemed so handsome, and all their motions so silent and dignified, that to Campbell the whole scene made a delicious contrast with the neighboring "howling fiends in the grass," the penguins (Campbell, 1877, 69).

Mrs. Barrow notes that at Tristan the nests are likely to be built near ponds, and that the adult mollymauks appear to continue frequenting them after the young have flown (Mathews, 1932, 41). The last is a particularly interesting comment in relation to Sir Hubert Wilkins's statement that at South Georgia the nests of *Diomedea chrysostoma* are used as resting places by the adult birds throughout the year (Wilkins, 1923, 488).

The eggs have long been used as food by the Tristan people, many hundreds being taken each season along with those of Rockhopper Penguins. According to information supplied by the wife of the resident missionary to Mr. J. G. Gordon, the mollymauks themselves are also eaten. "They are hunted from January to March, and in 1923, while 2,139 were taken in January, no less than 4,800 were killed in March" (Mathews, 1932, 40). The figures seem incredible, but if they in any way approximate the truth, the early extinction of this beautiful species at its principal Atlantic nesting ground is surely threatened.

At Gough Island, according to Captain Comer, this is the only resident species of smaller white-plumaged albatross. According to his observations, nest-building commenced on September 7, the nests never being placed close together, but scattered well apart among tussocks and brakes. The first birds began to lay on September 20, and within a week thereafter he began to find eggs regularly (Verrill, 1895, 440).

In the North Atlantic, the Yellow-nosed Albatross is said to have strayed into the River Trent in 1836, and to the coast of Iceland about 1843 (Andersen, 1895, 91). I have myself examined two much later specimens from the American side of this ocean. The first, which is in the Laval University Museum, Quebec, was shot in September, 1884, on the coast of Labrador. The other, now in the American Museum, was taken off Machias Bay, Maine, on August 1, 1913 (Murphy, 1922, 58).

It is curious that almost nothing is known about the nestling and immature plumages of this mollymauk. Lowe and Kinnear (1930, 179) have discussed the matter somewhat elaborately, and have come to the conclusion that "in the first juvenile plumage . . . the entire head, neck, rump and underparts are pure white." They then go on to hazard the assumption that the down is also pure white, and that the species therefore parallels *Diomedea epomophora* in moulting from white nestling down directly into white contour plumage. As these authors word the matter, "it seems to us that the plumage phases of *T. chlororhynchus* have been determined by very much the same factors as have influenced those characteristic of *Diomedea epomophora*."

The purport of the above is that while the head of *D. chrysostoma* changes with age from a dark brownish gray to a lighter gray, that of *D. chlororhynchos* begins with white feathering and darkens with age. I believe, however, that this conclusion must be regarded with caution, and that the whiteness of the heads of most black-billed juvenals of this species, collected at sea, is due to *wear*, which rapidly removes the surfacing of gray tips on feathers which are always basally white. The 'Scotia' party obtained at Gough Island a fledgling mollymauk which had just tumbled into a ravine on April 22, 1904. The bird was necessarily of this species, though Clarke (1913, 287) lists it as "*Thalassogeron* sp. inc." He states that while the sides of the face are white in this specimen, the hind neck is gray. Furthermore, Lowe and Kinnear are probably wrong in their guess as to the color of the nestling down, for Mrs. Barrow has specifically stated that on January 5, at Tristan, she saw one or two of the young, "which are covered with a fluffy blue down" (Mathews, 1932, 41).

I have examined the types of the Australian specimens described as *Thalassogeron carteri* and *T. bassi*. Both can be matched exactly among Atlantic specimens. The former is a young bird with a black bill and a very worn contour plumage, except for the wing quills. *T. bassi* also has a worn and white head, but the culmen has turned from black to yellow.

BULLER'S ALBATROSS

Diomedea bulleri

Diomedea bulleri Rothschild, 1893, Bull. Brit. Orn. Club, 1, p. lviii (New Zealand).

Names: Buller's Mollymauk. A synonym of the specific name is *platei*, the type of which was described from Cavancha, Chile. Many of the early records are given under the name *culminatus*, through confusion with that species, now called *chrysostoma*.

Characters: Not easily distinguishable from certain other gray-headed mollymauks except by bill characters, which are delineated in Fig. 52. The white forehead, in contrast with the gray hind head, might prove diagnostic of birds in full plumage. Forehead and fore part of crown white, blending into brownish gray, which is the color of the hind neck, sides of neck, and mantle; cheek, throat, and fore neck French gray, the lores and ear coverts darker; a black supra-orbital patch extending from the upper part of the lores to behind the eye; back, wings and a very broad anterior margin of their lower surface, sooty brown; outer secondary quills somewhat gray, the basal half of the inner webs white; innermost secondaries brown like the scapulars; lower back, rump, and upper tail coverts white; rectrices slaty gray, blackish on the outer webs, and with white shafts; ventral surface caudad from the fore neck, and including the wing-lining except for its anterior border, white. Iris brown; bill black on the latericorn and upper half of mandible, with the culmen, nail, and ramal portion of mandible bright yellow; transverse stripe at base of mandible, and skin of gape, orange; feet and legs light blue, richest among breeding birds.

All adults have bluish feet in life, but their dark color in dried skins explains why Godman (1910, 345) records them as red.

Adults collected by Beck at the Chatham Island breeding grounds during March were undergoing moult and replacement of the quills. Males average very slightly, if at all, larger than females. The following summary of dimensions is based upon 29 specimens almost equally divided as to sex.

Wing, 462–526 (500); tail, 175–199 (188.6); exposed culmen, 115–126 (120); width of maxilla at base, 26–30; depth of closed bill at base, 42.5–49; tarsus, 78–85 (81.1); middle toe with claw, 110–124 (117.2) mm.

Mr. Beck records the wing-spread of a male from Forty-Fours Islet, Chatham Islands, as 208 cm. (6 feet 10 inches).

The eggs of Buller's Mollymauk are described as varying from uniform creamy white to examples with a distinct zone of partly confluent reddish speckles around the larger end. Average measurements given by Buller are 101.6 x 63.5 mm. (Godman, 1910, 344). Oliver (1930, 159) gives the dimensions of two from the Snares as 106 x 66.5 and 102 x 65 mm.

Distribution: Confined, so far as known, to the South Pacific Ocean, between the New Zealand region and the west coast of South America. Breeds at the Snares Islands, and at several islands of the Chatham group.

Specimens of this mollymauk obtained on the coast of New Zealand previous to the date of its description by Rothschild, were confused with the Gray-headed Mollymauk (*Diomedea chrysostoma*). Beginning with the discovery of its breeding grounds at the Snares, by Reischek in 1888, it has gradually become apparent that it is not only specifically distinct from *chrysostoma*, but that it belongs to a more northerly climatic zone (Oliver, 1930, 159). During the course of the Whitney South Sea Expedition, Mr. Beck located additional breeding stations at the Forty-Fours Islet and Round Rock, Chatham Islands. The bird does not occur at any icy antarctic island, nor have I ever seen a record from latitudes approaching the zone of floating ice. Furthermore, its range to westward of its breeding area is so restricted that it has never yet been recorded as a member of the Australian sea bird fauna. Its inclusion within the South American list rests first upon an example in the Berlin Museum, described by Reichenow as *Diomedea platei* (Murphy, 1930, 6). Moreover, in the Brewster-Sanford Collection are a male and female taken by Beck twenty miles off Cañete, Peru, on June 26, 1913, and a male taken off Valparaiso, Chile, on March 9, 1914. Thus Buller's Mollymauk becomes the fourth species of the group of smaller southern-hemisphere albatrosses to be known from the Humboldt Current.

In the Pacific it appears to occupy a position somewhat analogous to that of *Diomedea chlororhynchos* in the Atlantic-Indian Ocean region. Both species dwell at temperate islands and range in lower latitudes than either *D. melanophris* or *D. chrysostoma*. *D. cauta salvini* agrees with *bulleri* and *chlororhynchos* in the temperate character of the breeding grounds, but its range has come to encircle the world.

Oliver states that off the coast of Stewart Island, New Zealand, this species associates with the White-capped Mollymauk (*D. cauta*), and like it has developed the habit of attending fishing-boats and following them into port.

On the Snares, Stead found Buller's Mollymauks mating and nesting on February 1. Along the steep slopes, dozens were sitting upon the conical piles of peat that formed the nests, but only a few eggs had yet been laid. All the nests were close to vegetation, and were on earth rather than on the outcrops of rock. The lowest was placed 12 or 15 meters above the sea (Oliver, 1930, 160).

The Snares are in approximately the same latitude as Bounty Island, and it is noteworthy, if the observations are correct, that *Diomedea bulleri* breeds three to four months later than *Diomedea cauta salvini*.

The first South American example of this mollymauk, which was taken at Cavancha, close to Iquique, Chile, and described as *Diomedea platei*, proves to be a young specimen of *bulleri*, entirely comparable with others of like age in our American Museum Collection. The head is suffused with buffy gray, as in other juvenals, but the forehead is already whiter than the crown. The body plumage is quite fresh; I should judge that the bird had not been many weeks out of the nest, despite the fact that it had already spanned the South Pacific. In young examples of this mollymauk, as in other yellow-billed species, the beak is at first black, the mandibular rami and culminicorn then turning horny and finally yellow.

WHITE-CAPPED ALBATROSS

Diomedea cauta salvini

Thalassogeron salvini Rothschild, 1893, Bull. Brit. Orn. Club, 1, p. lviii (New Zealand).

The White-capped Albatross (*Diomedea cauta*) breaks up into at least three well-marked sub species, of which only one, *Diomedea cauta salvini*, has thus far been recorded with certainty from South American waters. This form is therefore the one described below, but it has been thought advisable to add to the description some comparative notes on the other races. Moreover, in the biography of this albatross certain data on life history are taken, as indicated, from literature referring to the typical form, *Diomedea cauta cauta*, which was described in 1841 by Gould (Proc. Zoöl. Soc. London, 1840, p. 177) from Bass Strait, between Australia and Tasmania.

A third form, *Diomedea cauta eremita* Murphy (Amer. Mus. Novit., 1930, No. 419, p. 4) has recently been described from nesting grounds on an islet off Pitt Island of the Chatham group, east of New Zealand.

A characterization of the three races is as follows:

1. A large, white-headed and white-naped subspecies, with a light gray tinge on the cheeks in fresh plumage, and a grayish bill. Breeds on islands in Bass Strait, southeastern Australia, and wanders eastward at least to waters east of the Chatham Islands . . . . . *Diomedea cauta cauta*.
2. A slightly smaller subspecies (especially in bill and feet), with the head and nape light gray the pileum distinctly paler; bill grayish. Breeds at Bounty Island, and perhaps at other subantarctic islands of New Zealand, and wanders eastward across the Pacific to the coast of South America, and westward across the Indian Ocean into the South Atlantic . . *Diomedea cauta salvini*.
3. A short-winged subspecies, otherwise of about the same size as the last, with a dark gray head and nape, the pileum little if any lighter than the remainder; bill entirely bright yellow. Breeds at Pyramid Islet, Chatham Islands; known only from the immediate vicinity of the nesting ground . . . . *Diomedea cauta eremita*.

The following descriptive notes refer to the subspecies *salvini* which, so far as yet known, is the only one entering the South American area.

Names: White-capped Albatross, Shy Albatross, Salvin's Albatross; mollymauk, with any of the preceding adjectives. I believe the specific or subspecific name *layardi* to be a synonym of *salvini*, the former stage representing the worn and faded plumage of the latter (Murphy, 1930, 4).

Characters: The largest of the "mollymauk" group of albatrosses in the South American avifauna; gray plumage of head combined with a gray bill; entire under surface of the wings white, except for an anterior margin much narrower than in *D. melanophris*. Upper back slate gray, the feathers showing paler margins or subterminal bands and white bases; lower back, rump, and upper tail coverts white; scapulars ash-brown; wing coverts dark brown with white bases, the smaller coverts showing paler edges; primary coverts and quills dark brown or blackish, the quills with white shafts, white on the inner webs, and basal mottlings; secondaries dark brown with an ashy gloss, the basal portions of the inner webs white; rectrices hoary gray, browner distally, with white shafts; head and nape gray, the hue varying in fresh plumage between pale neutral gray and deep gull gray, distinctly lighter on the crown, producing a capped effect, and sometimes whitish on the throat; a narrow supra-orbital stripe, expanding into a spot in front of the eye, blackish, becoming pale toward the base of the bill; ventral surface of body, including the axillaries and under wing coverts, except those of a narrow anterior margin, white. Iris brown; bill bluish or greenish gray, with a horn-colored or "ivory" culmen, and a blackish terminal spot on the mandible; transverse fleshy stripe at base of mandible, orange; legs and feet bluish or bluish gray.

Dimensions of 32 males and females of *Diomedea cauta salvini* are as follows: wing, 523–585 (556); tail, 188–220 (205); exposed culmen, 117–135 (128); width of maxilla at base, 27–33 (30); depth of closed bill at base, 46–56 (51.6); tarsus, 80–95 (88.1); middle toe with claw, 121–139 (131.3) mm.

The typical subspecies is larger, with a wing-spread, according to le Souëf, of 244 cm. (8 feet).

Eggs of *Diomedea cauta salvini* from Bounty Island are described as white, with faint brown blotches at the larger end. Two measure 101.5 x 68.5 and 106 x 66 mm. (Oliver, 1930, 160).

Distribution: The southern oceans, chiefly in temperate latitudes, and apparently less common in the South Atlantic than in the Pacific and Indian Oceans. The subspecies *salvini* is known to breed only at the Bounty Islands, east and south of New Zealand.

The development of three forms of albatrosses so closely related that they must all be regarded as subspecies of *Diomedea cauta* seems to be correlated with the interesting zoögeographic fact that one of the three is extremely sedentary, another of at least rather restricted range, while the third wanders more or less around the globe. Negative evidence can never be final, but for the present we may say that *eremita* is known only from the immediate vicinity of its breeding ground on Pyramid Islet of the Chathams; *cauta*, the typical form, which nests on islands in Bass Strait, has been recorded only within the Australian-New Zealand region, *i. e.* between the eastern Indian Ocean and waters near the Chatham Islands; while *salvini* crosses the Pacific to the west coast of South America, and also reaches the Cape of Good Hope and the South Atlantic. I have seen neither specimens nor records of any form of this albatross from high southerly latitudes.

During the Brewster-Sanford Expedition, Mr. Beck observed the White-capped Albatross many times in the Humboldt Current, from Chilca, Peru, to Valparaiso, Chile, and thence southward to Ancúd. He collected a female 32 kilometers west of Cañete, Peru, on June 26, 1913, and a second off Valparaiso on March 4, 1914. Peruvian specimens which I have examined in the Rothschild and British Museum Collections comprise a male taken near the Ballestas Islands, Pisco Bay, March 5, 1912, and three males and a female taken off Lobos de Tierra Island, near the northern end of the Humboldt Current, on May 28, June 20, 26, and 27, 1912 One of the last is of the phase described as *layardi*, which seems to result merely from wear and fading of the gray head-feathering.

In the South Atlantic, the White-capped Albatross is best known from the vicinity of the Cape of Good Hope, the type locality of the alleged "*layardi*."

In these waters it is sometimes abundant (Alexander, 1922, 261), and we have two specimens taken, respectively, near Robben Island in Table Bay, and near Dyer Island which lies a little west of Cape Agulhas.

On September 6, 1925, the Argentine fishing steamer 'Undine' captured an example which is now in the National Museum at Buenos Aires, in latitude 35° 44′ S., longitude 53° W., not far off the mouth of the Río de la Plata (Dabbene, 1926, 325). This is the specimen which Mathews (1934, 213) has described as a new race (*Diomedella cauta atlantica*), on the grounds that its bill colors differ from those of *salvini*. Dr. Dabbene has given two records from the Magellanic region as well (1926, 324, 346), but these were based upon lirerature rather than upon specimens that had come under his own eye, and it appears that at least one of them referred in reality to *Diomedea bulleri*.

The name *cauta*, and its English equivalent "shy" or "wary," means nothing more than an impression of the original describer of the species. Alexander (1928, 16), who uses the vernacular name "Shy Albatross," says that it is appropriate because the bird rarely comes near a ship. Le Souëf (1895, 413), on the other hand, reports that the species is not in the least shy either on land or sea, and Richards (1909, 5) regards it as "bolder than the other albatrosses," stating that it usually keeps close to a ship and occasionally passes directly over the deck! Such diverse opinions have little universal meaning, since each reflects varying conditions of abundance, weather, season, food supply, or a multitude of other circumstances which might affect the behavior of birds at sea. As pointed out elsewhere, caution must be used in calling the Black-browed Albatross the most "fearless" of albatrosses, when the facts might be fully covered by the statement that it is the most abundant species. If a ship were to be followed by great numbers of White-capped Albatrosses, it is likely that Richards's experience would be duplicated, and that far from being "wily about a baited hook" (Green, 1887, 11), they would energetically endeavor to take a hook, upon which, as le Souëf found, they might easily be caught.

Oliver (1930, 162) writes as follows of the nesting White-capped Mollymauks of the Bounties, where the birds gather in August for the mating season:

> Perhaps the most remarkable thing about the bird life on the Bounty Islands is the complete intermixture of species, at any rate of the surface breeders, which breed there. The Big-crested Penguin is found on every available site where a foothold can be obtained and scattered freely among these birds are the nests of the White-capped Mollymawk. This species is able to build its nest on sloping surfaces and other places where the penguin would have difficulty in sitting on its egg. There is no vegetation, other than marine algae, on the islands. Indeed the conditions are too severe to permit of its growth; in summer the surface is sprayed with bird excrement, in winter the waves pass over it. The only materials plentiful at all are penguins' bones, guano and feathers, and it is of these that the White-capped Mollymawk constructs its nest. It is quite solid and is small for the size of the bird which evidently would cover it when sitting. It averages about 14 inches in diameter with a shallow hollow about 8 inches across. The height varies according to the surface, and if situated on a slope, one side will be built up higher than the other in order to make the top horizontal. The sides average from four to six inches in height. The Bounty Islands are visited so infrequently that it is not known exactly when the Mollymawks lay. On April 4th the young were fully fledged and would thus be about four months old. This would indicate that the eggs were laid in October.

Le Souëf (1895, 413) and Armstrong (1910, 155) have given excellent accounts of the White-capped Mollymauks of the typical race, *cauta*, which inhabit Albatross Island in Bass Strait. Here the albatrosses nest in small clusrers on the rocky ledges, and in larger colonies of a hundred or more pairs on the upper slopes of the island, below a central ridge and not far from the edge of a cliff which they use as a taking-off place. Cormorants nest among them, sometimes crowding within a foot of the albatross nests, just as penguins do in more southerly localities.

The nests are composed of earth and grass, cemented with excrement. In constructing a new one the albatross, seated on the ground, first digs a circle with the bill and draws the loosened earth toward the center. Thereafter the nests grow year by year, chiefly through additions of grass and excreted matter, rather than soil. Eventually they may measure from 8 to 25 centimeters in height, with diameters of 55 at the base of the pile and 45 at the top. The bowl is about 28 centimeters in diameter by 8 in depth. The nest is small for the size of the bird which, when sitting, seems to overflow the top.

Here the egg-laying season of the mollymauks comes about the end of September. Mated birds squat beside their nests, rub bills, and cackle. When two birds not of the same pair meet on ground away from the nests, they express a phase of the ancient amenities (so well developed among certain tropical representatives of the albatross family) by stretching out their necks and leaning forward with a gesture of kissing each other's cheeks, at the same time cackling and spreading their tails. If a free bird attempts to walk through a group of sitting albatrosses, however, the reaction is anything but courteous, for the sitters all lunge savagely at the intruder.

When a man approaches the nests, the mollymauks lean backwards until they sit upon their heels and tail, nearly upright, and glower by projecting the "eyebrows." They clatter their beaks, make vocal sounds much like the neighing of a foal, and, as a final resort, discharge from their throats a jet of green fluid. Just before they open their bills to eject this strong-smelling oil, the orange edge of the mouth, behind the bill, is bared.

Well-incubated eggs and newly hatched young have been found in this colony on November 26. The bare brood-patch just below the sternum of the sitting albatross forms almost a pouch, so that the egg slips out slowly from among the thick feathers when the bird erects itself upon the nest. Even when robbed of the egg, the albatross does not leave but, after making a futile search by poking its bill under its belly, it settles down as though nothing had happened. Young chicks are usually seen lying prone, with the head on one side, which gives them the appearance of being dead.

Ordinarily the mollymauks take flight from the brink of the cliff, wiggling their tails vigorously from side to side when they are fairly launched. Returning to their island, they often find difficulty in alighting at a particular spot, perhaps making several incomplete and unsuccessful efforts before they come down and topple awkwardly upon their breasts, just as the great albatrosses do.

Godman (1910, 349) writes:

This species is singularly dependent on the wind, and in calm weather is liable to be captured in any depression of the ground, for without a strong wind it cannot rise, and in order to fly it must reach the edge of a cliff or prominence and start with a downward movement.

Oliver (1930, 162) reports that the White-capped Mollymauks regularly follow fishing-boats at Half Moon Bay, Stewart Island, associating with Buller's Mollymauks and scrambling for offal tossed overboard. Gould (1865, 434) found remains of large fish, barnacles, and crustaceans in the stomachs of White-capped Mollymauks taken in Recherche Bay, Australia.

Of the Peruvian specimens of *Diomedea cauta salvini*, mentioned above, one is a bird in worn plumage, with a whitish head. It almost exactly matches the type of *Thalassogeron layardi* in the British Museum. Several of the Peruvian birds, collected during May and June, are in moult, with replacement of the quills in progress.

Well-grown chicks are represented among our Bounty Island birds. These were moulting from a light neutral gray down into a plumage exactly like that of their parents. Their bills were blackish in the younger stages, graying as they approached full size. The feet in life were light bluish, sometimes almost white.

Sexual dimorphism is almost negligible in this subspecies, as shown by figures for breeding adults from Bounty Island (Murphy, 1930, 4). Le Souëf reports (1895, 413) that in the typical race, *Diomedea cauta cauta*, the sexes are of slightly dissimilar size and appearance.

GALÁPAGOS ALBATROSS

Diomedea irrorata

Diomedea irrorata Salvin, 1883, Proc. Zoöl. Soc. London, p. 430 (Callao Bay, Peru).

Names: Waved Albatross, "Pájarote," "Pajarón," "Pájaro carnero."

Characters: A small albatross, with wing-spread well under 2.5 m., but with a relatively very large and conspicuous bill, and very short tail. In general form the species resembles the great albatrosses more closely than it does any member of the group known as mollymauks. Dorsal surface of body generally smoky brown, with a few irregular bars or spots of white on the mantle, longer scapulars, and inner secondaries; upper mantle and upper scapulars regularly barred with blackish brown and whitish zigzag or wavy lines, the dark bars predominating; head and neck white, tinged with yellow (Naples yellow to ochraceous buff) which is of variable extent from forehead to nape, and on sides of neck; hind neck and sides of neck further varied with fine transverse lines of grayish black and white, these vermiculated bars extending down the sides of the neck and chest; lower back, rump, and upper tail coverts coarsely barred with black and white zigzag markings, the upper tail coverts having broader white bars; cheeks, chin, and throat white; remainder of ventral surface finely vermiculated with white and dusky brown, darkest on the abdomen and flanks; under tail coverts whiter, more coarsely barred with dusky brown; under wing coverts and axillaries grayish white, rather finely vermiculated with dusky brown; edge of wing dark brown; quills blackish, more ashy on the inner webs, which are slightly vermiculated near the base; rectrices smoky brown, becoming white on the concealed parts. Iris dark brown; bill yellow (quickly discoloring after death); interramal skin azure; orbital skin black; legs and feet pale or leaden blue.

Below are the dimensions of 14 specimens of *Diomedea irrorata* which I have measured:

9 males: wing, 517–551 (542); tail, 130–138 (134); exposed culmen, 149–156 (152.8); width of

maxilla at base, 30–35 (32.9); depth of closed bill at base, 46–52 (50.5); tarsus, 99–105 (102.1); middle toe with claw, 129–137 (133.2) mm.

5 females: wing, 491–555 (528); tail, 127–140 (133.8); exposed culmen, 137–148 (141.6); width of maxilla at base, 30–31 (30.7); depth of closed bill at base, 44–49 (46.3); tarsus, 93–100 (96.6); middle toe with claw, 116–130 (123.2) mm.

Loomis's data, based upon 62 specimens from the breeding grounds, are similar, except that the wing and tail lengths are greater, as follows:

22 males: wing, 550–593 (568); tail, 137–158 (147) mm. 40 females: wing, 510–586 (547); tail, 129–150 (139) mm. The longest bill in the series of males measured 160 mm. This species has relatively the largest bill of any albatross in the world. Body-lengths (bill to tail) in five males ranged from 890 to 935 mm., and in four females from 850 to 870 mm. The wing-spread in a single male was 235 cm. (7 feet 8 inches), and in a female 232 cm. (Loomis, 1918, 81).

The eggs are more heavily marked than those of most albatrosses, and vary much in shape. They are from nearly oval to elongate-ovate, rarely much narrowed at the smaller end. The ground color is dull whitish, the larger end sparsely or heavily capped with more or less confluent spots, lines, and blotches of cinnamon-rufous and bay. The remainder of the shell is more or less speckled with the same colors. Dimensions of four typical eggs are: 99.6 x 65, 113 x 72, 108.4 x 64.4, 111 x 74 mm. The average of 25 eggs is 108.3 x 69.9 mm. (Snodgrass and Heller, 1904, 241; Loomis, 1918, 82).

Distribution: The only exclusively tropical albatross. Breeds at Hood Island of the Galápagos, ranging chiefly to southward of the archipelago and regularly reaching the coasts of Ecuador and northern Peru.

The Galápagos Albatross ranks as one of the most distinct and remarkable of sea birds discovered within modern times. When it was described, in 1883, from a specimen taken in the Bay of Callao, there was no clue as to its origin, and the breeding ground at the Galápagos was not known to science until the visit of the Webster-Harris Expedition, which located the Hood Island colony on October 25, 1897 (Rothschild and Hartert, 1899, 192). Yet, as a matter of fact, the Galápagos Albatross had been familiar to sealers, whalemen, and certain other ocean travellers as long ago as the very beginning of the nineteenth century. Not only did Habel refer rather uncertainly to the breeding albatrosses of Hood Island (Salvin, 1877, 458), but Captain Amasa Delano, who visited the Galápagos Islands in 1801, mentions the species in his journal, and fails to describe it in detail only because he did not regard it as distinct from one of the pan-antarctic mollymauks to which he had already devoted considerable space (Delano, 1817, 380).

Whether or not the Galápagos Albatross bred at James Island at the beginning of the nineteenth century is an open question, but at any rate Captain Delano knew an albatross when he saw one, and Salvin (1877, 452) was quite unjustified in assuming that the old seafarer referred to petrels (*Pterodroma phaeopygia*) which do not, by the way, sit and hatch "on the burnt stony ground."

In the waters about Lobos de Tierra Island, off the coast of northern Peru, I first became familiar with the Galápagos Albatrosses during the middle of January, 1920. They rarely came near enough to land to be seen from the beaches, but 8 to 10 kilometers from shore I would encounter small groups of them upon the water, only to have the birds take flight when my fishing-boat was still a good way off. In the light breezes then prevailing, they certainly flew in a more labored manner, and beat their wings more frequently, than is characteristic of any of the albatrosses of high southern latitudes.

Five years later, and at exactly the same season, I again found them common on this same coast but slightly closer to the equator and to ocean waters of permanently high temperatures. At Point Pariñas, the westernmost projection of the continent, I saw one bobbing about close to the rocks upon which waves were breaking. Off Talara and Lobitos they were often in the same sky-view with man-o'-war birds and Peruvian Pelicans, and both of the latter species gave the impression of being more buoyant and "comfortable" in the air. In fact, I find myself unable to regard the flight of the Galápagos Albatross as being in any way the equivalent of the wheeling, effortless locomotion exhibited by mollymauks which the traveller may see at certain seasons along this coast, a few score kilometers farther southward. Part of the difference in impression may, however, be due to the fact that I have never yet seen a Galápagos Albatross in a strong breeze.

In air the albatrosses looked about the same size as the pelicans and much larger than the man-o'-war birds. After I had shot one of each on the same afternoon, the striking truths and errors of such casual comparisons became apparent. As a matter of fact, the wing-spreads of all three were substantially equal, that of a male albatross being 231 centimeters (7 feet, 7 inches), that of a pelican 232, and that of a man-o'-war bird 230. The bulks, however, presented extraordinary differences which, in the cases of the albatross and pelican, had been largely imperceptible in life. The albatross weighed 2041 grams (4½ pounds), the pelican 3969, or almost twice as much, the man-o'-war bird only 1587. The albatross proved to be very small-bodied in comparison with the pelican, its apparent size being due to the wonderfully long, thick plumage, and the undercoat of dense down, a family characteristic as well developed in this equatorial species as in albatrosses which frequent the icy seas of the south polar circle. The man-o'-war bird was not only still smaller-bodied but also relatively thinly feathered.

It is interesting that both a heavier and a lighter species, each having the same wing-spread as the albatross, should appear to a human observer to be a better, *i. e.* easier, flier under the quiet, tropical meteorological conditions which generally prevail at the northern end of the Humboldt Current. Such an observation has doubtless no significance in the economy of the three species, but it might form an interesting basis for a study of the relation of structure to flight. It is only fair to note, by the way, that Beebe (1926, 108) records the weight of the albatrosses at Hood Island as "about ten pounds," but, in view of the weights of two adult and fairly fat birds which I collected myself, together with what we know regarding the weights of other species of albatrosses, I must believe that an error of fully a hundred per cent has crept into Beebe's figure.

The question of latitudinal zoning among sea birds, due to a "standard atmosphere" suitable for each species or type, has been interestingly discussed by Jones (1926, 36). Unfortunately, this author's data are partly in error: he disregards the range and existence of the Galápagos Albatross; he credits unduly great weights for the Wandering and Royal Albatrosses; he states that all the pan-antarctic albatrosses have abbreviated tails, although one type (*Phoebetria*) has in reality the longest tail of any species; he assumes that the densest atmosphere is found in high latitudes, whereas the belt of maximum mean atmospheric pressure is actually close to 30° in the southern hemisphere (Clayton, 1923, 28; cf. also Fig. 1); he disregards the variation by latitude in the average force of the wind.

Nevertheless, Jones's remark that among sea birds there is a repetition of general morphological type at latitudes roughly equidistant north and south of the equator is in large measure true, and his other observations may have a bearing upon the differences, noted above, between the flight of the Galápagos Albatross and the man-o'-war bird. Anyone who has voyaged northwards from the Roaring Forties, he says, must realize that while the southern albatrosses seem to be entirely masters of their element in high latitudes, they appear equally to lose their mastery as progress is made toward the tropics. The last birds seen, at about latitude 34° S., for example, have a relatively labored flight.

Jones then inquires as to whether the albatross should not be regarded as an "adjusted plane," confined within the limits of its own peculiar "standard atmosphere," which is characterized by maximum density or sustaining power. The buoyancy of air may be reduced so much by increased temperature and increased content of water vapor that its sustaining power near the equator might easily be at least 15 per cent lower than in colder latitudes.

By figuring the weight of birds in kilograms, divided by the area of the expanded wings in square meters, Jones shows that the plane surface of small sea fowl is relatively much larger than that of albatrosses. He believes that this is correlated with a principle which tends to limit the size of flying birds toward the equator. He calls attention, furthermore, to the light body and the vast wing and tail areas of the man-o'-war birds, creatures especially adapted to effortless flight in warm regions.

So far, so good; but I am still at a loss to explain why the heavy-bodied Peruvian Pelican can fly so gently and majestically in weather which causes the lighter Galápagos Albatross to give the appearance of hard sledging. It may be, however, that my familiarity with pan-antarctic albatrosses in gales of wind causes me unduly to disparage the tropical species. Coker (1919, 461) writes of the Galápagos Albatross: "Its wing strokes seem slow and deliberate, but the flight is rapid and graceful. It will soar for considerable distances, keeping just above the water and rising and falling with the waves."

The affinities of the Galápagos Albatross seem to be with the North Pacific representatives of the family. Its closest relative is probably *Diomedea albatrus*, with which it shows similarities in proportions, the form of the beak, and the peculiar tawny color of the head. Among the southern-hemisphere species, the Wandering and Royal Albatrosses appear to be more closely related with *irrorata* than do any of the mollymauks. The relatively enormous beak is the most distinctive structure of the Galápagos species. As Loomis (1919, 370) has shown, there is much variation in the shape of the bill among adult birds, some having straight and some concave culmens.

The observations of Gifford (Loomis, 1918, 75) tend to show that this albatross absents itself from the neighborhood of the Galápagos Islands for a portion of each year, particularly during the months of December, January, and February. This is just the period during which most of the records for the coasts of Peru and Ecuador have been made. The type, for example, was collected at Callao in December, 1881; I shot two specimens off Talara in January; Beck and I each observed scattered examples repeatedly along the Peruvian coast during the same season, which is the height of the southern-hemisphere summer. Coker (1919, 462) reports as many as thirty within view at one time in the waters between Eten and the island of Lobos de Tierra. To the Indian fishermen, who call it the Pájarote or Pajarón, the bird is well known. The time of its occurrence close to the coast is likewise known by them to be the season when the warm countercurrent from the north has checked upwelling alongshore, in other words, when the Humboldt Current is least active. Off the northernmost part of the Peruvian coast, however, and off the Gulf of Guayaquil, this albatross and other Galápagos birds are likely to be found at any time of year. The British Museum and Rothschild collections contain specimens of the albatross taken by Forbes near Lobos de Tierra Island at the end of May, the season when eggs are to be found at the breeding ground.

Since the nesting locality is equatorial, it is interesting that the pelagic range of the Galápagos Albatross lies almost entirely to southward, rather than to northward. Loomis (1918, 76) notes that the most northerly record for the species is in the waters about Tower Island, barely north of the equator. Beck is still more specific regarding the usual habits of the albatrosses in the neighborhood of their colony. He writes (1904, 11):

> An odd fact about the albatrosses is the direction of their flight from the island [Hood]. They fly straight out to southward and none are seen about the north side of the island nor about any of the other islands. We were on the island two days before we found them, though the island is not more than four miles across and there were hundreds of the birds.

The northernmost limit of the known range along the South American coast is at La Plata Island, Ecuador (1° 20′ S.), where I once examined a skin of a bird which had been shot by the keeper of the lighthouse in November, 1924 (Chapman, 1926, 184). From here the species has been encountered at many localities southward along the coast to Independencia Bay, Peru, which is in latitude 14° 20′ S. (Paessler, 1913, 42; Coker, 1919, 461). In these waters, the albatross is chiefly an offshore bird, *i. e.* characteristic of the belt outside that of coldest upwelling; and it becomes most abundant and familiar close to shore during the warm countercurrent or "El Niño" seasons, that is, during the same periods in which man-o'war birds and Royal Terns make their most southerly inroads from the tropical oceans to northward.

The explanation of a migration prevailingly to southward is doubtless connected with oceanographic conditions, as they are reflected in food resources. To northward of the Galápagos lies a warm and relatively barren oceanic region, while to southward and eastward are the rich zones of Humboldt Current water. Many forms of life are especially abundant in lanes marking the edges of cool and warm bodies of water, and I judge that it is in just such places that the Galápagos Albatrosses find much of their food. According to Beebe (1926, 108), the food of the albatrosses at the Galápagos consists of rather small squids, remains of which are sometimes disgorged by birds at the nesting ground (Loomis, 1918, 78). At sea, however, the albatrosses also pursue shoaling fish, such as herrings and anchovies. This is determinable from their association with boobies and pelicans, besides which Coker (1919, 462) observed one devouring a fish about 30 centimeters in length.

At the eastern end of Hood Island, in the southeastern corner of the Galápagos group, is the only known breeding ground of this albatross. The colony, which has fortunately not been found by all visitors to the island, has, nevertheless, been made to supply eggs to whalers and others since the first invasion of these seas. Wolf notes that about the year 1876 more than fifty laborers engaged in collecting the lichens which furnish orchilla dye lived for a month upon albatross eggs (Godman, 1910, 330). Subsequent inspection by scientific parties has seemed to disclose progressive reduction in the number of the birds. In May, 1899, Heller and Snodgrass (1904, 240) found the nests "averaging about twenty-five feet apart." In June, 1929, the visitors from the 'Mary Pinchot' reported: "Probably in most cases there were not more than half a dozen nests to an acre" (Fisher and Wetmore, 1931, 26).

In April, 1925, Beebe (1926, 108) visited the colony at the beginning of the nesting season, there being at this date about a thousand adult birds present. The nests were among shrubbery, sometimes close together, sometimes scattered about singly, and only a small proportion of eggs had yet been laid. The so-called courtship antics, which are really a perennial social pastime, were in full progress, and are thus described:

In performing, mated birds face each other about a foot apart. One points its bill straight up, at the same time uttering a grunting moan. Its partner follows suit and then they bow alternately several times and next cross bills and fence with quick vibrating movements of the head. Again they point their bills skyward only to cease and bow and go through the fencing process once more. This may proceed until their mutual attentions are interrupted by the approach of a third albatross, who indicates a desire to take part in the ritual.

The sequence is not always the same, but the upward stretch always begins it, and all the phases are enacted by each bird in turn. The grunts or groans or rasping notes are sometimes frequent or the whole thing may take place in silence. There is no emotional climax. It begins and ends in the calmness which the gentle eyes of these birds and their philosophical treatment of an intruder such as myself indicate as a deep-seated character. Fortunately it was a very easy matter to obtain a perfect series of motion pictures of the fencing, and thus to preserve what mere words so completely fail to delineate.

According to Loomis, the billing, fencing, and dancing of the albatrosses were of constant occurrence at Hood Island in September, 1905, as well as in June, 1906, that is, at the end, as well as at the beginning, of the nesting season. He writes (1918, 77):

. . . although the view was obstructed by rocks and bushes, a glance anywhere over the rookery always revealed one or more pairs in action. Standing opposite one another, each bird threw its head up, the bill in this position being nearly or quite vertical, then the pair bowed, then fenced for perhaps a minute, using the bills as foils. Other features were often added, which did not seem to have any regular order. In these the birds usually performed alternately. While one was doing the stunt, the other assumed a statuesque pose, standing very erect, intently watching the performance. At its conclusion the two joined in a fencing bout. Then the second bird performed, and afterwards the fencing was repeated, and so on to the finale. The additions were as follows: 1. Bird touched ground beside it with bill; 2. Mouth was opened very wide; 3. Bill was pointed straight upward and a moaning note uttered; 4. Bird reached around and touched wing with bill. Occasionally a third bird took part at the beginning, but one soon dropped out.

Dr. Drowne, of the Webster-Harris Expedition, thus describes the post-nuptial performance of the albatrosses in October, 1897, immediately after the scientific discovery of the colony:

They would stand opposite each other, and throw their heads up in the air; then make two or three preliminary bows and parries, and after fencing a minute or less, one would throw up its head and utter a note with his bill wide open and then assume the first position again. The other would follow the example, and the same performance would thus be gone through with many times (Rothschild and Hartert, 1899, 126).

Drowne adds that the birds sometimes had to run 30 meters to take off from the ground, that they were generally tame but that they sometimes menaced or attacked intruders, and that there were "several thousand" of them in the colony.

Loomis's text and illustrations show that the birds sometimes go through their exercises when one or both are sitting. He says, too, that if a human being bows to an albatross immediately after the performance, the bow is likely to be returned. They are, however, quite capable of expressing resentment toward a human visitor, the emotion being accompanied by the erection of eyebrow ridges, so that the top of the head appears broad and flat, and by a rapid snapping of the mandibles. "On one occasion when a bird was being chased, its mate left the egg and followed in pursuit for fifteen or twenty yards, menacing with the bill" (Loomis, 1918, 78). This may be the individual which Beck recalled when he wrote (1904, 11), "Nor will I soon forget the old rascal who came for me on the dead run and who, if I had not luckily cracked him on the head with the butt of my collecting pistol, would have lunged his powerful beak half way through me."

During the last week of June, 1906, the California Academy Expedition found "thousands" of albatrosses

. . . breeding on the southern part of Hood Island, occupying the open spaces among the bushes and the rocks, from the shore back to an elevation of three or four hundred feet. Some shared the nesting quarters of the man-o'-war birds. Generally they had no neighbors except an occasional booby. The season for fresh eggs was nearly over, only two being taken; but eggs in an advanced state of incubation and birds a week or two old were abundant. The single egg was laid on the bare ground, usually in a slight depression.

The nestlings sat bolt upright or lay stretched out on the ground. When the sun was out they moved about a little. The old birds were very solicitous in the care of the young, sheltering them during drizzling weather and warning off Galapagos hawks or human intruders by snapping the bill threateningly (Loomis, 1918, 76, 77).

The gait of the Galápagos Albatross suggested to Beck the "swagger of a Bowery tough," and to Beebe "flat feet, fallen arches, crippled limbs. On the ground these master fliers tottered miserably along as if each step brought acute agony." The head sways from side to side with the rocking of the body, and all the postures of walking and standing lack the balance and relative at-homeness displayed by the Wandering Albatross on the ground.

The dates of the life cycle apparently vary somewhat from year to year, a common phenomenon among tropical sea birds, and one deserving of further investigation. Thus the Webster-Harris Expedition saw plenty of young albatrosses at the end of October, 1897, whereas the California Academy party could find but one young-of-the-year at the end of September, 1905. This lone youngster, which was just passing out of the down, would bow its head every time one of its parents snapped the bill. A number of addled eggs were scattered about near it, and many adults in very worn plumage appeared to be remaining ashore. Salutations were still in vogue among them, and the birds which passed each other would click their bills as if in greeting. When the sun was hot, they sought the shade of the bushes. "A single instance of revival of the erotic ardor was witnessed" (Loomis, 1918, 76). This is interesting in connection with similar post-nuptial behavior of the Wandering Albatross, as observed by Wilkins (1923, 481).

By November practically all of the albatrosses disappear from the neighborhood of the Galápagos, not to return before the following March or April.

The average date for the hatching of the eggs would appear to be about July 7, with a probable incubation period of 65 to 70 days. The egg is deposited in a bare space between shrubbery, with no attempt at nest construction. The albatrosses show no resentment or interest when small birds or lizards come within reach of them (Fisher and Wetmore, 1931, 26).

> The adults have a hoarse croaking note which seemed to be used in anger and in talking to the young and to each other. Often an adult would look down at its young and utter several hoarse notes. Another note was a sort of moan uttered when alone or when in company with another bird and usually with neck outstretched and bill pointing upwards. The young, a few days old, had a kind of chuckle which was given in a rather high key (Loomis, 1918, 78).

The nestling plumage of the Galápagos Albatross exhibits a definite dichromatism, one phase having light drab-gray natal down, the other dark drab down (Loomis, 1918, 79). From their secondary down the young albatrosses moult into a plumage resembling that of the darker adults. In the suppression of a distinctive juvenal plumage they therefore differ markedly from *Diomedea albatrus*, the species to which *irrorata* appears to bear the closest general resemblance.

Whether or not the dark and light plumage aspects of the adults are correlated with age is uncertain. Loomis writes (1918, 81):

> The light and dark markings of the upper back, sides of breast, and upper and lower tail-coverts are much coarser in some examples than in others. Their relative prominence also varies, giving the surfaces as a whole a lighter or darker appearance. The general aspect of the lower parts is lighter in some specimens and darker in others. In the extreme light manifestation, the breast, abdomen, and sides are finely vermiculated with white and gray, growing darker laterally and posteriorly. In the extreme dark style the vermiculations are coarser and the flanks and abdomen are nearly uniform dark gray.

WANDERING ALBATROSS

Diomedea exulans exulans

Diomedea exulans Linnaeus, 1758, Syst. Nat., edit. 10, 1, p. 132 (Cape of Good Hope).

Names: Gony (in the immature, mottled plumage, "Leopard Gony"); Cape Sheep; "Carnero del Cabo," "Albatros Errante." Synonyms of the specific name are *chionoptera*, *spadicea*, and *adusta*, besides which various subspecific names have been applied.

Characters: One of the two largest of sea birds, and also of all flying birds if dimensions rather than weight form the standard of comparison; condors are heavier but have a lesser wing-spread. From the other species of great albatross (*Diomedea epomophora*), mature, white examples of the Wandering Albatross can best be distinguished by the structure of the narial tubes. Maximum wing-spread about 3.5 m. (11½ feet); maximum body-length (tip of bill to tip of tail) about 135 cm. Sexes unlike in the mature stage of plumage.

Adult male in the white stage: Head, neck, mantle, most of scapulars, back, sides, rump, tail, and the entire ventral surface, including the breast, under tail coverts, axillaries, and under wing coverts, white; outermost scapulars sometimes sparsely vermiculated with faint zigzag ashy or brownish lines, and the hindermost few bearing a subterminal grayish brown patch, sometimes obsolescent; tertials white with a faint oval spot on the distal part of each outer web; coverts along the edge of the wing white, sometimes extending well away from the anterior edge, the remainder of the upper wing coverts being mostly slaty brown, with white margins, the white inner webs showing slight vermiculations; inner median and greater coverts white, like the adjacent inner secondaries, forming first a conspicuous olecranal patch which develops with age into a white alar bar as the mottled coverts are replaced in a direction away from the body by more and more white coverts; alula dark brown, the inner webs of the feathers white; primaries terminally blackish brown, basally white, the white encroaching farthest toward the tips on the inner webs, the shafts yellowish or straw-color; innermost secondaries white, the outer secondaries with blackish brown outer webs, the area of which increases distally along the mid-wing.

Adult female: Noticeably smaller than the male, and differing in that the pure white areas are much less extensive. A sooty brown patch, of variable extent, on the crown; hinder neck obscurely, and remainder of dorsal surface caudad to the tail coverts heavily, vermiculated with ashy or brownish zigzag bars, which are coarsest on the distal parts and outer webs of the scapulars; sides of neck and breast, and the flanks, similarly vermiculated; longer scapulars and parapteral plumes tipped with blackish; outer wing coverts almost entirely slaty black, mottled with white mainly along the edge of the wing; an olecranal patch formed by the white inner secondaries and the greater and median coverts; rectrices mostly black terminally and on the outer vanes.

The plumage of adult females also represents a stage passed through by male birds. The transition between the juvenal plumage, which is chocolate-brown except for the white face, forehead, throat and wing-lining, through the mottled or "leopard" stages, and finally to the maximum whiteness of old males, is fully described in the biographical text. At all ages the lining of the wing is white, a fact which helps to distinguish Wandering Albatrosses in immature plumage from certain other large Tubinares.

The flesh colors of Wandering Albatrosses change before and after the breeding season, particularly the hues of bill and feet, and probably those of the eyelid. Nesting birds at South Georgia have a brown iris; blue eyelid; buffy yellow beak, with a horny culmen and unguis; bluish gray legs and feet, with a pinkish plantar surface. The winter, or non-breeding colors, are described in the life history. Birds with red eyelids have been taken at sea equally in the American Antarctic (Gain, 1914, 155) and in the New Zealand area (Lowe and Kinnear, 1930, 162), so the attempt to employ the color of the eyelid as a taxonomic character (Mathews and Iredale, 1921, 55) is futile.

Measurements of Wandering Albatrosses derived from mixed museum series are always likely to become confusing rather than helpful, because birds of different sizes, and of two or more geographic races, mingle at sea. Not only are additional specimens needed from the Tristan and Gough Island breeding grounds, in order that the size range of the local subspecies may be determined, but further study of birds frequenting New Zealand waters is also needed. Strikingly small adults, as well as others of maximum size, occur among series from the New Zealand area, and it is quite possible that the nesting albatrosses of temperate islets, such as the Sisters, of the Chatham group, are racially distinct from those of such cold islands as Macquarie. Names which might be applicable to such races have been freely bestowed, but the facts have never been run to earth.

In the following table, the "American" birds come from South Georgia and from the South Atlantic and South Pacific Oceans not far from the coasts of South America. The Indian Ocean specimens include birds from Kerguelen, Marion, and Crozet Islands and adjacent waters.

	Wing	Tail	Exposed culmen	Tarsus	Middle toe with claw
Indian Ocean 10♂	625–679 (640)	190–205 (197)	162–177 (171)	118–128 (123.2)	167–176 (171.7) mm.
American region 10♂	590–674 (644)	186–202 (195)	156–173 (168)	115–128 (120.7)	163–176 (169.6)
American region 4♀	585–611 (601)	177–200 (187)	157–167 (161)	111–119 (114)	161 (161)

Additional bill measurements of the 10 males from the American region are as follows: width of maxilla at base, 40–46 (42.9); depth of closed bill at base, 66–69 (67.8) mm.

The figures show the relative uniformity in the size of 20 adult antarctic male birds, and the characteristic sexual difference in dimensions. Miscellaneous tables of measurements, such as that of Lowe and Kinnear (1930, 166), show far greater discrepancies, but these authors have included immature birds, besides which I suspect that several of their listed specimens belong to the small Tristan race.

In further support of what I have said above about the imperfectly classified Wandering Albatrosses inhabiting the New Zealand region, I append the extreme measurements of 32 males collected in all parts of that area:

Wing, 585–652; tail, 184–199; exposed culmen, 144–170; tarsus, 112–125; middle toe with claw, 154–168 mm.

The first step in an analysis of such data would be a thorough study of nesting birds from the various temperate and sub-antarctic islands of New Zealand.

The eggs of the Wandering Albatross are highly variable in shape and size. The average form might be called elongate-ovoid, but some specimens are very broad and others extremely attenuated. The surface is coarse and granulated, often mammillated, and marked with many small pits and depressions.

They are white, usually but not always speckled with reddish brown, the pigment occasionally forming good-sized blotches. The color is more or less concentrated at the larger end, sometimes forming a wreath about halfway between the end and the line of greatest diameter.

Verrill (1895, 439) thus contrasts the dimensions and cubic contents of eggs of the antarctic and the Tristan races of the wandering albatross:

Average of 6 from South Georgia, 134.1 x 81.3 mm. (440 cc.).

Average of 87 from Gough Island, 127 x 76.9 mm. (365 cc.).

The largest of his South Georgia eggs measured 139.7 x 82.3 mm., with a volume of 470 cc.; the smallest measured 130 x 77.7 mm.

Twelve eggs which I collected at the Bay of Isles, South Georgia, between December 18 and January 12, show greater variability. The longest and narrowest measures 137.5 x 74.9; the shortest, 121.6 x 81.5; the broadest, 127.1 x 82.8 mm. The shell is about .65 mm. in thickness.

Dabbene's (1926, 335) figures for a series from South Georgia show a still greater range in size. They are: axis, 120–144; diameter, 75–86 mm.

The size of eggs from Kerguelen Island has been recorded as 133.4 x 81 (Hall, 1900, 12), 126 x 80.8, 129 x 78.2, 132.3 x 82.6 (Kidder and Coues, 1876, 12); and from the New Zealand sub-antarctic as 137 x 74, and 135 x 78 mm. (Oliver, 1930, 150).

The weight of six freshly laid South Georgia eggs ranged between 429 and 487 grams, the average being 466.8, or just over a pound avoirdupois. These data agree with those from other parts of the far south. Thirty from the islands south of New Zealand, for example, had an average weight of 17 ounces (Buller, 1888, 189). One from Kerguelen Island weighed a pound (Hall, 1900, 12). Auckland Island eggs weighed by McCormick ranged between 15 and 21 ounces, but this record is not above suspicion of possible confusion with eggs of the Royal Albatross (Ross, 1847, 1, 149).

Distribution: Circumpolar in the west-wind belt of the southern hemisphere, and ranging normally from the tropic of Capricorn southward to latitude 60° S., occasionally entering the zone of pack-ice. (The flight range, however, has not yet been distinguished from that of the next subspecies, to which most of the northerly records, in the Atlantic at least, may refer.) Breeds at northerly antarctic islands, such as South Georgia, the Prince Edward and Crozet groups, Kerguelen, Auckland, and Antipodes, but apparently not at the South Sandwich Islands, Bouvet, or Heard. The breeding albatrosses of Gough Island and Tristan da Cunha are regarded as a different subspecies. It is not unlikely that a race distinct from the antarctic form also nests in some part of the New Zealand area.

Much that is well heralded in nature carries a tinge of disappointment when it is finally found. A few things, on the other hand, seem beyond over-advertisement. When I faced my first big tree in California, expectation sank into nothingness. The feeling was similar when for the first time I watched and heard the dual performance of the Skylark. With a handful of such experiences, in which reality can hardly fail to transcend hope, I would group the sighting of a great albatross at sea.

For me the event came in latitude 23° S., longitude 35° 45′ W., off Rio de Janeiro, on October 28, 1912. We had just encountered an abrupt change from tropical weather, and a heavy ground swell indicated storms to southward. At six o'clock in the morning the steward of the 'Daisy' came to notify me that a "Gony" was about, so I hurried on deck. Near-by, in the morning sunlight, flew the long-anticipated fowl, even more majestic, more supreme in its element, than my imagination had pictured. It was mature, all white and black, doubtless an adult male, and as it turned and turned, now flashing the bright under side, now showing the black that extended from wrist to tip on the upper surface of the wings, the narrow planes seemed to be neither beating nor scarcely quivering. Lying on the invisible currents of the breeze, the bird appeared merely to follow its pinkish bill at random.

The albatross remained with us only a few minutes, but at noon the same bird, presumably, was back again, covering tens of miles in the swift wide circles which it traversed astern. When banking, it sometimes tilted to an angle of 90 degrees so that the lower wing cut the water, and it may well have used the great webbed feet more than the stubby tail in steering. Twice it dropped into the sea and allowed us to draw away a long distance before it arose to overtake us. It was a curious sight when the albatross prepared to alight under our stern, and then, changing its purpose, ran heavily across the water for fully a hundred paces before the wings could raise the large body again into the air.

From this date and place we saw Wandering Albatrosses every day until we reached South Georgia, on November 24. Within two days of the time of our first meeting, they had become abundant.

In popular tradition the first duty of an albatross, as of a whale, is to be large. Wing-spreads credited to the Wandering Albatross in serious works on ornithology and in recent editions of standard encyclopedias fit no aërial animal living since the extinction of the giant pterodactyls. When application of a tape replaces the eager recording of sailors' yarns, a vast shrinkage occurs, although the measurements still leave the albatross in a secure position as king of the air in our modern world. Before considering the credible dimensions and weights in the published record, however, it will be necessary to call attention to the confusion of two species of albatrosses, and to the impossibility of ever allocating some part of the older data between them.

In the literature, three main forms of the great albatross are recognized. The first is the "original" Wandering Albatross, upon which Linnaeus's name, *exulans*, has been fixed. The second is the "Snowy" Albatross (*Diomedea chionoptera*), alleged to be a whiter bird, but in reality nothing else than the fully mature male of the typical Wandering Albatross. The third is the Royal Albatross (*D. epomophora*), which is an altogether distinct species, differing in structure, plumage, and life history from the Wandering Albatross. To sailors, voyagers, and until recent times to ornithological recorders, any great albatross was merely *the* albatross, as distinguished from a mollymauk, a Sooty Albatross, or some other member of the tribe bearing a descriptive adjective.

For such reasons a wealth of published observation, much of which is too valuable to be cast away, is based not upon one species of albatross but upon the Wandering and Royal Albatrosses in combination. This is especially true of notes made from shipboard, for even yet no ready and certain means have been advanced for discriminating between these two forms at sea. The facts should be remembered in connection with many of the general comments in this biography and the following two. They have a special bearing upon the consideration of measurements in which certainty as to which species is referred to is sometimes out of the question. Fortunately, however, a comparison of data known to be exact indicates that the Wandering and Royal Albatrosses are of approximately the same size, or at least that they attain about the same maximum size.

How large, then, is an albatross? The current Encyclopaedia Brittanica says that it reaches the "unique wing-spread of 17 ft.," a statement that leaves little room for the imagination of even an old salt. A search for reliable sources of information scales this maximum down by a third, or thereabouts. The highest figure reported by a credible observer is that of Lord Campbell, who says that he measured several birds of 12 and 13 feet across the wings, at islands in the Indian Ocean, during the course of the 'Challenger' cruise. The measurements were, however, taken from living, struggling birds. Campbell (1877, 85) writes:

> Two of us approach, one on each side, and badger them till they spread their wings, which we then seize and extend, and as their bills . . . are six feet or more away, . . . we can quietly proceed to measure. Thus is the huge albatross completely circumvented!

But for the reasons given, and in view of the wealth of more carefully taken measurements, it seems necessary to regard 13 feet (396 centimeters) as excessive. The following data more closely approach credibility.

> One of a number caught measured 12 feet in extreme wing-spread and weighed 18 pounds (Scouler, 1826, 204).

On April 4, 1839, lat. 42° S., west coast of America, numbers were taken with hooks and lines in thick drizzly weather. A female taken April 1 weighed 18 lbs., and measured 9 feet 7 inches across the wings. The largest caught on April 4 had an expanse of 10 feet (Pickering, in Cassin, 1858, 398).

June 8, 37° 15′ S.; 16° 27′ E., seven albatrosses captured. Largest 3 feet 10 in. from base of bill to extremity of tail; expanse of wings 11 ft. 8 in. Wing-spread of others, from 10 ft. 4 in. to 11 ft. (Bennett, 1860, 72).

Wing-spread averaging 10 ft. The largest measured was 12 ft. Body length, from tip to tip, 4 ft. Weight, 15 lbs. and upward (Hutton, 1865, 278, 296).

Male, South Atlantic; wing-spread 10 ft. 3 in.; weight 16½ lbs. (Pelzeln, 1869, 147).

Marion Island albatrosses measure from 11 to 12 feet, from tip to tip of the wings (Spry, 1876, 121).

Latitude 34° S., longitude 4° 29′ E. Spread of wings of an adult male 10 feet 3 inches, nett weight 19 pounds. The feet when spread out were 9 inches broad. A female taken at the same time weighed about 15 pounds (Saunders, 1880, 165).

The heaviest bird weighed 19 lbs., and measured 11 feet 6 inches from tip to tip of the wings (Salvin, 1881, 147).

A "two-year old" bird had an expanse of 10 feet 4 inches, and weighed about 14 lbs. Another one weighed 18 lbs. (Lucas, 1887, 2).

South Atlantic; killed one measuring 9 ft. 1 inch between tips of wings. Larger ones caught off Cape Horn (Banks, in Hooker, 1896).

Wing-spread, 2.90 m. (Vanhöffen, 1901, 308).

Wing-spread of measured examples, 312 cm.; length, 135 cm. (Reichenow, 1904, 346).

Captain Libouan took a bird with a wing-spread of 3 m., 5 cm. (Menegaux, 1917, 64).

One found stranded on the beach at Bunbury (110 miles south of Fremantle), West Australia, July 17, 1930; wing-spread, 11 ft. 6 inches (Whitlock, 1931, 264).

In addition to the above, we have the convincing testimony of Gould and of Green, both of whom measured many albatrosses with their own hands. Gould writes:

After killing numerous examples of both sexes and of all ages, I found the average weight of the *Diomedea exulans* to be seventeen pounds, and the extent from tip to tip of the wings ten feet one inch (Gould, 1865, 427).

Green reports that a sea captain who had captured an incredible number of albatrosses during forty years (the writer had frequently seen him take twelve or more in a day at sea) made a point of measuring them accurately across the wings, and 11 feet 4 inches was the largest. Green himself measured considerably over a hundred, and his maximum was the same (Green, 1887, 4, etc.). Furthermore, Dixon (1933, 122) clinches the matter with the following specific records:

During the twenty-nine years I had the albatross under observation I have never seen any individuals larger than those I was able to catch. Of some two hundred that were caught on various voyages, forty-two were measured. The largest had a wing spread of eleven feet four inches, the smallest nine feet seven inches, and the average ten feet two inches.

Finally, I may report that the same figure (11 feet 4 inches, or 345.4 centimeters), was the greatest expanse noted by myself among Wandering Albatrosses collected in the South Atlantic and at South Georgia.

From all of this evidence I conclude that a wing-spread of about 11½ feet, with the wings of a dead bird stretched out as tightly as possible, represents the maximum expanse of any known bird. The 12-foot albatross needs verification; the 13-foot albatross is probably a myth.

Further observations should be made to confirm Gould's figure of an average weight of 17 pounds, in view of the difficulty attending the use of scales on shipboard, particularly on sailing vessels tumbling about in the southern oceans. Weights of 19, 19½, and 20 pounds are recorded for individual examples by several observers (Saunders, 1880, 165; Salvin, 1881, 147; Campbell, 1877, 85). Bennett adds that the complete skeleton of a 20-pound albatross weighed only 2 pounds 10 ounces (Bennett, 1860, 72, etc.). The largest example I weighed on the breeding ground at South Georgia tipped the scales at 13 pounds (5897 grams), but the instrument was not above suspicion, besides which the birds may have been less fat during the breeding season than at certain other periods.

The Wandering Albatross is common in the southern oceans on both sides of the South American continent, the normal records for its presence, in large numbers and with regularity, along the eastern coast to the vicinity of the Río de la Plata, and thence across the Atlantic toward South Africa, being too numerous to cite. It appears to be somewhat less plentiful on the American side of this ocean than in waters near the African coast, a fact which has been attributed to the prevailing westerly winds in these latitudes but which is more directly due to currents of low temperature which penetrate farther northward along west Africa than on the eastern shores of South America (Saunders, 1866, 124). Owing to the highly mixed character of the west-wind drift, the South Atlantic surface waters show unusually pronounced changes of temperature, color, and salinity, but the eastern half of the ocean is prevailingly cooler than the western half. Cold water borne by the Falkland Current northward along the Patagonian coast mingles off the mouth of the Río de la Plata with the southward-flowing warm water of the Brazil Current. Moreover, much of the Pacific water carried in the westerly drift past Cape Horn takes a direction toward South Africa (Clowes, 1933, 189). While the surface temperature of this water is relatively high for the latitude in the vicinity of the Horn, enormous masses of ice later enter it from the Weddell Sea region, so that in the longitude of Bouvet Island it has become very cold. Similar oceanographic conditions account for the abundance of Wandering Albatrosses during certain seasons in the cool current which flows northward along the western coast of Australia.

Most of the more northerly records for the Wandering Albatross seem to relate to the season of southern winter, as might be expected. Beyond latitude 30° S., in the Atlantic, the birds are likely to be seen on any day of the year (Hutton, 1865, 278).

Extremely suggestive are the detailed observations of Captain C. C. Dixon, based upon records of Wandering Albatrosses kept by him during 2002 days at sea between the latitudes of 20° and 60° S. His notes upon the seasonal shift of the pelagic population from west to east agree admirably with the more recent observations of Wynne-Edwards (1935, 290) regarding similar movements of migrant petrels in the North Atlantic. Dixon (1933, 121) writes:

My records indicate that these albatrosses are practically confined to the area between 30° S. and 60° S. I have observed very few north of 30° S. and none within the tropics. The farthest north I have seen one is 24° S., off the Brazilian coast, in summer. This was unusual as most of those seen north of 30° are observed in winter and spring. There is a good deal of variation in the density of their numbers in different regions, depending on season. Thus, in spring, 92% of the birds seen were between 30° and 50° and only 3% south of 50°, whereas in summer 73% were between 30° and 50°, and 26.5% south of 50°. In autumn there is a shift northward again, and by winter 96.9% are between 30° and 50° and only 0.1% south of 50°. . . . In winter and spring the vast expanse of ocean from the 120th meridian of west longitude to the Horn is practically deserted, whereas in summer this region is the favoured one. There seems to be a progressive shifting of the centre of abundance from west to east each season as if the birds flew around the earth from west to east with the prevailing winds. For instance, in winter 82% are on the hemisphere 90° E.–180°; in spring the centre of abundance has shifted slightly towards the east so that 73.5% are in the hemisphere 90° E. to 90° W.; in summer 67% are in the hemisphere 180°–90° W., and in autumn 63% in 90° W. to 90° E.

It is interesting to note that in summer there is a considerable concentration of albatrosses in the region of the cold currents off the west coast of South America, and up past the Falkland islands in the Atlantic.

Since Wandering Albatrosses, like many other Tubinares, follow ships, northbound vessels are more likely to encounter them in extraordinarily low latitudes than are vessels bound southward from the equator (Sperling, 1872, 75). Wilkins (1923, 510) reports that several pursued the 'Quest' to within sight of St. Helena, and Studer (1879, 107) observed one northward to 14° 9′ S., 7° 49′ E. For the American coast, Crawshay (1907, 144) reports one off central Brazil on August 2. In the region between the Falkland Islands and the Strait of Magellan they are often very abundant (Paessler, 1909, 100), and they are said at times to penetrate the Magellanic archipelago (Dabbene, 1902, 391; Oustalet, 1891, 157), although in this region there is a particular likelihood of confusing the species with *Diomedea epomophora*.

A number of records show the accidental presence of the species in the North Atlantic. Examples are said to have been collected near Dieppe in 1830 and near Antwerp in 1833 (Andersen, 1895, 91), while in the Rothschild collection is the skull of a specimen taken on the Atlantic coast of Morocco. In view of the large number of Wandering Albatrosses captured on hooks by sailors, and sometimes transported on shipboard for long distances, such casual occurrences far outside the range have little meaning. Alexander significantly remarks that records in the northern hemisphere mostly date from the period when sailing ships had not yet been largely displaced by steamers on the ocean routes. He writes, further:

From a becalmed ship, or one travelling slowly, Albatrosses can often be captured without injury by hook and line, salt pork being used as bait. The hook lodges in the bill without penetrating it, but, as the bird . . . pulls backwards, by keeping the line taut it may often be landed on deck. The bulwarks prevent captured specimens from flying . . . . On deck Albatrosses show symptoms of seasickness and usually soon vomit the contents of their stomachs. Old-fashioned sailors sometimes captured them in order to make feather rugs or other articles of their skins, and this is presumably why they were sometimes called "Cape Sheep." The webs of the feet were made into purses or tobacco-pouches and some of the long hollow bones into pipe-stems (Alexander, 1928 7).

On the Pacific side of South America, the Wandering Albatross is common along the southerly coasts at all seasons of the year, and as far north as Valparaiso during the southern winter. Scouler reports the species near the islands of the Juan Fernández group, and states that in this region it is common well to northward of the range of the Sooty Albatross (Scouler, 1826, 204). Beck, during the course of the Brewster-Sanford Expedition, also observed and collected a number of specimens near Mas Atierra Island in December and January, while from September until March he found the species common along the Chilean coast between Ancúd and Valparaiso. Our American Museum Collections establish the fact that both *Diomedea exulans* and *D. epomophora* belong to the fauna of the Chilean coast, which creates an uncertainty regarding many of the older records for such localities as the Chonos Islands, Guafo, Mocha, Chiloé, etc. (Sclater and Salvin, 1869, 284; Paessler, 1909, 99; 1913, 43).

In the Indian Ocean the Wandering Albatross has been reported from the neighborhood of Mauritius and the southerly edge of the southeast trade-wind zone, where the maximum atmospheric temperatures do not exceed 23° C. (Studer, 1879, 107), southward to a point 800 kilometers south of Heard Island, where the last example of the species left the wake of the 'Challenger,' still some 300 kilometers to northward of pack-ice (Moseley, 1879, 254). Vanhöffen (1901, 316) states, more specifically, that the southern limits of the range in the Atlantic-Indian Ocean region may be marked by a line slanting from about 46° S. 10° E. (between Gough and Bouvet Islands) to 59° S. 65° E. (to southward of Kerguelen and Heard Islands). In general, the pelagic range terminates well short of pack-ice. The species was, however, reported by the Scottish National Antarctic Expedition in 61° S., by the French Expedition off the Palmer Archipelago, and by the 'Valdivia' party at the edge of the floes in 63° S. (Reichenow, 1908, 549; Menegaux, 1907, 680). The most southerly record is that of Gain (1914, 156), who states that although Wandering Albatrosses are rare south of Deception Island, a few were observed in the American quadrant of Antarctica southward to latitude 68° 30′ S., at the edge of the pack and far beyond the antarctic circle. It seems clear that whaling operations have sometimes attracted albatrosses, along with other pelagic birds, to waters south of their former ranges, and that this is especially true in American Antarctica. Apparently both Bouvet and Heard Islands, as well as the South Sandwich, South Orkney, and South Shetland groups, are outside the breeding range of *Diomedea exulans*.

Much discussion may be found in the literature as to whether the same individual albatrosses follow ships for several successive days. Fortunately, this question can be definitely answered in the affirmative, even though the fact has been doubted by such excellent authorities as Nichols and Alexander (1928, 8). In my own experience I have noted examples with easily recognizable characters, such as a peculiarity of plumage, in the wake of the brig 'Daisy' for four or five days, as mentioned in several of the preceding albatross biographies. Dixon (1933, 123) writes from his full experience concerning the Wandering Albatross:

The same bird, identified by a broken tail or wing feathers or broken webs in the feet, has been seen several days in succession. The distance traversed was frequently 120 miles during the hours of darkness—too far to see a vessel, except from a height of about 10,000 feet, and they are never seen above 500 feet, or very rarely above 200. Thus they cannot rise high enough to see a vessel if resting all night.

Other observers have determined the matter by means proof against error. Tschudi (1856, 140), for example, tells of hooking a Wandering Albatross and of painting its neck and breast with tar. The bird was then released, and it remained for six consecutive days in company with the ship, never being out of sight for more than an hour at a time during the daylight periods.

Most observers, by the way, seem to regard the Wandering Albatross as strictly diurnal in habit, both by land and sea (Hutton, 1865, 278), but Saunders (1866, 124) and Dixon report quite otherwise, stating that on moonlit nights, and in the summer twilight of the pan-antarctic oceans, they are often active throughout the dark hours. Because the species feeds largely upon squid, and since many forms of such cephalopods have a proclivity to approach the surface of the ocean in the dark, it would seem highly probable that the albatrosses carry on part of their fishing at night.

And what of the distances flown by Wandering Albatrosses during the long periods they spend at sea? Here again we find testimony of varying weight. An example of many accounts in the seafaring record is the following:

In the Brown University Museum is a manuscript taken from a vial which was found tied to the neck of a Wandering Albatross. The bird was shot off the coast of Chile by Captain Hiram Luther on December 20, 1847, in latitude 45° 50′ S., longitude 78° 27′ W. The note reads:

Dec. 8th, 1847. Ship 'Euphrates,' Edwards, 16 months out, 2300 barrels of oil, 150 of it sperm. I have not seen a whale for 4 months. Lat. 43° S., long. 148° 40′ W. Thick fog, with rain.

According to these figures, the albatross had travelled 3150 nautical miles (5837 kilometers) as the crow flies during the twelve-day interval between the writing of the manuscript and the shooting of the bird.

Still more satisfactory and impressive is the evidence of a ringed albatross, as related by Professor Menegaux (1917, 64). An aluminum band of the Paris Museum was affixed to the leg of a Wandering Albatross at Kerguelen Island, on December 21, 1913, by Monsieur J. Loranchet. The bird was captured while in courtship performance near the nest. On December 19, 1916, or almost exactly three years later, this banded albatross was recaptured by Captain Libouan, of the French four-master 'A.-D. Bordes,' near Cape Horn (56° 10′ S., 78° 04′ west of Paris). Kerguelen and Cape Horn are 6083 statute miles, or 9788 kilometers apart, a distance equal to 38 per cent of the circumference of the world in that latitude.

Several other questions immediately arise from such data. Was the banded albatross straying so far from its nesting ground during a "relief period," while its mate was incubating, or was it a non-breeding bird at the time of so long a flight from home? Interesting possibilities for continued banding work are suggested, especially since albatrosses, unlike most of the smaller sea fowl, are caught each year in fairly large numbers by sailors on the long southern passages. The case of Loranchet's bird, taken alone, would suggest that Wandering Albatrosses actually may circumnavigate the world in the west-wind zone, a supposition entirely in harmony with what we know of the pelagic habits of the bird and of the meteorological and topographic conditions throughout the high forties and the fifties of south latitude.

Now all that I have thus far written has ignored the fact that many South Atlantic Wandering Albatrosses, and some specimens from other parts of the southern oceans, are of notably smaller size than other examples taken at sea or on nesting grounds at the antarctic islands. Such relatively small birds have long been known in collections, and their dimensions have proved puzzling to ornithologists attempting to classify series of specimens taken at sea.

The first published clue to the solution of this problem was that of Verrill (1895, 438), who quoted Captain George Comer, a thoroughly competent and experienced observer, to the effect that the nesting Wandering Albatrosses of Gough Island are "quite a little smaller" than those of South Georgia. Verrill then went on to clinch the matter by demonstrating that the largest Wandering Albatross eggs from Gough Island were smaller (in volume) than the smallest eggs of the species from South Georgia. The facts are now fully established. The native Wandering Albarrosses of the relatively mild, prevailingly snowless islands of Gough and the Tristan group are of a different race from those inhabiting the antarctic islands to southward. It is but one of many proofs that among sea birds of the southern hemisphere latitude, to a far greater extent than longitude, is correlated with geographic variation. As we progress southward the species and subspecies tend to become more nearly circumpolar in distribution. Thus the Wandering Albatrosses of South Georgia are indistinguishable from those of Kerguelen Island and other partly ice-clad localities in the Indian Ocean, even though these breeding stations are far more remote from one another than are South Georgia and Gough Island.

In the case of the Wandering Albatrosses, the taxonomic question could be disposed of very simply were it not for the usual bugbear of nomenclature. In 1758 Linnaeus applied the name *exulans* to an albatross figured by an earlier writer, and collected off the Cape of Good Hope. In 1896 Salvin described as *Diomedea chionoptera* the breeding bird of Kerguelen Island. Thus one course which might be adopted would be to call the Gough-Tristan albatross *D. exulans exulans*, and the sub-antarctic albatross *D. exulans chionoptera*. But it would be quite impossible to show that the name bestowed by Linnaeus should properly apply to the smaller of the two forms. It so happens that museum specimens I have examined from the Cape of Good Hope are mostly very large and white male birds, exactly comparable in appearance and dimensions with others collected on the antarctic breeding grounds of the Atlantic and Indian Oceans. Possibly rhe smaller, sub-antarctic or south temperate subspecies also visits the Cape, but rhe antarctic bird would be likely to outnumber it a hundred ro one. Since the sources cited by Linnaeus offer no aid, I conclude that the southern circumpolar race should retain the appropriate subspecific name *exulans*, while the Tristan race should bear the next available name. I have so treated the matter in the succeeding biography This is the opposite conclusion from the one reached by Mathews (1934, 813), but I have been unable to see the matter as he does either upon a basis of measurements or of geographic probabilities.

From the earliest times the fact that Wandering Albatrosses engaged in nesting differ so markedly among themselves in the color and pattern of their plumage has been a cause for wonder and comment. A characteristic observation is that of Campbell (1877, 85), who visited the Prince Edward Islands in the 'Challenger' at Christmas time, 1873, and remarked that the nesting albatrosses varied greatly in color from old, very white birds to dark, youngish ones. The same is true of practically all other colonies, though evidence has been advanced that at the Auckland and Antipodes Island nesting grounds most or all of the Wandering Albatrosses breed in the brown or immature plumage, the so-called old, or very white birds being unknown at the Aucklands and uncommon at the Antipodes (Archey, 1923, 119; Rothschild, 1912, 8). Motion pictures made by Beck in this region a few years ago seem to bear out the allegation but, even though true, it does not necessarily indicate that a separate race of Wandering Albatross is native to Auckland and Antipodes. The point is that albatrosses quite as "young" and spotted as those of the Auckland region can be found at Kerguelen and South Georgia, sometimes mated with the whitest birds of the "*chionoptera*" type. Just why the Auckland albatrosses are all of the dark and mottled stage is unknown, but it is suggestive that in most localities the majority of the dark birds are relatively late arrivals at the nesting ground, the bulk of those in such plumage being engaged in courting when the whiter birds are already incubating. In this connection it would be interesting to learn the significant dates in the life cycles of the Wandering Albatrosses which nest at Auckland and the Antipodes. Archey remarks that at the Antipodes they breed later than *Diomedea epomophora*, and Waite (1909, 566) that at Auckland most of the Wandering Albatross eggs were quite fresh in February, 1907. This should be remembered in connection with what I shall have to say about the succession of age- and plumage-types during the breeding season at South Georgia.

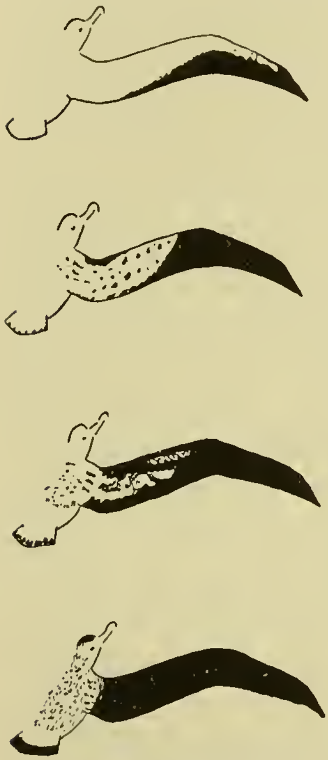


Fig. 54. Wandering Albatrosses, showing plumages intermediate between the "*chionoptera*" and *exulans* stages. Sketched from living birds on the nests at South Georgia.

From Matthews (1929).

Wilkins (1923, 481) states that the albatrosses breed at an apparent age of two years, though he gives no information as to how he correlated plumage with age. More important is his note that the birds do not preferably mate with others of their own plumage-state; in fact, mixed ages seem more common among the pairs.

Matthews (1929, 568) writes:

> In the moult of the first year after leaving the nest the brown-black plumage of the young adult gives place to white feathers with black cross pencillings, except on the face, which is white. The wings and tip of the tail remain black. This is the typical *exulans* plumage, and in succeeding moults white feathers replace the barred ones more and more until the *chionoptera* plumage is attained. This is white, including the tail, with black ends to the primaries and outer secondaries, and with a trace of pencilling on the scapulars.

Aside from the fact that the above indicates a too rapid transformation, and fails to distinguish between the sexes, it leads to a wrong conclusion in one lesser respect, for the first whitening of the young albatross's plumage results not from moult and replacement of feathers, but rather from wear. In the juvenal bird the concealed parts of the dark feathers are white and, as the tips are abraded away, the surface of the body becomes mottled with whitish spots which gradually extend their area over the neck, breast and back. The plumage sequences, as exemplified by a very large series of specimens from the southern oceans all around the globe, are as follows:

Natal down, silky and pure white (Layard, 1867, 460).

Nestling several months of age, entirely covered with dense gray down.

Nestling "yearling" from the breeding ground, dark brown, with white face, forehead, throat and wing-lining. Smoky gray down still clings to various parts of the body, being particularly thick on the flanks and scapulars. The down on the belly is matted like sheep's wool.

Yearling collected at sea, similar to the last, but with the belly largely whitish from wear, and the back slightly so. Shafts of the dark brown primaries beginning to whiten; tail, including the coverts, entirely dark.

Older stage, as represented by many collected at sea and on breeding grounds, chiefly during the months of November and December. Rich brown wings and back, the feathers tending to become paler and light-edged with aging; neck mottled, with an increasing amount of white showing through; crown brownish; brownish band across breast; lower breast and belly white, more or less washed with brownish, the characteristic speckled and vermiculated feathers appearing at the borders of the white areas and along the flanks; white feathers sprouting among the tail coverts, but the quills still dark.

Still older birds. Increased vermiculations on breast and flanks; the collar speckled gray rather than brownish; upper and lower tail coverts white, with vermiculations, and the new rectrices largely white except at their tips; back still spotty, but with an increasing growth of white and heavily vermiculated feathers; crown-patch reducing in size; old primaries very worn, with shafts which are ivory-white well toward the tip of each; white olecronal patch beginning to develop on the wings.

In female Wandering Albatrosses the whitening process goes little beyond the peak of the stage last described. Their backs become prevailingly white, though still with heavy transverse penciling; the tail may also be white save for a few subterminal spots and specklings; but at least a trace of the dark crown-patch invariably remains, and the wings are prevailingly dark on their upper surfaces.

The males, however, increase their whiteness with successive moults, until in some old birds the entire body is white except for the distal part of the wings, a few faint vermiculations on the scapulars, and grayish marks on the rectrices. The inner webs of the primary quills always show a variable amount of white speckling which, together with the well-marked bill characters, serve unfailingly to distinguish adults of the species from *Diomedea epomophora*. Such old males, in the height of plumage, represent the typical "*chionoptera*" stage, and it is interesting to note that numerous examples I have examined from several localities are far whiter than the type specimen of *chionoptera* itself. The type of "*Diomedea rohui*" Mathews, in the Rothschild Collection, is such a white bird, matching exactly many specimens from Kerguelen and South Georgia. It is marked a female, but this is doubtless erroneous.

With regard to colors of the Wandering Albatross's fleshy parts, there is variation not only according to age but also to season. Alexander (1922, 261) noted during his voyages that South Atlantic individuals had decidedly yellow bills whereas those of the Indian Ocean and Australian waters had rosy bills; but Matthews (1929, 563) has canceled any geographic significance in this observation. He reports that during the southern winter the bills of South Georgia adults are salmon-pink, and the legs and feet also pink, but that at the beginning of the nesting season the bill turns to a yellowish buff hue, and the feet become light gray, with a pinkish spot at the heel. This agrees with my own observations on living birds and with the color notes on the labels of Beck's specimens from both the South American and the New Zealand regions. The culmen and unguis always remain more or less horn-color.

In chicks the bill is flesh-white, with a yellowish tip, the feet at first brown and later whitish or flesh color, the webs being darker.

Sometimes purplish, lilac, or violet tinges show on the sides of the bills of birds taken at sea. The iris is brown at all ages, and the skin of the eyelid usually light bluish gray. However, a British Museum specimen taken by the 'Discovery' Expedition in 35° S., 13° W., had a "scarlet" eyelid, and Gain (1914, 155) gives "lacquer red" as the color in a bird he captured at Deception Island on January 10, 1910. In any case, the eyelids are never black, as they are at all ages in the Royal Albatross.

A curious fact, which seems more than accidental, is that Wandering Albatrosses show a propensity for selecting breeding grounds at or near the western ends of islands in the pan-antarctic zone. Wilkins (1923, 508) refers to his observations on this point at both Gough Island and South Georgia. The nesting sites, throughout the Roaring Forties and beyond, are usually those most exposed to bad weather and the winds. At Adams Islet, off Auckland Island, which is occupied by both major species of albatrosses, the Royal Albatrosses are said to confine themselves to the eastern end while the Wandering Albatrosses occupy the western or windward end (Waite, 1909, 566). I can find no specific data for Kerguelen or other Indian Ocean islands, but at South Georgia the breeding grounds are all on islets and headlands near the westerly end of the island. Wilkins (1923, 481) states that he found no breeding areas to eastward or southward of Possession Bay, and he also comments on the probable advantage to the species of being able constantly to take off from windward coasts.

The greatest nesting grounds at South Georgia are on Bird Island, which is about 5 kilometers long by 1½ in breadth, and is separated by less than 2 kilometers of water from the northwestern end of the main island. On the grassy islets in the Bay of Isles, a short distance to eastward, there are additional large colonies, while a very small number of pairs occupy similar sites on adjacent promontories of the mainland. On parts of the southerly coast of this same end of South Georgia there are perhaps other groups, for Shackleton and his comrades report subsisting upon the flesh of nestling albatrosses in King Haakon Bay, after their long boat journey from Elephant Island in the South Shetlands. Possibly, however, the birds which Shackleton found were albatrosses of a smaller species, such as one of the mollymauks of the region. The British and American sealers of a century and more ago also feasted upon the young South Georgian albatrosses, the flesh of which they found to be "sweet but not firm" (Weddell, 1825, 51).

Although Wandering Albatrosses are to be found in the oceans around most or all of the low antarctic islands throughout the year, they do not come ashore for the preliminaries to the mating season before October (Gould, 1865, 427). At South Georgia the birds begin to land during November, but tardier and younger recruits keep coming until the middle of February or later.

My first acquaintance with the species at the breeding grounds was at the Bay of Isles, on December 15, 1912, when many of them were already at the nests and others in the early stages of courtship. The albatrosses with nests were mostly squatting upon them, and when we approached they would rise up on straight legs and snap their bills with a single resonant clap. No eggs had yet appeared, but the colony was well sprinkled with young birds of the previous year, which were sitting here and there, between, rather than on the nests. Some of these chicks were almost wholly covered with down, while others had lost the greater part of their gray fluffy covering and were in the blackish juvenal plumage, with white face and wing-linings. The youngsters sat back on their heels, turned up their toes until it seemed that they would surely topple over, snapped their bills in the manner of their parents, and also uttered curious gobblings and cacklings with wide-open mouths.

During the same period I observed the remains of a number of dead chicks of various ages, which had probably been destroyed by skuas. At South Georgia I judge that the mortality from this cause is relatively low. During the incubation period I saw the skuas succeed in taking only one albatross egg, this being at a mainland nest near my tent on February 15.

From December 15 until the middle of February I was privileged to see the courtship performances of the Wandering Albatross going on continuously, for as the early, older, and whiter albatrosses would settle down to the business of mating, nest-building, and incubation, the territory still empty would fill up with younger birds which had certainly not been anywhere near the breeding grounds until several weeks after the bulk of the mature albatrosses had arrived. Late-comers, many of them in the heavily blotched plumage which sailors know as the "leopard" stage, continued to reach the Bay of Isles and to begin courtship at least as late as mid-February, or fully eight weeks after the appearance of the first albatross eggs. On February 13 I noted new batches of dark-plumaged birds of both sexes squealing, chattering, posing, quarreling, and mincing around one another with unfolded wings—all this going on among the nests of quietly incubating white birds which I had had under continuous observation since December.

Many hundreds of the birds occupied Albatross Island, in the Bay of Isles, an extensive grassy tract rising to ridged hillocks. This nesting ground was at a distance from the anchorage of my vessel, and I was able to keep it under my eye only at intervals of several days but, fortunately, a few pairs of albatrosses made their homes on a small promontory of the mainland, close to the site of my tent, where I could usually spend some time daily.

Albatrosses in general present complicated patterns of social behavior, and since the courtship and mating régime of the Wandering Albatross seems to be highly distinctive from that of its smaller relatives, I propose to quote some of the historic descriptions of the performance, and then to add to my own notes the detailed observations of Wilkins and Matthews.

Writing of South Georgia birds in 1825, Weddell (1825, 58) said:

> There is something humourously remarkable in their way of mating; the couple approach one another with great apparent ceremony, bringing their beaks repeatedly together, swinging their heads, and contemplating each other with very deliberate attention. Sometimes this will continue for two hours together, and to a person inclined to be amused the whole transaction would appear not unlike one of our own formal courtships in pantomime.

Moseley's (1879, 172) version, as observed at one of the Indian Ocean islands during the 'Challenger' cruise, is that

> . . . the male standing by the female on the nest, raises his wings, spreads his tail and elevates it, throws up his head with the bill in the air or stretches it straight out forwards as far as he can, and then utters a curious cry, like the Mollymauks, but in a much lower key. Whilst uttering the cry the bird sways his neck up and down. The female responds with a similar note, and they bring the tips of their bills lovingly together.

From my own observations it seems clear that most of the early arrivals at the nesting ground are male birds, which claim and occupy individual territory in anticipation of the coming of mates. For some time, therefore, the early female albatrosses are outnumbered four or five to one. The males leave their squatting-posts to cluster about the first females, which are commonly besieged by from two to six, or even more, ardent yet orderly suitors. The males throw forward their breasts, stand upon their toes so that the metatarsal joint clears the ground, stretch out one or both wings, raise and spread the tail, gobble and squeal, and then touch bills with the female, which also responds in kind to most of the other gestures. Waite (1909, 566) noted on islands south of New Zealand that drops of oil ooze out of the beak during the billing reaction, and concluded that a slight regurgitation accompanies the performance. The sounds produced by the syrinx are varied by percussion notes from the beak, which begin as choppy clips and end in rapid vibratory shivering. The booming, mechanical sound of this is concluded by a vocal shriek or groan from both participants.

Although the object of each male is apparently to confine the attentions of the female exclusively to himself, there is considerable etiquette in the performance, for each in turn holds the center of the stage before the hard-pressed female. The rivals may be by no means idle during a spectacle which is primarily dual, and yet, to a certain extent, at least, they appear to stand by while one particular bird holds the center of the stage. At times they turn toward one another, expressing what might be assumed to be a low opinion of rivals in general, for their jargon certainly has an abusive sound. They also appear to threaten with snapping beaks, although I gained no evidence of actual combat between males until after mating had taken place. The female seems to distribute her attentions about equally among the suitors. At times the males least occupied at the moment walk away from the group for a short distance, with their heads swaying from side to side and hung almost to the ground. The attitude gives them a diabolical look, and it would be easy to imagine that dark and sinister thoughts were occupying their minds!

Such coteries are gradually broken up by the mating of pairs and the continuous arrival of new females at the breeding ground. The couples engaged in nest construction continue affectionate demonstrations, and take turns in raking together and patting down the foundation of their home. While one bird sits on the heap, the other will squat *vis-à-vis*, and the two will cross bills, nibble each other's heads and necks, chatter so rapidly that the beaks can be discerned only as a blur, or point their bills straight upward and squeal like young pigs. The hollow chop of the bill, a gobbling note, like that of a turkey cock, soft grunts, and an assortment of caterwauls, complete the lover's repertory. Occasionally the male rises, makes a few stately deliberate steps, bringing each foot down with a stamp, and then poses before his lady with both wings widely outspread and head held high, a come-to-my-arms attitude, indeed. The female is then likely to step off the empty nest, while the male takes her place with much bowing. From time to time the two seem to regard each other with particular intentness, stretching up the neck and looking forward with bifocal vision. When they take this attitude a supra-orbital ridge of feathers is thrown out, forming a pronounced "eyebrow."

This turn and turn about, with the pair together, continues as a rule until the egg appears. A bird alone on the nest usually means that an egg is beneath, but not invariably. A sure method of determining the fact, however, is to walk up to the sitter. If no egg is present, the bird will always rise to its feet at the approach of an intruder, soon squatting again if it be disturbed no further.

A bird on an egg, on the other hand, will not move except to turn in the nest so as to face the enemy.

At the Prince Edward Islands, Moseley (1879, 172) noted that the albatross's egg is held in a sort of "pouch" during incubation. The truth of this, as I observed at South Georgia while the sailors were egging, is that the egg sometimes becomes so enveloped by the thick feathers along the brood-patch that it will be thrown out of the nest if the bird is suddenly tipped over.

The courting and pairing behavior of the South Georgia Wandering Albatrosses is very carefully described by Matthews, of the British 'Discovery' expedition, as follows (1929, 565, 566):

In courting before pairing several males gather around one female and bow to her, bringing the head close down to the ground. As they do this they utter a harsh groaning sound, and the female bows and groans back at them. After several bows the males open the wings to about half their extent and side-step around her. They then edge into a position so that they are directly facing her and open the wings to their widest extent so that the tips of the primaries are raised above the level of the head and are curved forwards towards the female. At the same time the males raise the head so that the bill points straight up into the sky, and give vent to a loud braying cry. They then close the wings and start all over again. Several males do this at the same time around the one female, but they do not all act in unison so that unless they are watched carefully one gets the impression of half a dozen male birds dancing round the female and going through a series of haphazard actions, but one finds that they all adhere to the same course of action if attention is directed to each in turn.

After pairing has taken place and before incubation has started the courtship ceremonies are even more elaborate than before. The nests are built on the bases of those of the last season, which are now trodden down to about half their full size. The female sits on the half-built nest and the male walks around among the surrounding tussac picking up bits of peaty moss and mud. He brings these to the female and deposits them on the edge of the nest and bows to her, at the same time making a groaning sound. She returns the bow and groan to him and then takes up the load of material which he has brought and arranges it on the nest, shuffling around on half-bended legs to stamp it down with her large webbed feet. The male then sits down on the ground close alongside the nest and makes a vibrating bubbling noise in the throat several times, at the end of each call stretching the head up and braying with the bill open. The female answers him, and then they start nibbling the feathers of each other's throats, heads and necks. This is followed by a further round of bubbling and braying and then the male gets up and goes to fetch another load of nest-building materials.

After every four or five loads that the male brings to the nest both sexes go through a more passionate demonstration of affection. The male brings his load and deposits it, and after bubbling and braying, and nibbling each other's heads and throats they both stand up, and the female steps down off the nest. Facing each other they both stretch up their heads and give a harsh bray with the bill widely open. Immediately after the bray the bill is brought so that it points vertically downwards and is thrust among the plumage of the breast. The bray is expiratory, and a lower, inspiratory note is made while the bill is touching the breast. They then lean forward together and touch the tips of each other's bills. After this they both keep the neck bent forwards, and bend the head upwards slightly and vibrate the mandibles very rapidly causing a peculiar rattling sound. The syrinx is not used in producing this sound, which has a slight musical ring, rising from a low note to a high one during its performance. This is owing to the increasing quickness of the vibrations and to the filling of the lungs with air during the process so that the thorax acts as a sound-box.

After these antics are repeated several times the male starts to walk sideways around the female, working his head from side to side at each step, and the female steps around without moving her position so that she is facing him all the time. The male spreads his wings widely, and pointing his head upwards repeats the vibration of the mandibles. He next bends forward, doing it again, and the female answers him, at the same time spreading her wings too. They continue in this attitude stretching out and touching bills, then vibrating and touching their own breasts with the tip of the bill twenty times or more, after which pairing takes place and they return to the nest, the female sitting down on it, and the male carrying on his work of collecting material for it.

The excellent account of Matthews is accompanied by photographs which illustrate several important stages of the ritual.

The nests of the Wandering Albatrosses are used year after year, but there is no reason to believe that they are occupied by either of the same birds as before, unless accidentally. The piles of earth and vegetation are, of course, greatly tamped and broken down by occupation, particularly during the final monrhs of loafing by the nestling, and mating is followed by a rehabilitation of last year's remains (Andersson, 1908, 56; Loranchet, 1916, 240; Kidder, 1875, 19).

In beginning a nest on a new spot of ground, according to Hutton (1865, 278), the mated albatrosses first scratch a circular trench with their bills, and then push the earth and vegetal mould from this toward the center until they have made a considerable pile. The subsequent division of labor between the sexes has been described above by Matthews. The mound is packed down with the feet, and more earth, moss, sodden grass-bents and tufts are added until the structure forms a truncated cone which may be a meter in diameter at the base, and half or more of that height, with a bowl 45 centimeters across and 12 to 15 in depth (Hall, 1900, 12; Moseley, 1879, 172). Several nesrs near my tent at South Georgia were remarkably uniform. They were steep-sided, built up to a height of 60 centimeters, and of the same diameter across the top.

The incubating albatrosses spend much time in perfecting them. They bend over the edge, scratch up the wet peaty soil around the base, and plaster the sides of the nest with this and with the remains of food which they regurgitate. The nests become, therefore, increasingly cylindrical and increasingly smooth and finished in appearance. A bird thus engaged will now and then shake its head and grate its mandibles with a lateral motion, in order to work the sticky earth out of the bill. It may then resume its masonry, or interrupt the task by a nap.

While the nests are sometimes very close together, or equally close to those of Giant Fulmars, this certainly has nothing to do with sociability. Favorite sites are on ridges, or near slopes or banks from which the birds can readily take flight. On rounded hilltops the nests may form clusters, as little as 2 meters apart, but as a rule a larger portion of individual territory is claimed, and the average distance between nests, even in well-populated colonies such as those in the Bay of Isles, would run to many meters.

Fear or resentment seem never to be shown by the sitting albatrosses. A man may crouch down beside one and look into its large, brown, calm, and expressive eyes, and after a few moments the bird is likely to lay its head upon the soft pillow of its back, perhaps keeping the exposed eye wide open. During incubation they retain this dozing attitude a good part of the time. But their ears, as well as their eyes, remain alert, for I have often seen them withdraw the bill from the wing coverts and gobble angrily when a skua flew close overhead. Moreover, when their more timid neighbors, the Giant Fulmars, are frightened from their nests by the approach of a man, the albatrosses snap at the ugly birds as they rush pell-mell past, endeavoring to take wing.

Either sex may begin the incubation process, though at the Bay of Isles most of the albatrosses taking the first turns were undoubtedly males. I made an effort to determine the time spent on the egg by each member of a pair, the periods of relief, etc., but the record was seriously interrupted by other occupations, and by spells of blizzardy weather. My observation on a mainland nest near my tent convinced me, however, that the male of a familiar pair remained continuously on the egg from February 5 until February 14, the female thereafter until February 21. Throughout the first period, of nine days, I had the nest under pretty constant notice during all the hours of daylight, and it is unlikely that there was a change of guard. At eight o'clock in the morning of February 2, I watched the relief take place at another nest. The female had already returned from sea, and was walking around her sitting mate, gobbling violently. Then she began to snap gently at his wings and tail as if trying to drive him from the egg, which he seemed loath to leave. I missed the sequel because at the moment I discovered the crews of two wrecked whaleboats under the snout of a distant glacier, but a few hours later the female bird was sitting alone upon this nest.

The notes of Sir Hubert Wilkins (1923, 481), who had perhaps a better opportunity for observations on the incubating albatrosses at South Georgia, indicate much more frequent relief periods. He reports alternation of marked pairs at intervals of from four to twenty-four hours. It is probable, nevertheless, that the breeding birds range so far from home that extended absences are common.

We found our first South Georgia eggs at the Bay of Isles on December 20, and all of these were in nests which had been empty five days earlier. On December 20, 80 eggs were collected as food by the crew of the 'Daisy,' and on December 28 other nests in the same colony yielded more than a hundred. The dates agree with the first layings at Kerguelen. As noted elsewhere, tardy birds kept on supplying new eggs at South Georgia until late February. During the height of the season, whalemen from the permanent stations sometimes gather more than a thousand eggs a day.

The eggs are white, usually with a faint rosette of fine red spots near the larger end. Matthews records one, taken at the Bay of Isles in January, which was entirely covered with red markings. They make a great contrast with penguin eggs because of the thinness and fragility of their shells. They are, in truth, so delicate that I have often seen them broken by the expansive force of the breath while they were being blown. They weigh roughly a pound apiece, more precise data being recorded above.

From an epicurean point of view, the egg of the Wandering Albatross is a delusion and a snare. I can compare it with nothing else than beaver-tail soup, and this entirely because of its effect upon the appetite rather than from any similarity in taste. You boil your egg until the contents are of just the right consistency, snip off the smaller end, sprinkle with salt, and dig in. It is delectable! By the time you have progressed halfway to the bottom, you begin to wish that the bird had laid a somewhat smaller egg and, if you have the stomach to scoop the inside of the shell clean, you are sure to hope that you may never see another. However, that first rich taste soon wipes out the memory of what had followed, and within a few days you once more fall a victim to the insidious temptation which never fails to cloy.

There seems to be a difference of opinion as to whether the paired albatrosses lay another egg after removal of the first. All observers agree that when the nest is robbed, the ousted bird steps on again as quickly as possible and continues to sit for at least a number of days (Hall, 1900, 12; Kidder, 1875, 19). This was our experience, without exception, whether the egg was taken by sailors or by a skua. Kidder's observation at Kerguelen Island, and the testimony he received from the whalemen, led him to believe that a second egg was never laid after the rifling of the nest. I had no opportunity to determine the point with finality at South Georgia, for it appeared probable that second eggs in robbed nests were in certain instances produced by other birds than the original owners. However, Wilkins definitely states that at South Georgia another egg will be deposited by a mated pair of albatrosses within about five days of the time they are deprived of the first. This is probable, because it agrees with the reactions of most other water birds.

Wilkins, whose published notes stamp him as one of the best bird-watchers who have ever served in the far south, also records the fact that more or less stolen mating takes place between Wandering Albatrosses of neighboring nests. This doubtless represents an unbalance in the succession of reactions which lead toward the fixation of mating between two particular birds. Paired albatrosses usually sit together at the nest until the egg is laid, but sometimes one of them may remain alone for a short period. Under such circumstances Wilkins saw old white males copulate with other females than their own partners. Occasionally this led to trouble between the interloper and the returning male of the other nest, but in the main the battles were an exhibition of feints and mere snaps of the beaks rather than real blows. Interested females kept up a clatter of beaks during the difficulty (Wilkins, 1923, 481). The mate of the brig 'Daisy' reported to me on December 28, 1912, that he had just seen a fight between two cock birds which resulted in the drawing of blood on the faces and necks of the contenders.

Most surprising of all Wilkins's observations is that dealing with the continuance of the mating act after the hatching of eggs, and even after the young albatrosses are partly grown. Howard (1929, 51) quotes Whitman on the reproductive cycle of the Passenger Pigeon in captivity, as follows:

> Incubation and sexual activity are mutually exclusive and antagonistic phenomena. The two never occur together. Coition ceases immediately as incubation begins. The rise of sexual activity during incubation disrupts the cycle, and the sex activities generally appear shortly after incubation terminates.

Some such pattern was formerly regarded as true among all wild, as well as domesticated, birds, but it is now known that certain hawks, as well as other species, depart from the rule. In the case of the Wandering Albatross there can be no possibility of a second complete breeding cycle during the same year as the first. But at the time of Wilkins's second visit to South Georgia in April, after the 'Quest' had returned from her polar voyage, the young albatrosses had all hatched, and yet he found that apparent copulation of the adults was taking place with as much enthusiasm as during the egg-laying period.

The Wandering Albatross is one of the few species of Procellariiformes, or probably the only one, in which the sexes can be distinguished by the mature plumage. The females never achieve the whiteness of males, and in particular they never lose a crown-patch of dark feathers. Among upwards of a thousand which I have examined, either in the form of skins or as living, mated birds at their nests, no female has represented the "*chionoptera*" stage, and every museum specimen labelled *chionoptera* has, in my experience, been a male. The only apparent sexual distinction among most Tubinarine birds is that of size, the males being usually, though not invariably, slightly larger than the females.

Now it is quite possible that the rôle of sexual selection has had something to do with the differences in plumage of the adult Wandering Albatrosses. Let us consider certain contrasts between the habits of this species and some of its relatives. The smaller albatrosses exhibit plumages which, throughout the lives of the birds, are exactly alike in the two sexes, and it is worth noting that among at least some of these, such as the Galápagos, Black-footed, and Laysan Albatrosses, a social behavior of the "courtship" type continues throughout the period of incubation, and even through the subsequent rearing of the young. Both sexes take part in such reactions which, however, are by no means confined to mates. Rather, the performance is more in the nature of a community dance, in which members of several families may participate at once. In the Wandering Albatross, on the other hand, the sexual dimorphism, apparent as a pronounced difference in size as well as plumage, is correlated with a limited and strictly mutual pattern of behavior between two mated birds, as soon as the selective courtship phase has been completed. Thereafter, despite the sporadic intermating to which I have referred, there is nothing to be seen on the breeding ground to correspond with the haphazard and quadrille performances of the North Pacific albatrosses.

Nevertheless, while they are at sea, far away from the islands on which they nest, the Wandering Albatrosses indulge in dances in which many individuals take part, and which are highly reminiscent of the customs of the lesser species referred to above. I first saw this on November 26, 1912, on the whaling banks some 65 kilometers off the northeastern coast of South Georgia. The weather was prevailingly calm and foggy, and thousands of Wandering Albatrosses were among other sea birds resting upon the ocean. The albatrosses were not evenly distributed through the hordes of other waterfowl, such as prions, Cape Pigeons, diving petrels, and Mother Carey's chickens, but were grouped together in the assemblages that the whalemen call "gams," in some instances with Giant Fulmars mingled peaceably among them. From six to about twenty of them might be together in such groups, and from time to time the huddled albatrosses would suddenly become interested in others around them and would begin to bill and bow, spread their wings, bob their heads, and caress each other by nibbling with the beak. The reaction worked rhythmically, for the initial movements of one bird would spread rapidly through a group, and within a few moments all of them would be spinning on the water, each paying attention first to one neighbor and then to another.

Since this maritime exhibition was simultaneous with the wooing going on at islets in the Bay of Isles, I naturally thought at the time that it represented a preliminary stage of courtship. The opinion was later dispelled, however, for after the end of the breeding season, on March 26, 1913, I witnessed the same dance in latitude 38° 50′ S., longitude 31° 30′ W., hundreds of kilometers from any land. On this occasion the wind was again light and the ocean relatively calm. Scores of Wandering Albatrosses were about in the characteristic gams, and the whirlings, raising of wings, billing and squealing were in progress as lustily as during November. Yearling young, in the black plumage, were taking the same part as adult birds, which rules out any courtship connotation. The albatrosses were merely expressing an ancient custom of their family, more fundamental than the particular type of courtship which has been developed by each species. A similar incident has been reported by Fisher (1904, 78) of a group of six Black-footed Albatrosses (*Diomedea nigripes*) in the North Pacific. In this case the observation was made during the breeding season of the species, and the familiar bowing, pointing upward of the beak, and the gesture of tucking the bill under the wing, were made in the same order as during the terrestrial courtship dance of that species.

My notes for December 15, 1912, made during the first visit to the nesting ground of the Wandering Albatross, contain the statement that "the pink ear-stain, previously noted at sea, was not unusual." Unfortunately, I neglected to trace the origin and nature of this stain, which probably exudes either from the meatus of the ear or from a gland on the side of the head. The phenomenon has been repeatedly noticed from early times, but the limitations ascribed to its presence are not borne out. Thus Bennett (1860, 72) reported that "birds in white plumage" had the delicate rosy streak on either side of the neck. Hutton (1865, 278) regarded it as a pre-nuptial mark of the male birds and believed that it was to be found only between June and August. Kidder (1875, 19) regarded it as a characteristic of nesting albatrosses. Matthews also (1929, 564), referring to South Georgia birds, says:

> Those seen ashore nesting usually have a patch of salmon-pink colour over the ears, sometimes on one side only. This appears to be a stain of some sort and is not a true pigmentation of the feathers; it is not constant, sometimes being absent, or on one side only, as stated above.

Now we found this same stain on birds of various ages, and of both sexes, captured at sea during the months of November and March, while the brig 'Daisy' was bound either southward or northward in the Atlantic, that is, both before and after the breeding season. On November 4, 1912, a stormy day in latitude 33° S., longitude 46° W., many Wandering Albatrosses were seen at very close range, and I noticed that all were characterized by pinkish feathers about the region of the ear. Again, while I was on the South Georgian whaling banks on the occasion when the "gamming" phenomenon was first noted, many groups of albatrosses were scrutinized through glasses as the birds sat on the water, and nearly all I saw, both white birds and those in immature plumage, showed a decided pink or rusty tinge on the head.

It is worth while to suggest that the next observer determine something of the chemical nature of this curious stain, and find out whether it gives off any perceptible odor. There is certain evidence, noted hereafter, that the Wandering Albatross has a keenly developed sense of smell, and it is at least possible that the brightly colored exudation has its source in a scent gland. The stain is evidently durable, for a number of our American Museum specimens show it clearly after years in a cabinet.

My stay in the northwestern region of South Georgia was not prolonged enough for me to see the hatching of any Wandering Albatross eggs. From reports of other observers we learn that this begins in April. During this month Wilkins saw both eggs and newly hatched young; on May 9 the Swedish Expedition found downy young in every occupied nest (Andersson, 1908, 56). The period of incubation is, therefore, between two and three months, and the date of hatching varies widely with the individual and latitudinal variation in the time of egg-deposition. At South Georgia egg-laying goes on for close to three months.

On February 13 I collected a series of embryos ranging in stage from the primitive streak to birds as large as newly hatched domestic fowls. The largest of these showed the pattern of feather tracts and had relatively short, down-bent bills. After hatching, the bill keeps this decurved form for about four months before it assumes the adult shape (Matthews, 1929, 567).

The chick is at first guarded as carefully as the egg, for it would be equally liable to fall a victim to the ever-watchful skua. According to Loranchet (1916, 240), the youngsters grow so rapidly that after a few days they are left alone in the nest, but Matthews states that they are commonly brooded continually by one of the parents for months. They are fed upon regurgitated food, and during the process the chick's bill is not thrust down the throat of the adult, in the penguin manner, but is held slightly opened within and across its parent's bill. The pabulum is then spilled into the trough of the infant's upturned mandible.

By July or August the oldest of the young albatrosses are nearly as large as their parents, and so fat that they are probably every bit as heavy, though still enveloped in an exceedingly dense coat of gray down. Then something happens which is so extraordinary and spectacular that the early accounts of it found little credence, although we know now that it is paralleled in greater or less degree among all Procellariiform birds. With the setting in of the antarctic autumn, the adult albatrosses completely abandon their nestling offspring, not for a matter of days or weeks but forever. Off on their Odyssean wanderings go the old birds, leaving the obese, well-muffled youngsters sitting on the trampled tops of their nests, where they remain quietly no matter how the wind howls or the snow beats down upon them. Their metabolic processes must be very slow, as they squat on their tiny hillocks and draw upon their own abundant blubber for the heat and energy required for further development.

This latter growth-period is surely the nearest approach to hibernation to be found in the bird world. For three months or longer the young albatrosses receive no visits from the adults and subsist entirely without food. Toward the end of this time, they begin at last to amble down off their nests and to try first their legs and afterwards their wings. Flight practice involves a long course of what might be called ground-training. All such youngsters as have not left the nests by the time the old albatrosses return for a new breeding season are promptly driven off, for the adults come back to the ancestral home ready for expressing a chain of instinctive behavior which includes no immediate provision for the care of well-developed offspring.

Such scattered data as are available indicate, therefore, that the young Wandering Albatross spends from seven to eight months in the nest after coming out of the egg. References to a ten-month period in the nest, which are common in the literature, include the weeks of incubation. During half the term of nestling life, more or less, the chicks are fed by their parents and during the other portion they starve.

The data on the life of the young albatrosses are drawn from many scattered sources (Layard, 1867, 461; Verrill, 1895, 437; Hutton, 1865, 278; Buller, 1888, 189; Buller, 1905, 128; Thomson, 1878, 162), but they piece together to form the only hypothesis consistent with the known facts. Thomson reports, for instance, that the eggs of the Tristan subspecies are laid at Inaccessible Island during January and that the adults all depart from the island in July. Yet we know from the accounts of many observers that yearling chicks are in the nest at Tristan and the neighboring islands until November. Buller quotes Buckland to the effect that on the islands south of New Zealand the adult albatrosses desert the young in June and do not return to the nesting ground until the following October. The Maoris of New Zealand were well acquainted with the fact, and correctly attributed to the excessive fatness of the chicks an ability to survive through the absorption of their own tissue, and to remain strong and lively at the time when their parents came back to hustle them out of their nests.

One puzzling question regarding the economy of the Wandering Albatross is cleared up by the portion of the life history just outlined, for it becomes evident that the adult birds manage to free a portion of their sexually active lives from family cares. Knowing that from ten months to a year must elapse between the date when the egg is laid and the date when the young albatross flies away from its island home, it might otherwise appear that the parent birds would barely finish with the care of a chick before they would be called upon to resume courtship and proceed with the production and rearing of another generation. Yet we know, too, that vast numbers of albatrosses are ranging over the great southern oceans, hundreds or thousands of kilometers from land during many months of every year. If the rearing of young occupied a full year, it would be necessary to assume that the adults do not breed every season, an assumption with little or nothing to support it, although many have made it as a way out of the recognized dilemma. Matthews (1929, 568), for instance, writes:

> The adult albatross do not breed every year, as they do not finish feeding their young until after the new season's eggs are laid (by other birds) and incubation has started. Consequently there must be an interval of at least one season between the consecutive matings of any one bird.

When it is understood, however, that the young are left to their own devices for at least a quarter of the calendar year, the difficulty clears up, and a sufficient period of rest is allowed between the reproductive cycles of the adults.

Furthermore, the long fast of the chicks enables them to redistribute their tissue, and to convert mere weight into strength of bone and muscle. The young birds become rapidly thinner as soon as they abandon a sedentary for an active life, *i. e.* as soon as they leave the nests voluntarily or are turned out by the amatory adults. The stomachs and intestines of several that I examined during this period were absolutely empty.

At the Bay of Isles I saw the first flight-practicing yearling albatrosses on December 17. One in particular I watched for some time on Albatross Islet. It had lost most of its down, though gray fringes still clung to the flanks. It would stand on the hillside and face the wind, spreading its long weak wings to their full extent. Then, after beating in a rather wobbly manner for a few minutes, it would spring off the ground and poise in the air for three or four seconds. The whole performance was repeated many times in rapid succession.

On December 23, at the same place, a goodly number of blackish juvenals, with white faces, could be seen extending their flights out over the fiord and obviously making heavy weather of it. Even as late as February 13, youngsters of this same generation, some of them yet wearing downy ruffs on their necks, were still to be found both ashore and on or over the water. Buller (1905, 128) reports that such chicks make only short trips to sea, and do not leave the vicinity of their island until the following year. This is probably incorrect; I saw few if any juvenals near the coasts of South Georgia after February, while in March I saw and collected a number of such birds on the open ocean 1500 kilometers from any nesting locality.

The bulk of the Wandering Albatross's food consists of cephalopods. Squid beaks are almost invariably present in the stomachs of birds taken on the breeding grounds, and the incubating albatrosses disgorge little piles of these which they subsequently work into the walls of their nests. The ejected squid beaks examined at South Georgia seemed to be identical with those found in the stomachs of sea-elephants in the same region. On March 24, 1913, in latitude 43° S., we caught twelve Wandering Albatrosses on hooks from the brig 'Daisy,' and one of them ejected on deck a fresh squid with a body 30 centimeters long. Buller (1905, 128) refers to examples caught from a sailing ship which had in their stomachs beaks of large cuttlefish, the beaks being as large, in fact, as those from a "four-foot octopus." The capacity of the albatross's stomach and gullet is indicated by Saunders's report of one which contained cuttlefish and ten pounds (well over four liters) of water, the latter probably swallowed unintentionally while the hooked bird was being hauled on board a vessel (Saunders, 1880, 165). The members of the Swedish Antarctic Expedition at South Georgia found fish in one Wandering Albatross stomach (Andersson, 1908, 56), and the 'Discovery' party found remains of Nototheniid fish up to 45 centimeters in length (Matthews, 1929). Of two specimens shot by Beck, 60 kilometers west of Corral, Chile, on October 22, 1913, one contained pieces of a large fish, the other three skinned-out bodies of shearwaters (*Puffinus creatopus*), which the collector had thrown overboard as bait. Forster (1785, 556) reports that he found in the stomachs whole fish, crustaceans, various mollusks, bones of birds, and the beaks and pens of cephalopods.

More remarkable is the observation of Sir Joseph Banks, during his voyage with Captain James Cook. He states that a Wandering Albatross shot at sea discharged a great quantity of *Holothuria obtusata*, by which he means the Portuguese man-o'-war, now called *Physalia*. Banks was astonished at the ability of the bird to devour "such blubber," because of the severe and innumerable stings it can give, but he later obtained additional evidence that the great albatrosses habitually eat these creatures (Banks, in Hooker, 1896, 259, 260). The testimony of Banks is unimpeachable in all respects save that of the identity of the albatross in question. The species was either *Diomedea exulans* or *D. epomophora*, an uncertainty which applies to most observations on the great albatrosses at a distance from their breeding grounds.

Wandering Albatrosses are also attracted by the free grease and refuse of modern whaling stations, the establishment of which has apparently led to the extension of their range southward to such localities as Deception Island (Gain, 1914, 165). On the whaling banks off South Georgia, these birds gather in great numbers, with other Tubinares, about the carcasses of whales. They greedily devour the blood-clots, and the crustaceans belched up by dying whales. They can even swallow the circular piece of blubber and fibrous tissue which is cut out of the flukes of each whale by the Norwegian whalemen in order to accommodate a chain from the steamer.

Not infrequently it is expedient for the whalemen to pump their catch full of compressed air, waif it, and set it temporarily adrift. Formerly a handful of plain tow was used to plug the air-hole, but it was promptly learned that the strong bills of the Wandering Albatrosses are well equipped to pull out such plugs as soon as the tow becomes soaked with oil from the blubber. The albatrosses then swallow the whole plug, and the whale may sink and be lost. The difficulty has been overcome by soaking the plug in petroleum fuel oil, which apparently makes it so distasteful to the albatrosses that they never extract it.

The last observation at least suggests that the albatrosses may have keen olfactory perception. It has been popular to credit most birds with a negligible sense of smell, though some recent experimental work may make a revision of opinion necessary. Bennett (1834, 151) and Burne (1908, 65) have made dissections of the head of the Wandering Albatross. The latter authority shows that the olfactory organs are highly developed in the species, the bulbs measuring 7 millimeters in diameter, and receiving large nerves from the nasal septum and from the lateral wall of the chamber. The olfactory eminence is also remarkably prominent, lying in a prolongation of the nasal cavity. Burne regards the equipment as the most highly specialized organ of smell reported among birds, excepting that of the Apteryx.

A fact accidentally discovered in the field by Beck offers rather convincing empirical evidence. It has always been his custom to bait Tubinares within collecting range by laying a trail of animal oil or melted fat on the water. Near the Falkland Islands, on September 20, 1915, he made the discovery that hot grease was far more effective than cold grease in drawing up Wandering Albatrosses and small petrels from a distance. Thereafter, it became his regular technique to heat his bait on the galley stove before spreading it on the ocean. It would be hard to interpret the difference in results which he repeatedly noticed on any other grounds than the ability of the birds to follow up a scent.

In capturing its prey, the Wandering Albatross is, of course, a "scooper" rather than a diver. It does not pounce upon food like a frigate-bird, or like some of the shearwaters, but first alights and then feeds while swimming; "in fact, it sits down to dinner" (Hutton, 1865, 278). As a devourer of other birds, or under certain circumstances even of its own kind, it is by no means above suspicion, a trait which it shares with other Tubinares to an extent not generally appreciated. Bird bones and feathers have occasionally been found in its stomach (Forster, 1785, 556; Bennett, 1860, 72; Lucas, 1887, 7). During the New Year season of 1885, when James Anthony Froude was steaming across the Indian Ocean towards Australia, he made a number of observations upon the ferocity and flesh-eating propensities of several larger members of the petrel tribe. He writes that the chief object of some of the passengers seemed to be to shoot the birds following in the wake of the ship. "My acquaintance from the Diamond Fields," he adds,

> . . . had a rifle and emptied case after case of cartridges at them, for the most part in vain. A dancing platform to stand on, and an object moving sixty miles an hour, are not favourable to ball practice. One albatross, I am sorry to say, was hit at last. It fell wounded into the water, and in a moment the whole cannibal flock was tearing it to pieces—not a pleasant sight (Froude, 1886, 66, 67).

Finally, there are a number of tales, doubtless mostly apocryphal, of men in the water being attacked by Wandering Albatrosses. The only one that seems to be worth citing is the highly circumstantial account by Green (1887, 10) of a

> . . . sailor who was swooped at by an albatross after falling overboard in 42° S., 90° E. The man seized the bird by the neck and drowned it, and then used the buoyant body as a float until he was rescued nearly an hour later.

An excellent word picture of albatrosses feeding in the wake of a vessel is that of Richards (1909, 7):

> Ever on the alert, no suitable morsel escapes the hungry horde, and it is wonderful how accurately they can pick out the "wheat from the chaff," no second glance being given to the odds and ends unfit for food. But with all their eagerness to be first at the feast, the prizes go to the ones that can stop and alight the quickest, and most of them make a bad mess of it; swooping

rapidly to the coveted spot, they find it difficult to check their speed, and many have to pass and circle back again. With those more fortunate, or expert, wings are thrown suddenly back, the tail is widespread and depressed, and—a most comical effect—the broad, webbed feet are expanded and thrust out forward, exactly as a skater digs his heels in the ice to stop his headway. Once on the water, the wings are kept partly expanded and raised high over the back, the wind's levitation thus bearing most of the weight. Actually, the birds now walk on the water, paddling with the big feet quite sufficing to lift the bodies clear, and, gulping food rapidly as they go; the whole performance is most grotesque. With all this excitement, there is no noise; in a few moments the last scrap has disappeared, a hundred wings are extended, and, with a final "push," each bird rises lightly to windward, resuming his tireless vigil in our wake.

The bill of the Wandering Albatross is a highly efficient organ for seizing and holding such slippery creatures as squids, the arrangement of the plates effecting an extraordinarily firm grip. When the jaw is shut the massive infralabial plates of the beak are in contact with the rostral hook, making a vise in which even an eel would be helpless (Lönnberg, 1904, 489).

The flight of the Wandering Albatross, as observed over the ocean, has been a subject for rhapsodizing since ships first penetrated into the southern hemisphere. Only recently, however, has any attempt been made to determine the mechanics of its flight by exact methods, such as those employed by Idrac. To ordinary observation the aërial performance of the great bird seems more inexplicable than that of its smaller relatives. Black-browed Mollymauks, for example, give the impression of constantly adjusting their wings in a strong breeze—of bending the manus at right angles to the upper wing and thus "shortening sail." But the Wandering Albatross appears more nearly to have one style of flight which is suitable for all weathers except a calm. Even though the constant rocking movement of balance-stress may be observed, the huge wings seem to be set in the same manner for hurricane or cat's-paw, and the bird has the appearance of gliding as though all directions were downhill.

Hutton's much-quoted description of the bird in the air, down to the water, and up again, is as follows (1865, 278):

The flight of the Albatros is truly majestic, as with outstretched, motionless wings he sails over the surface of the sea; now rising high in the air; now with a bold sweep, and wings inclined at an angle with the horizon, descending until the tip of the lower one all but touches the crests of the waves as he skims over them. Suddenly he sees something floating on the water and prepares to alight; but how changed he now is from the noble bird but a moment before all grace and symmetry. He raises his wings, his head goes back, and his back goes in; down drop two enormous webbed feet straddled out to their full extent, and with a hoarse croak, between the cry of a Raven and that of a sheep, he falls "souse" into the water. Here he is at home again, breasting the waves like a cork. Presently he stretches out his neck, and with great exertion of his wings runs along the top of the water for seventy or eighty yards, until, at last, having got sufficient impetus, he tucks up his legs, and is once more fairly launched in the air.

The apparent difficulty with which albatrosses alight during a calm has been described by many observers. Wilkins (1923, 508) aptly observes that when its members seem to stick in all directions under such conditions, the erstwhile graceful creature looks as ill-knit as a bunch of keys tossed into the air.

Moseley (1879, 540), watching with a more critical eye than Hutton, states that the Wandering Albatrosses

> . . . move their wings much oftener than is suspected. They often have the appearance of soaring for long periods after a ship without flapping their wings at all, but if they be very closely watched, very short but extremely quick motions of the wings may be detected. The appearance is rather as if the body of the bird dropped a very short distance and rose again. The movements cannot be seen at all unless the bird is exactly on a level with the eye. A very quick stroke, carried even through a very short arc, can of course supply a large store of fresh momentum. In perfectly calm weather, Albatrosses flap heavily.

With this the notes of Richards (1909, 5) are in agreement:

> Albatrosses do not follow for long periods, however, without wing movements; at comparatively brief intervals there is a well marked flap, which is apparently not required for progression, but rather for the execution of a sudden turn or rise. To increase their elevation it seems necessary for them to face the air current. Their best point of sailing seems to be like that of a schooner, that is, "on the wing," namely, neither directly ahead nor abeam, but between the two.

The effect of weather conditions is even more apparent at the breeding grounds of the Wandering Albatrosses than it is on the open ocean. The windier the day, the more they come into the South Georgian fiords to wheel magnificently above their nesting territory. In quiet weather one may see only the grounded birds, looking like pasturing sheep on the green tussock-grown islands, and an all-day watch may disclose only two or three leaving, or sweeping in from the distant watery horizon. But when gales blow and heavy seas race past the anchorage, cooping a ship's crew on board, then the albatrosses fairly fill the air, and no blizzard, apparently, can be severe enough to stem their riotous enjoyment.

The wind is their friend at the nests no less than at sea, for their supreme gift of flight is not without its accompanying penalty. Campbell writes (1877, 85):

> They appear to dread the act of alighting . . . , flying round and round their nests close to the ground before they make up their minds, and when they finally do, often toppling forward on their beaks. One fellow we saw go completely head over heels.

Wilkins (1923, 481) says that the albatrosses flying above the nesting grounds never collide or touch wings in the air, even when hundreds of them are sweeping back and forth together above their sitting mates, but that the absence of wind brings them to grief when they finally come down among the grassy hummocks. At least half of them make a faulty landing, striking the ground violently with their breasts and turning turtle. This usually causes them to vomit their stomach contents, after which they have a very dejected appearance. The reaction, however, is a common and trifling one for albatrosses in general; it has been remarked, in connection with a North Pacific species, that every albatross seems called upon to empty itself whenever an unusual circumstance brings its head lower than its stomach!

After making the high-speed three-point landing, in which the widely parted feet and the bill or breast may all be involved, the apparently embarrassed new arrival will waddle up to its mate upon the nest, and the two will engage in hoarse conversation.

The distribution of the Wandering Albatross's body weight compels it to stretch forward its neck when walking and to adopt a widely swaying gait.

Sometimes, especially when ascending a slope, the bird must also partly extend its wings as balancers. And yet its postures and actions are less grotesque than those of some of the smaller tropical albatrosses, such as the species peculiar to the Galápagos. To a certain degree the Wandering Albatross has superior terrestrial adaptations to any of the lesser species. It has assuredly become more graviportal, and in spite of its greater weight it can stand longer and walk much farther than the Sooty Albatross or any of the species known as Mollymauks.

If wind is important for happy landings, it is still more so for taking off. Here, again, the stiffer the breeze, the less the difficulty. In a flat calm the birds are faced by almost insuperable obstacles against leaving the ground, and launching is possible at all only if they can run down hill. Even this procedure may sometimes result in failure, in which case the birds seem to have a certain comprehension of their predicament for they are likely to make their way laboriously to a higher eminence before the second attempt (Hall, 1900, 12). Even under the worst conditions, I believe that they make rather better going than their unwieldy neighbors, the Giant Fulmars, which have a relatively greater weight in proportion to wing-area.

Under favorable weather conditions, the albatrosses run as nearly as possible into the wind, appearing to beat the air chiefly with the tips of their wings, and then rise at a very steep angle (Waite, 1909, 566). Ordinarily they must run from a few lengths to 30 to 40 meters, or even more, and the pattern of direction, position, and movements by means of which they launch into flight is so fixed that any interference with them makes it quite impossible for the birds to climb into the air at all. At the Bay of Isles, on February 1, 1913, I made the experiment of driving an adult albatross away from its nest, down wind, and also down a slight slope. The bird seemed helpless, and no sooner was it outside its own familiar territorial beat than it appeared completely dazed and at a loss as to its whereabouts. It promptly gave up every attempt to fly, and persisted in squatting on the ground even when I touched it. I finally urged it to the shore and into the bay, but its only response was to land again.

Still more indicative of the fixed pattern of action necessary for taking flight is the unexpected result of Carmichael's experiment at Tristan da Cunha. This early visitor to the island tossed an adult Wandering Albatross over a high cliff, first taking care that its wings were expanded. Though the bird had a hundred meters or more of clear fall, it never succeeded in collecting itself, but dropped like a stone to its death (Carmichael, 1818, 490).

The difficulty of taking flight from the water in the absence of wind is indicated by the unwillingness of Wandering Albatrosses to leave the surface of the ocean during a calm, especially if accompanied by fog or a soft perpendicular rain. Sir Joseph Banks records the trouble he had in making one take flight during a calm on January 1, 1770, by shooting close to it repeatedly. Eventually it did fly away, thus proving at least its ability to do so (Banks, in Hooker, 1896, 208). Rain, unless driven by wind, soon destroys the momentum of flight and compels an albatross to beat its wings frequently (Hutton, 1865, 296). In heavy fog, according to Green (1887, 4), all the Wandering Albatrosses settle on the water.

One November day, on the whaling banks off South Georgia, a dense fog came up about two o'clock in the afternoon, the wind dying away about the same time. Within a short time the water was covered with Wandering Albatrosses, which were so reluctant to rise again that they allowed themselves to be almost run down by the steam whale-catcher on which I was prospecting. Smaller sea fowl took to the air as we approached, but the albatrosses would swim rapidly, or desperately if necessary, to get out of our path. As they swam the feet were held far apart, and the flexed foot thrust forward until it was half out of water before the backward stroke was made. When they were driven to take wing by being actually bumped off the bows of the slow-moving steamer, they would start across the water, beating heavily, running foot after foot with the legs widely straddled, the tail working from side to side, the head and neck pumping up and down. Some of them would run a hundred meters, perhaps, before the whipped-up wake would be left behind.

The webbed feet of the Wandering Albatross are enormous (sometimes 20 centimeters in width). They seem disproportionately large even for so huge a creature, and remind one of Indian snowshoes. I fancy that the size of the feet is even more important for taking off from the water than for furnishing propulsion while in it. They are no less important, indeed, during the act of alighting, for this is usually accomplished by sliding or skidding on flat feet for some distance, the bird being buoyed by its planes so that it sinks very slowly to the swimming position and then tucks away the wings.

The strength of the Wandering Albatross on the wing is well attested by the extreme rarity with which this species is driven ashore by the terrific gales of the southern oceans. On certain leeward coasts, such as that of western Australia, vast numbers of Tubinares sometimes become exhausted by struggling to keep offshore during the winter storms and subsequently become stranded on the beaches. Whitlock (1931, 264), who has kept a long record of such incidents and has listed many species and thousands of examples of stranded birds, reports that he has known but one Wandering Albatross to come to grief in this manner.

Hutton, who for nearly half a century gave careful attention to the problems of albatross flight, has summed up his conclusions as follows:

Sailing flight depends, of course, upon the principle of the inclined plane. The bird acquires momentum by flapping its wings and then, holding them extended and motionless, waits until its momentum is nearly exhausted, when it once more propels itself forward as before. In the case of the Sooty Albatross the interval may, under favourable conditions, be about half an hour, and the difficulty is to explain why the friction of the air does not sooner bring the bird to a standstill. It was pointed out in 1889 by Mr. A. C. Baines that the birds usually rise in a slanting direction against the wind, turn round in a rather large circle, and make a rapid descent down the wind. They subsequently take a longer or shorter flight in various directions, almost touching the water. After that comes another ascent in the same manner, followed by another series of movements. Now, as the velocity of the wind near the surface of the sea is diminished by the friction of the waves, when the bird ascends into the more rapidly moving upper current its *vis inertiae* makes the wind blow past it, and so its stock of energy is increased. When it descends it will be moving faster than the lower stratum of wind and will again develop new energy if its *inertia* is sufficient to prevent its attaining the new velocity of the wind at once. So that the bird must fly against the wind when ascending and with it when descending. Thus the energy constantly lost by the friction of the air is partially renewed by these manoeuvres. This explains why the birds can sail longer in a high wind than in a calm. It is because in a high wind and with a high sea there is much greater difference between the velocities of the wind near the surface and a short distance above it; and this, again, is an explanation of why an Albatross keeps so close to the surface of the sea, only just topping the waves and occasionally rising high in the air (Hutton, 1903, 85).

The most careful and detailed studies of albatross flight are those made by Idrac (1925, 1926) in the ocean near South Georgia. This author's observations relate to the typical scaling flight, with the energy derived from wing-beating eliminated to the greatest possible degree. Opinions derived by visual means were checked by cinematograph records of Wandering Albatrosses, the Black-browed Albatross, and other Procellariiform birds.

In the open oceans, says Idrac, where there are long and regular swells, varying with the strength of the antecedent breeze, an upward thrust of air results from the reaction of the swell upon the wind. Full use of this is made by albatrosses and similar birds, even though the effect of the rebound is confined to a relatively thin layer above the surface of the water.

The albatross first skims the water between two wave crests, and usually on a slope which is opposite to the wind. When the rebounding air, coupled with whatever momentum the bird may have derived from previous muscular exertion or from a rapid descent, heaves it upward far enough to face the free wind, it rises in a straight line to an altitude of 8 to 10 meters. Then it swerves to the right or left, still mounting. This is followed by the descending glide, with the wind from the side, on the quarter, or from the rear, which brings it back to the trough, whereupon the same series of maneuvers is repeated, and so over and over again. Complete rotary evolutions such as these are made by *Diomedea exulans* within an average period of 10.7 seconds. The maximum height to which the bird rises is greater in a strong wind than in a weak, but it rarely exceeds 15 meters. The inclination of the trajectory is less pronounced in rising than in descending. This type of flight is not possible at all for the Wandering Albatross unless the velocity of the wind is at least 6 meters per second in the layer just above the water. Moreover, it is possible under any circumstances only for birds of such structure as to permit high dynamical air speed.

Idrac's reasoning seems to be substantiated by sound physical data in his motion pictures and measurements. His ballistic calculations led him to the interesting conclusion that the trajectory adopted by the albatross is precisely that which permits it to get the most benefit from the wind at the summit of its climb, and also to profit most from the rebound of the air from the waves when it has descended to its lowest level. The reactions of the bird, in short, lead it to place itself in such positions with respect to wind and wave that variations in the velocity of the wind will always tend to increase its air speed. The air speed of the Wandering Albatross, according to Idrac's measurements, averages 22 meters per second, with extremes noted of 14 and 28 meters per second. The last rate is equal to one statute mile in 58 seconds, which is about the speed estimated by Vinciguerra (1884, 799). It would seem, therefore, that rates equivalent to a ground speed in excess of a hundred miles (161 kilometers) an hour may readily be attained by the Wandering Albatross under favorable conditions. This agrees, surely, with the casual impression one gets on a windy day at sea, when the great white bird appears on one horizon, wheels by, and disappears toward the other, while the watcher stands spellbound.

Now all such theories which assume that a flying creature can have sensory appreciation of the speed of the air in which it is enveloped, and in which it forms part of a moving medium, would seem to run counter to the physical facts presented by Acworth (1930). In a curious work, this author rather too elaborately demonstrates that birds in flight do not ordinarily feel the "pressure of the wind," since they form an intrinsic part of the moving medium, with their own speed superimposed, plus or minus, upon that of the wind, the direction of flight being a resultant vector. From this it follows that, regardless of the strength of the wind, a bird flying in any direction feels only the pressure from directly ahead, such pressure being proportional only to its rate of speed. The situation, says Acworth, is precisely like that of a fish moving within a current in the sea, or of an insect being carried along by the apparently still air enclosed within a railway carriage.

Acworth, however, fails to take sufficiently into consideration the effects of inertia, the gustiness or puffiness of most breezes, and the friction of water which produces a drag upon the lower layers of moving atmosphere. Anyone who has seen a flying sea bird suddenly blown backward like a kite when it rises from the lee of a long roller to the wind-whipped crest, will realize that the medium of a free breeze over the ocean is a very different physical environment from air carried forward at the same rate in a closed ship's cabin. If the speed of the wind had no bearing upon the gliding flight of an albatross, the aërial performances of the bird would be the same in light winds, or even in calms, as they are in a gale. In other words, if a gale were the same as a light breeze to a flying albatross, the birds would not tend to settle upon the water during calms, which they ordinarily do.

So far as I know, the phenomenon of towering, equivalent to the spiral, soaring flight of certain birds of prey, has been reported of Wandering Albatrosses only through my observations at South Georgia (Murphy, 1914, 451). November 24, 1912, the day of our arrival at Cumberland Bay, was sunny, clear, and almost perfectly calm. During early morning there was a little motionless fog along the coast of the island, but it soon lifted, revealing the white-robed mountains under the brightest of skies. As my brig was being towed toward its anchorage by one of the whaling steamers, innumerable birds were about, and for the first and only time I saw many Tubinarine species flying high. Among those which circled far up under the blue vault, until they became almost indistinguishable specks against the light cirrus clouds, were hundreds of Wandering Albatrosses. Since some of these approached, or probably surpassed, the limit of human vision, it is likely that they towered to an altitude of at least 1500 meters above the bay and the surrounding land. Two other smaller species of albatrosses, as well as numerous individuals of the Giant Petrel, Cape Pigeon, Antarctic Whale-bird (*Pachyptila desolata*), and *Procellaria aequinoctialis*, were taking part in the same performance. Especially noteworthy is the fact that the greater part of the spiralling was taking place over water, for similar flight on the part of vultures, etc , has been interpreted as the result of vertical currents arising from the heated surface of bare land areas.

The Wandering Albatrosses are infested with Mallophaga. Matthews (1929, 567) observed that on sunny days these insects were prone to come out of the thick plumage and crawl about on the surface of the nesting birds. The two species which I collected from their feathers have been identified as *Lipeurus densus* and *Eurymetopus taurus* (Kellogg, 1914, 85, 87). It is interesting that the former occurs also upon a North Pacific albatross, *Diomedea albatrus*. Waite (1909, 566) reports ticks as large as peas imbedded close to the eyes or beaks of incubating Wandering Albatrosses, and Scouler (1826, 204) found roundworms in the stomach, and an abundance of tapeworms in the intestines.

Concerning predatory enemies of the Wandering Albatrosses we know little or nothing, but Dixon (1933, 127) has published the following with reference to their awareness of large fish:

> On three occasions I had the opportunity of observing the attitude of albatrosses and sharks towards one another. On each of these occasions we had the small boat out when both albatross and sharks were close to us and to one another at the same time. At first it seemed as if the albatross entirely ignored the presence of the shark, but on closer observation it was seen that the albatross was keeping tab on the shark's movements, or, in nautical parlance, "kept his weather eye lifting." (The albatross was at the time swimming, not in flight.) The albatross never allowed the shark (a small blue one, 5 ft. 6 in. or 6 ft. long) to approach closer than about three feet before he lifted and alighted again some yards away. He also never disputed with the shark the right to a morsel of food they both neared about the same time.

TRISTAN WANDERING ALBATROSS

Diomedea exulans dabbenena

Diomedea chionoptera alexanderi Dabbene, 1926, El Hornero, 3, p. 338 (South Atlantic, latitude 38° 30′ S., longitude 56° W., 100 miles off the coast of Argentina).

Diomedea dabbenena Mathews, 1929, Bull. Brit. Orn. Club, 50, p. 11 (new name for *D. c. alexanderi*, preoccupied).

Names: In South America, "Albatros Errante Menor." This subspecies has been included within all of the specific names applied to the preceding form.

Characters: Differs from the typical form in its smaller size, particularly in the much shorter bill. The two races cannot be distinguished with certainty at sea.

The measurements of three specimens from Tristan and Inaccessible Islands, mentioned below, are as follows:

	Wing	Tail	Exposed culmen	Width of maxilla at base	Depth of closed bill at base	Tarsus	Middle toe with claw
♂	612	180	149	39	60	108	167 mm.
♀	607	171	149	38	60	109	155
♀	616	188	144	39	60	109	166

These figures agree well with the dimensions of the type specimen, as recorded by Dr. Dabbene (1926, 339), except that he gives the notably small figure of 136 mm. as the length of the culmen.

In the American Museum are two skins of Wandering Albatrosses collected in the South Atlantic by members of the 'Blossom' party of the Cleveland Museum of Natural History. Both were taken in low latitudes, well to northward of Tristan da Cunha, during the southern-hemisphere winter, and both appear to be of the small south-temperate subspecies. The male, collected in latitude 30° 14′ S., longitude 5° 42′ W., on September 9, 1925, is a very white-plumaged bird, with faint vermiculations from crown to upper tail coverts, and rectrices which are white save for a few terminal blotches and bars. Its length in the flesh was 104 cm., and its wing-spread 283 cm. (9 feet, 3 inches).

The female was collected in latitude 26° 28′ S., longitude 36° 31′ W., on August 6, 1925. Its wing-spread was 282 cm. Other measurements of these two specimens follow:

	Wing	Tail	Exposed culmen	Width of maxilla	Depth of maxilla	Tarsus	Middle toe with claw
♂	570	184	149	38.8	59		169.5 mm.
♀	578	182	139	38.8	53	105.4	151.3

The dimensions of the above five specimens, together with Dabbene's figures, represent about all the precise data available concerning the size of *Diomedea exulans dabbenena*. These are sufficient, however, to indicate the validity of the subspecies, the maximum wing-spread of which seems to be about 50 or 60 cm. less than the maximum expanse of *D. exulans exulans*.

The eggs of *D. exulans dabbenena* are best known from Verrill's description of Gough Island specimens (1895, 439). In appearance they agree in all ways with those of the antarctic race, but are consistently smaller. In a few instances one linear dimension of a Gough Island egg, particularly the axis, may equal the maximum for South Georgia specimens, but this will be more than compensated for in the other dimension, with the result that the Gough Island eggs average less in volume by 20 per cent or thereabouts.

Verrill's figures for 87 eggs are as follows:

Average	127 x 76.9 mm. (365 cc.)
Largest	130.8 x 82.3 (435)
Smallest	120.4 x 72.4 (315)
Longest	144 x 72.4
Shortest	117.3 x 81
Narrowest	122.4 x 71.6

The dimensions of a single egg from Inaccessible Island are given as 134 x 76 mm. (Mathews, 1932, 38).

Distribution: Breeds at Gough Island and the islands of the Tristan da Cunha group, in the South Atlantic; ranges widely, approaching the Atlantic coast of South America and probably entering the Indian Ocean. The birds of this subspecies mingle at sea with those of *Diomedea exulans exulans*. The limits of the pelagic range are unknown.

The presence of a sub-antarctic or practically south-temperate race of the Wandering Albatross, nesting at central South Atlantic islands and differing in its smaller size from the antarctic form, is a good example of Bergmann's principle of size as related to latitude, which is described in the account of the Emperor Penguin. A correspondence between bulk, distribution, and thermal economy has been pointed out among many subspecies in the northern hemisphere and, even though the evolutionary significance of the principle may have been overworked, it is interesting to find it illustrated among sea birds of the outhern oceans.

The observations of Captain Comer as to the relatively small size of Wandering Albatrosses at Gough Island, and the comparison of Gough Island eggs with those from South Georgia, have been considered in the preceding biography. Captain Comer reported also that the Gough Island nests are "from 4 to 10 inches in height and from 12 to 16 inches across, the top being nearly as broad as the bottom" (Verrill, 1895, 437). These dimensions are much less than those of Wandering Albatross nests at South Georgia and other antarctic islands.

Dr. Roberto Dabbene, the distinguished Argentine ornithologist, who has examined hundreds of albatrosses captured along the southerly coasts of South America, was at one time considerably puzzled by adult Wandering Albatrosses of strikingly small size, taken in the same parts of the ocean with large birds like those of the antarctic breeding grounds. In 1926 he described and named two such small specimens captured by the commander of an Argentine cruiser, 160 kilometers east of the coast of Buenos Aires, on March 6, 1914. Dr. Dabbene expressed the opinion, no doubt correct, that his specimens represented a temperate Atlantic race, with headquarters at Gough Island or Tristan da Cunha (Dabbene, 1926, 339; 1927, 563).

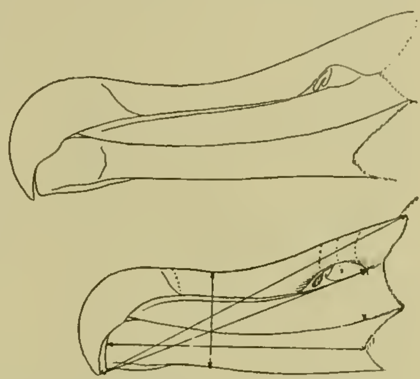


Fig. 55. Bills of South Atlantic Wandering Albatrosses drawn to the same scale. *Upper.* ♂ (?) in the brown immature plumage (Atlantic coast of Patagonia, April, 1888). *Lower.* ♂ in adult plumage (latitude 38° 30′ S., longitude 56° W., March 6, 1914).

The wing, tarsus, and toes of the lower specimen are also shorter than those of the upper. Both sketches by Dr. Dabbene, from skins in the National Museum at Buenos Aires.

At the Tristan group (latitude 37° S.) the Wandering Albatross apparently finds its northernmost nesting grounds. At Tristan itself, Carmichael (1818, 490) encountered breeding birds in December, 1817, reporting, furthermore, that the adults built up no nest-cone but made merely a slight concavity in dry ground. I suspect, rather, that his observations were made too early in the season of southern spring for him to see the nest-making at this island. On level parts of the higher land at Tristan, Earle found young in the nests in May. When he approached, the adult albatrosses clattered their mandibles rapidly, producing a loud noise. On October 11, Earle found the same young in the same nests, from which they had never stirred. Thus they remain, he states, for the greater part of a year before they can fly (Earle, 1832, 327, 365).

Sperling (1872, 75) also refers to the Tristan Albatrosses:

> We visited the island of Tristan d'Acunha in September 1868. I was much interested in this magnificent mountain, the nursery of the wandering Albatros, its snow-covered summit jutting into the clouds, the sides variegated with green slopes and jagged dun-coloured rocks, and its black beach fringed with the restless foam of the Atlantic, whilst vast masses of sea-wrack wave their slimy arms in the swell round the coast. The Albatroses, which nest on the highest ledges of the cliffs, present the appearance of mere white specks, so great is the altitude.
>
> The inhabitants, who had not much ornithological information to impart, stated most posi-

tively that the Albatroses remained at the island throughout the year, laying their eggs in January, and the young flying in November, and that consequently there is almost always on the island a supply of young birds, which are consumed in great quantities for food, and appear to be considered rather a delicacy.

When the 'Challenger' visited Tristan during the month of October, young Wandering Albatrosses were on nests within the crater of the terminal cone of the volcano, around the shores of a small lake more than 2000 meters above the sea (Moseley, 1879, 490).

Probably the "delicacy" of the young albatrosses as food led to the eventual extinction of the species as a breeding bird of Tristan itself, for since the opening of the present century several observers have found that it no longer occurs at the main island, and that very few still return to the neighboring island of Inaccessible, whither the men of Tristan make boat journeys every year for penguin and albatross eggs and other supplies (Barrow, 1910, 275; Wilkins, 1923, 495; Mathews, 1932, 38). The 'Challenger' naturalists learned that the Wandering Albatrosses reached Inaccessible annually in early December, and made their nests on the grassy spaces of the plateau (Thomson, 1878, 162).

At Gough Island, which lies some three degrees of latitude south of Tristan, and which has never been permanently inhabited by man, the Wandering Albatrosses still remain in possession of their nesting grounds at the western or windward end of the island (Wilkins, 1923, 495). Here they begin to lay about Christmas time. Captain Comer took the first egg on December 26, and by January 3 he noted that there were "plenty" of albatross eggs. The reproductive cycle evidently lags as one proceeds northward through the breeding range of the species as a whole, for at South Georgia Comer found the first eggs of the albatross on December 13 (Verrill, 1895, 437). At Inaccessible and Tristan the eggs do not appear until about the middle of January, as noted in two or three of the reports already cited. I suspect that Mathews's record of an egg taken at Inaccessible Island on November 1, 1924 (1932, 38) may be in error as to the date.

Comer's notes on the Gough Island Wandering Albatross state further:

The old nests are usually taken and built higher, the bird sitting on the nest and reaching out and picking up the moss and mud and short grass around her. . . . They do not build near other birds but lay scattering and generally on knolls, and usually on high land where there is a good chance to run against the wind and so rise from the ground. . . . When robbed they will remain on their nest for a few days and then leave. I have taken a second egg from the same nest, but my belief is that the first bird had left the nest and another taken it. The albatross skeleton I send you was a female and had just laid when I killed her; there were no other small eggs in her, such as I have always found in the other birds that lay again.

The young albatrosses have to be at least ten months old before they can fly, and I think it safe to say that not more than five out of a hundred live to leave their nests. They are killed by sea-hens and nellies [skuas and giant fulmars] (Verrill, 1895, 437).

Among hundreds of Wandering Albatrosses examined in many museums, I have seen but three or four actually taken on the breeding grounds of the Tristan group or Gough Island. Three of these are in the Rothschild Collection, of which one breeding but not fully mature male, and one older female, were collected at Inaccessible Island, and another female at Tristan da Cunha. All three specimens were obtained during a visit of H. M. S. 'Odin,' at the end of November, 1904. Numbers of birds collected on the ocean in the general vicinity of these islands present many uncertainties, for a good proportion of them are indistinguishable from antarctic specimens.

In fact, we yet know next to nothing of the pelagic ranges of the two subspecies. Doubtless they are more or less zonal, like the ranges of the two Sooty Albatrosses, with an intermediate belt of ocean in which both forms occur. Perhaps the Tristan birds regularly pass the Cape of Good Hope and cross the Indian Ocean to the Australian region, as *Diomedea chlororhynchos* seems to do. Solution of such questions must await the study of an adequate series of Wandering Albatrosses from the Tristan breeding grounds. When we learn all the characters of the subspecies, it may become much simpler to identify all Wandering Albatrosses collected at random on the wide ocean.

As related in the New Bedford 'Mercury' of February 10, 1832, a Wandering Albatross taken by the American ship 'John,' on May 5, 1831, in latitude 38° 10′ S., longitude 54° 3′ W., bore on its neck a circular medallion of light pine, with a carved inscription, placed there by the crew of the French whaler 'Mariland' of Havre, on February 10, 1830, in latitude 31° S., longitude 0° 12′ west of Paris. In other words, this bird had practically crossed the South Atlantic, from Africa to Argentina.

ROYAL ALBATROSS

Diomedea epomophora

Diomedaea epomophora Lesson, 1825, Ann. Sci. Nat. Paris, 6, p. 95 (Campbell Island).

Names: In South America, "Albatros Real." Synonyms of the specific name are *regia* and *sanfordi*, besides which most of the early references were published under the name *exulans* because of failure to distinguish this species from the Wandering Albatross.

Characters: A "white" albatross in both sexes and at all ages, juvenal plumages included. The wings, from elbow-joint to tip, are darker, however, than in adult males of *Diomedea exulans*. Transverse vermiculations, when present, are coarser than in *exulans* and are confined to the mantle and parapteral feathers. The scapulars, wing coverts, lower flanks, and tail quills may show a few grayish or brownish mottlings, blotches, or shaft-marks, which are more conspicuous in young than in old birds. Wing-spread slightly less than in *exulans*, the maximum being apparently about 3 meters (under 10 feet); maximum body-length about 115 cm. Sexes alike except that females average slightly smaller than males. Head, neck, back, tail, entire under surface, and flanks, white, with a few irregular dark markings and transverse bars as noted above; scapulars grayish, narrowly edged with white; wings blackish brown, blending into clove-brown toward the anterior border; lesser wing coverts mottled with white, many of the feathers having white borders as well as white bases; innermost median and greater coverts white with gray frecklings; primaries blackish, basally white especially on the inner webs, the shafts of the outer quills cream-colored except at their tips; secondaries mostly blackish brown, only the proximal quills being mainly white on their inner webs; lining of wing white. Iris brown; eyelid black; bill white, with a roseate tinge in life, a black line along the cutting edge of the maxilla, and the unguis horn-color; legs and feet fleshy white, with pinkish and bluish tints on the webs.

The certain means of distinguishing specimens of this species from those of *Diomedea exulans* lie in bill characters even more than in plumage. The naricorn of *epomophora* is rotund and bulging, the nasal tubes much more prominent than in *exulans;* the nostrils are circular in outline, and directed forward instead of obliquely upward as in *exulans;* the culminicorn is obtusely pointed posteriorly.

Measurements and weights of Royal Albatrosses show a wide range, which is perhaps correlated with zonal and subspecific distinctions. The differences are so marked that weights and dimensions are in the main reserved for discussion in the following text. However, the average measurements of six specimens from the South Atlantic and waters near Tierra del Fuego are as follows:

4 males: wing, 673; exposed culmen, 178; tarsus, 123; middle toe with claw, 167 mm.

2 females: wing, 654; tail, 180.5; exposed culmen, 174.5; tarsus, 123; middle toe with claw, 162 mm.

Oliver (1930, 155) states that Royal Albatross eggs from Campbell Island are broadly elliptic, white, with a darker zone at the larger end, and that two measure 127 x 76, and 125 x 81 mm. Godman (1910, 320) reports that among four from the Auckland Islands, only one had rufous markings at the larger end, and that the axes of the specimens measured 121.9–127.2, the diameters 78.7–81.3 mm.

Distribution: More northerly than that of *Diomedea exulans exulans*, since *epomophora* nests at no glacial antarctic island. Breeds, in the New Zealand area, at Campbell Island (latitude 52° 30′ S.), one or more of the Auckland Islands, Round and Forty-Fours Islets of the Chatham group. In the American region, the species probably breeds in the interior of Tierra del Fuego. At sea, *Diomedea epomophora* is known principally from regions at no great distance from the supposed breeding grounds; truly pelagic records (*i. e.* those based upon examples observed far from land) are rare and untrustworthy. Thus in the New Zealand region the species is known from Campbell Island eastward and northward to the Chathams and the Kermadecs. It is common off the coasts of South Island, New Zealand. In American waters it is common in the southern Atlantic and Pacific Oceans, close to the continental shores, and also in the channels near Cape Horn.

There is probably no large sea bird about which less is known than the Royal Albatross. The reason for this has been made clear in the account of the typical race of the Wandering Albatross. For two centuries or longer, an albatross has been regarded as an albatross and, although *epomophora* was described by Lesson as long ago as 1825, it received no ornithological acceptance until Buller renamed it *Diomedea regia* in 1891. Since the latter date, indeed, the existence of a second species of great albatross, distinct from *D. exulans*, has been repeatedly questioned and even denied. The facts are now perfectly clear, but as to how many of the multitudinous observations recorded in the literature on the Wandering Albatross actually refer to the Royal Albatross—and *vice versa*—we shall never have any certain means of determining.

The Royal Albatross is an abundant species along the southern coasts of South America. In view of the wealth of published records, it is curious that Lowe and Kinnear (1930, 163) should write as recently as 1930 that "*D. epomophora* is not found outside the Australian Seas." The history of the species in South American waters is as follows:

In 1901, Berg (1901, 284) reported an example taken at Mar del Plata, Province of Buenos Aires, on March 16, which he identified doubtfully with the *Diomedea regia* of Buller. For many years the record, though verified, was regarded as casual or accidental (Dabbene, 1927, 563). On October 22, 1913, Mr. Beck shot a female 65 kilometers off Corral, Chile. This specimen was mistakenly described as a new species of albatross (*D. sanfordi*) by Murphy, who pointed out the features in bill structure which distinguish *epomophora* from *exulans* (Murphy, 1917, 861; Rothschild, 1918, 39; Stone, 1918, 249; Mathews, 1919, 428). During the subsequent course of the Brewster-Sanford

Expedition, Beck took three additional specimens, *viz.* two males 50 to 60 kilometers east of the Strait of Magellan and the Río Gallegos, Argentina, on May 26, 1915, and a second female in latitude 51° S., longitude 68° W., south of Puerto Santa Cruz, on September 10, 1915. All of these specimens have been compared with an excellent series since obtained for the American Museum by members of the Whitney South Sea Expedition in New Zealand waters and at the Chatham Islands.

To continue with the South American records, Dr. Roberto Dabbene (1926, 340) has reported upon 23 specimens of *Diomedea epomophora* taken off the Atlantic coast of Argentina, and one from the Cape Horn region. Twenty of the birds were captured from the fishing vessel 'Undine' in latitudes 35°–36° S., longitudes 53°–54° W., between the months of May and September. A handsome pair of these specimens is now in the American Museum Collection, the remainder in the National Museum at Buenos Aires.

Whence come the Royal Albatrosses which visit the coasts of Chile and of Argentina and Uruguay? The orthodox answer would be that they cross the Pacific to South America, round Cape Horn from the westward, and enter the South Atlantic. But there are several objections to such a theory, and much likelihood of the existence of a South American breeding ground as suggested in two letters I have received from Dr. Dabbene, the substance of which is as follows:

Mr. P. W. Reynolds, a Member of the British Ornithologists' Club, who resides at Harberton Harbor, Beagle Channel, Tierra del Fuego, has discovered large white albatrosses nesting on the slopes of the mountains near Lake Cami, in the interior of Tierra del Fuego. To reach this locality from the Strait of Magellan the birds pass up Admiralty Sound. Mr. Reynolds does not know to what species these great albatrosses belong, but Dr. Dabbene believes that they are *Diomedea epomophora*.

Dr. Dabbene writes, furthermore: All of the large albatrosses captured during the austral-winter months by the Compañia Argentina de Pesca, at points some two hundred miles off the coast of the Province of Buenos Aires, are Royal Albatrosses. About 50 specimens have thus far been received at the National Museum. Now, it is hardly to be credited that birds captured in such numbers in the South Atlantic come all the way from New Zealand breeding grounds. Rather, they should originate in islands of southern South America, and the discovery made by Mr. Reynolds in Tierra del Fuego doubtless supplies the clue.

Crawshay (1907, 145) refers to "a Wandering Albatross, found dead inland, roughly stuffed but in good condition, in Mr. A. A. Cameron's house at Useless Bay settlement," Tierra del Fuego. If this specimen is by any chance still in existence it would be exceedingly interesting to determine whether it is a Royal rather than a Wandering Albatross.

From such information we may be sure that innumerable reports of Wandering Albatrosses in waters around the southerly parts of South America refer in reality to Royal Albatrosses.

During the period of the Brewster-Sanford Expedition, Mr. Beck did not distinguish between the two species of great albatrosses. It is therefore impossible to determine from his notebook to which bird his sight records apply, except when he mentions that a specimen was collected. Even the latter entry is not necessarily final, because off Corral, in October, he shot a Wandering Albatross with one barrel of his gun and a Royal Albatross with the other. Nevertheless, it may be worth while to cite his complete record of great albatrosses seen in the field, eliminating only such as are judged from accompanying specimens to have been Wandering Albatrosses. Most of the following entries undoubtedly represent Royal Albatrosses, since we know that this species is much the more common of the two in the inland waterways of southern Chile and Argentina. Indeed, it is somewhat doubtful whether the Wandering Albatross ever leaves the open sea in this region.

1914

Ancúd, April 7, 15 kms. offshore.
Gulf of Peñas, July 4, common 30 kms. out from Cape Tres Montes.
Magallanes, July 4, a few in the Strait.
Mar del Plata, October 9, "hundreds."
Cape Horn, December 29, common.

1915

The wide channel off Brecknock Island, January 21, "plenty."
Magallanes, February 5, one.
Ushuaia, April 30, three or four.
Good Success Bay, Strait of Le Maire, May 6, 9, and 10, common.
Off mouth of Río Gallegos, May 24, a number.
Off Cape Vírjenes, May 25, and 27, several.
Good Success Bay, August 4, one.
25 to 30 kms. north of Staten Island, August 6, two.
North of Cape San Vicente, August 7, one.
80 kms. off the Río Gallegos, September 10 to 12, several.
Latitude 48° 27′ S., longitude 65° 36′ W., September 15, one.
65 kms. northeast of Staten Island, September 27, several.
125 kms. north of Staten Island, September 28, two.

1916

1000 kms. from Port Stanley, on the steamship route toward Montevideo, February 3, four.

With further reference to the origin and range of South American Royal Albatrosses, a study of the published information, and of the more than fifty examples of the species which I have examined in museums of the United States and Europe, brings out one very striking fact. This is that practically all the specimens were killed relatively close to land contiguous with a known or probable breeding ground. Thus all but one of the South American birds were captured a short distance off the coasts of Chile, Argentina, or Uruguay. The exception is a specimen in the United States National Museum taken 800 kilometers off the coast of Chile. (Possibly, however, our Corral specimen may have reached South America by crossing the Pacific, as suggested below.) The labels of all eastern-hemisphere birds testify that they were collected either at their breeding grounds on islands south of New Zealand, at the Chathams, or in adjacent waters. I have yet to see a Royal Albatross from the vast, remote reaches of the southern Atlantic, Pacific, and Indian Oceans, whereas the aggregate numbers of Wandering Albatross skins in the museums of the world cover almost the whole checkerboard of these seas as marked off by the meridians and parallels.

A few sight observations, to be sure, tell of Royal Albatrosses in a truly pelagic environment. Thus Buller (1905, 138) reports one which, in his opinion, flew at least 3000 miles during the four days in which it followed a steamer along a course of 970 miles. But I frankly doubt the ability of any observer to distinguish between such a bird in the air and an old white male of the Wandering Albatross. The latter, as a matter of fact, might be the "whiter" of the two birds because it would have fewer dark feathers on the proximal parts of the wings and in the scapular region. The attempt to convert such notebook entries as "The purest white Albatross I have seen" into authentic records of the Royal Albatross, as Lowe and Kinnear (1930, 166) have done, shows a failure to appreciate the features which actually distinguish *epomophora* from *exulans*.

From data now at hand, we are justified in regarding the Royal Albatross as mainly a sedentary species, with widely separated breeding grounds centering, respectively, in the New Zealand region and at the southern tip of South America, from the neighborhoods of which it does not stray far. By contrast, we can appreciate how aptly Linnaeus named the other species *exulans*, the wanderer. Furthermore, it seems probable that the relatively restricted range of the Royal Albatross is correlated with certain structural characteristics, such as a lesser wing-spread than that of the Antarctic Wandering Albatross.

As pointed out by Mathews (1912, 260), Buller appears to have written a somewhat composite description when naming the Royal Albatross *Diomedea regia*, confusing the adult with the whitest phase of *D. exulans*. He correctly diagnosed, however, the youthful plumage and nestling down, both of which are peculiar to the species. Uncertainty about the appearance of adult Royal Albatrosses seems to have continued up to the present, for the descriptions and portraits are mostly faulty in some respect. The colored plate in Godman's 'Monograph of the Petrels,' for instance, shows almost nothing in the way of exclusive characteristics of the species.

In the Royal Albatross a distinctive juvenal plumage is practically suppressed. The nestling, which is covered with white down, shortest on the head so that the bird looks as though it had had a hair-cut (Archey, 1923, 118), moults directly from the down into the white plumage of the adult type. Among the features in which the juvenal plumage differs to a slight extent from that of mature birds are the following: the mid-wing is at first entirely brown, without partly white coverts; some of the white feathers of the mantle have heavy brown shaft-streaks, broadening to drop-shaped spots at the tips; the shafts of the primaries are whitish or cream-colored only toward their bases; asymmetrically placed blotches are more numerous in various parts of the plumage.

As regards transverse wavy bars, or vermiculations, the condition seems to be directly the opposite of that obtaining in the Wandering Albatross. Young Royal Albatrosses do not show these. Old birds sometimes have them on the back and scapulars, but the flanks and ventral surface are apparently always immaculate. The exposed parts of the primary quills (*i. e.* all except the bases) are entirely dark, without the mottlings and white wedges which mark the inner webs of the quills in the oldest and whitest examples of *exulans*. The elbow-patch is less conspicuous in *epomophora* than in *exulans*. The tail of *epomophora* is white at all ages, save for a few irregular spots.

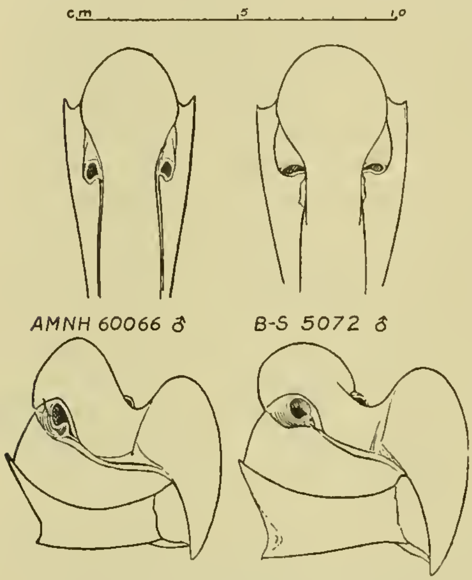


Fig. 56. Distinguishing characters in the narial tubes of the two species of great albatrosses.

Two left drawings: *Diomedea exulans* (near the Cape of Good Hope, November, 1892). Two right drawings: *Diomedea epomophora* (off Río Gallegos, Argentina, May 26, 1915).

The bill of the nestling Royal Albatross, even at an early age, shows the distinguishing characters of the species quite as well as that of an adult. The round nostrils stick out like torpedo-tubes, with the lumen running straight backward so that it may be followed with the eye for a considerable distance when viewed from in front. In *exulans*, on the other hand, the course of the tunnel in the somewhat pinched nostril is sharply toward the mid-line, so that only the lateral wall is visible from the front. Furthermore, the proximal end of the culmen in *epomophora* is of a different shape, as shown in the figure, and its bill is widest at the base instead of at a somewhat distal point. Iredale (1927, 282) and others have pointed out that the hook of the beak is weaker in this species than in the Wandering Albatross, but I do not find this distinction great enough to be dependable.

The female Royal Albatross is somewhat smaller than the male and usually has more dark feathers in the wing coverts. Waite (1909, 572) reports that the size difference is conspicuous in life, and that, in particular, the necks of the females look more slender.

In the main, the two great albatrosses have mutually exclusive nesting grounds. *Diomedea epomophora* breeds at no glacial antarctic island, finding its southernmost station at Campbell where, it is said, *exulans* does not occur. The Aucklands are occupied chiefly by *exulans*, but at the eastern end of Adams Island, of this group, a small colony of *epomophora* is established. Formerly the Royal Albatrosses bred also at Enderby Island, at the opposite or northern end of the Aucklands. At different islets of the Chathams both species have colonies, *epomophora* at Forty-Fours and *exulans* at the Sisters (Oliver, 1930, 150).

The Royal Albatross is said to have the earlier nesting season wherever the two species are found close together. At Campbell Island eggs are common about the first of December, whereas in that part of the world the egg-laying of the Wandering Albatross is alleged to be delayed until late January or early February (Buller, 1905, 138). Waite found incubation of Royal Albatross eggs far advanced in February, and Archey (1923, 118), who says that the nests were 50 meters or more apart, found newly hatched young on March 3. As we know from the life history of the Wandering Albatross, eggs may in some instances be laid throughout a rather long season at any one locality. Therefore observations on the Royal Albatross made by visitors who remained only briefly at the nesting island should be verified before they are accepted as final. Oliver's notes bear further upon this subject:

> The breeding places of the Royal Albatrosses are the exposed upper slopes of Adams Island and Campbell Island among the tussock grass formation that exists there. On Campbell Island the nests are scattered over a wide area. Their numbers have been much diminished in recent years owing to the island being used to run sheep. The nests are large volcano-shaped structures made of peaty earth and grass and with the hollow at the top lined with grass. Evidently the bird continually adds to the nest by raking up with its beak the surface soil within reach, as there is always a bare circle round the nest. Surrounding this circle is a dark green ring of vegetation. The nests are about three feet in diameter at the base and about half this distance across the rim at the top. The height is about a foot or more. The Royal Albatross begins to lay late in November and fresh eggs are generally plentiful early in December. Evidently the laying season extends over a period of about a month or else some seasons are later than others, for Reischek on January 31st, 1888, noted that eggs were nearly hatched, while Archey records that in 1923 the first chicks were hatched on March 3rd. The parents share the work of incubation and feeding the young which must be closely guarded until it is at least four months old, for if either egg or nestling were exposed for an instant it would be destroyed by skuas. After a while the young is deserted by the parents and it must then undergo a period of fasting until it is able to fly. Usually it remains on the nest until the parents return the following year to lay (Oliver, 1930, 156).

From the last sentence it appears that this species has the same custom as the Wandering Albatross and other Procellariiformes with regard to abandonment of the well-grown nestling young. Buller (1905, 138) quotes Harris to the effect that by June (the December of the southern hemisphere) the adults leave the young and go to sea, not to come ashore again until the following October. After the old birds have returned, and are sitting upon eggs, the long-forsaken, long-forgotten, and long-fasting chicks, which had been ousted from their nests, sometimes approach their indifferent parents and nibble at their heads as though pleading for food.

There is a well-known correlation between size and rate of growth which is illustrated remarkably among both the penguins and the albatrosses. In each family the two largest species have a greatly prolonged period of helpless infancy, as compared with the various smaller species among their respective relatives. That this has worked out in the case of the great albatrosses, hand in hand with a contemporaneous period of exceptionally prolonged starvation, is a singular phenomenon.

Archey found fish bones and the beaks and crystalline lenses of cuttlefish in the stomachs of young nestling Royal Albatrosses.

Oliver states that in the New Zealand area the Royal Albatross migrates farther northward than the Wandering Albatross and that the limit of its northward range corresponds with an air temperature of about 21° C. (70° F.).

> On land this bird walks in exactly the same manner as its relative, the head being stretched forward in a horizontal position and the wings partly folded and held well up. On the day that I landed in North East Inlet, Campbell Island, it was . . . blowing a furious gale. With two companions I climbed to the top of the Mount Lyall ridge and in the open valley on the leeward side there was a certain amount of shelter. Here scattered over the landscape were seen the white forms of the Royal Albatross. Near the top of the ridge I watched at close quarters a bird rising to fly. First it deliberately walked up the slope towards the ridge, nearing which it started to run, then as it felt the force of the gale, opened its wings and at once rose against the wind and sailed off. No better example could be seen of the method of utilising the power of the wind for the gliding flight of a bird. It would be impossible for the bird to take flight from a flat surface or in a calm. To rise it must have the lifting power of the wind and in this instance it actually sailed off in the teeth of the gale, perhaps not so remarkable a feat in view of the fact that, at the point it departed, namely, the crest of the ridge, there would be a strong upward current of air (Oliver, 1930, 155).

Waite (1909, 572) also has something to say of the Royal Albatross's difficulties with its launchings and landings. When he forced one to walk over a 15-meter precipice *with the wind*, it was unable to take flight and fell with a thud to the bottom. He noted also that whenever a bird chanced to get into the lee of a ridge of land while rising, it was likely to tumble heavily.

My tables of measurements of Royal Albatrosses present certain puzzles, partly to be accounted for by the fact that most specimens from Campbell Island and from the South Atlantic Ocean seem to be notably larger than many others (comparing only like sexes) taken in the northerly parts of the New Zealand area. In particular, the Chatham Island breeding birds are relatively so small that I suspect them to be of a different geographic race from the typical or Campbell Island form. For example, the culmen of a Campbell Island nestling still partly covered with down, collected on November 5, 1899, is 186 millimeters in length. The longest culmen among 17 breeding adults from Round and Forty-Fours Islets, Chatham group, is 170 millimeters, and the average for five adult males is only 162.6. The differences between the two groups of birds and their respective nesting localities are similar to those concerned with the two subspecies of Wandering Albatrosses, *D. exulans exulans* and *D. exulans dabbenena*, in the South Atlantic. Incidentally, I suspect that a small race of the Wandering Albatross also nests somewhere within the New Zealand region. It might be easy to find existing names for such small subspecies of both the Royal and the Wandering Albatross, but the tagging on of names from the slap-dash taxonomic amusements of recent years has no relation to the painstaking solution of an interesting problem in geographic variation.

It will, of course, be impracticable to work out the systematic place of the South American Royal Albatross until the facts about the Fuegian nesting grounds have been investigated.

My figure for the maximum total expanse of the wings in this species, namely 3 meters, may be unduly low. It is based upon actual notations on the field labels of male specimens from New Zealand seas and the South Atlantic. Possibly, however, the largest birds from Campbell Island or Tierra del Fuego have a greater wing-spread. In every other dimension they equal the maxima for *D. exulans exulans*, and in length of bill they are slightly larger. It is of interest that Solander recorded the expanse of what appears to have been a very large Royal Albatross as follows: "Spatium inter alas expansas 10 ped 7 unc." (Mathews, 1912, 259). It is not unlikely, however, that Solander employed the Swedish foot-unit, in which case the expanse would be barely over 10 feet of the English system, or 305 centimeters. In any event, it seems clear that the wing-spread of the Royal Albatross, perhaps even more than that of the Wandering Albatross, has been vastly exaggerated in many published accounts.

Since the "wing-length," that is the length of the hand and its quills, averages only slightly less in *epomophora* than in *exulans*, it follows that if the expanse of the former is notably shorter, the difference actually lies in the length of the mid-wing and humerus. This seems to be suggested by such unsatisfactory measurements as I have been able to make from skins. What we need, however, is a comparison based upon measurements in the flesh, and measurements of the skeletal elements, respectively, of large males of *Diomedea epomophora* and *D. exulans exulans*.

Weights of adult nesting Royal Albatrosses from the Chatham Island colony, as recorded on Beck's labels, ranged from 6350 to 6804 grams (14 to 15 pounds). A chick in the British Museum, taken from a Campbell Island nest on October 20, 1899, weighed 8711 grams, a further suggestion of racial distinction between the birds of these two localities. Solander recorded the weight of the large adult taken during the voyage of Captain Cook as "Pondus 28 libr." (Mathews, 1912, 250). If Solander used the Swedish pound, the weight should read 26¼ pounds avoirdupois, or 11,907 grams.

In the following table, the averages of four South Atlantic males, in the second line of figures, are taken from Dabbene (1926, 341); the other 36 specimens I myself have measured. The greatest width of the maxilla among four South Atlantic birds ranges between 42.5 and 46 millimeters, the depth of the closed bill at base between 64 and 71 millimeters.

		Wing	Tail	Exposed culmen	Tarsus	Middle toe with claw
South Atlantic and	2♂	(650)	198–202 (200)	172–184 (178)	123–130 (126.5)	(167) mm.
Fuegian region..	4♂	(673)		(178)	(123)	(167)
Campbell Island, and waters about New Zealand....	6♂	638–671 (655)	186–204 (195)	172–186 (177.3)	120–129 (124.7)	162–179 (170.8)
Chatham Islands .	5♂	590–630 (615)	186–195 (191)	156–168 (162.6)	112–120 (117.4)	151–162 (157)
South Atlantic and Fuegian region..	2♀	646–662 (654)	179–182 (180.5)	169–180 (174.5)	117–129 (123)	160–164 (162)
Campbell Island, and waters about New Zealand...	8♀	600–658 (624)	182–200 (190)	156–177 (168.5)	109–126 (118.4)	150–167 (157)
Chatham Islands .	12♀	593–639 (616)	175–197 (189)	151–170 (160.8)	111–120 (113.6)	146–158 (150.5)
Off Corral, Chile..	1♀	(627)	(182)	(151)	(114)	(153)

The last specimen in the table is the bird heretofore referred to as taken 65 kilometers west of Corral, by Beck, and is the type of "*Diomedea sanfordi.*" Its small size, especially of bill and tarsus, has always puzzled Dr. Dabbene and me, as well as other workers (Mathews and Iredale, 1921, 57), since the measurements are so much lower than those of females collected in the South Atlantic. It will be noted, however, that the dimensions of this specimen entirely agree with those of 12 breeding females from the Chatham Islands. In every other respect it likewise resembled the Chatham birds which, in turn, are smaller than the Campbell Island specimens. Perhaps the female Royal Albatross shot off Corral was a stray bird from the Chatham Island breeding grounds, which are in about the same latitude, 6143 nautical miles (11,383 kilometers) distant across the Pacific. We have already seen how mollymauks from the New Zealand area (*Diomedea bulleri*, *D. cauta salvini*) turn up in the Humboldt Current, along the coast of Peru and Chile. The same is also true of some of the New Zealand petrels, such as *Puffinus bulleri* and *P. carneipes*. If a like interpretation of the Corral Royal Albatross proves acceptable, the Chatham Island subspecies will be known as *Diomedea epomophora sanfordi*. This race would then be listed as an accidental or casual member of the South American avifauna, while the Fuegian race, whatever name it may ultimately bear, would be the resident form.

THE PETRELS

FAMILY PROCELLARIIDAE

THE FULMARS, CAPE PIGEONS, WHALE-BIRDS, GADFLY PETRELS, SHEARWATERS, ETC.

SUBFAMILY PUFFININAE

This subfamily includes all the petrels except the storm petrels (Hydrobatinae) and the diving petrels (Pelecanoididae). The general characteristics of the group have been sufficiently discussed for the purposes of this book in the preceding account of the order Procellariiformes.

The following arrangement of species differs somewhat from that of Peters (1931, 46). While no linear classification can be wholly satisfactory, it seems to me that both *Priocella* and *Pagodroma* belong in the fulmarine group, while *Halobaena* resembles *Pterodroma* rather more than it does the whale-birds (*Pachyptila*).

GIANT FULMAR

Macronectes giganteus

Procellaria gigantea Gmelin, 1789, Syst. Nat. 1, part 2, p. 563 (Staten Island).

Names: Giant Petrel, Nellie, Glutton, Stinker, Stink-pot. South American Spanish names are "Pajarón," "Pájaro Carnero," and "Quebrante Huesos." A synonym of the specific name is *ossifraga* besides which many subspecies have been proposed.

Characters: A large, prevailingly dark-colored fulmarine petrel, with the head and throat in adult stages usually somewhat lighter than the body plumage, and with a large and heavy, deeply sculptured bill of ivory-like texture. A white phase differs from any albatross in being entirely white save for a few asymmetrical fleckings. In dark birds, the under surface of the wing is likewise dark, in which respect it differs from the wing-lining of the dark juvenal Wandering Albatross.

Adults (sexes alike): Plumage subject to wide variation, which is discussed below. An average type of adult, apparently found at breeding localities throughout the world, is grayish brown, somewhat darker on the dorsal surface than ventrally; the quills of wing and tail are usually somewhat slaty, and the shafts, particularly those of the primaries, more or less ivory-white except distally; the head and neck incline toward a lighter gray, which may become nearly white, but which always shows a darker mottling caused by brownish or sooty tips and shaft-marks.

Much confusion has been caused by failure to discriminate between the color differences due to age, and the size differences due to sex. Thus, with the exception of the all-white birds, which are white from the egg, all Giant Fulmars pass through the following stages: (1) juvenal plumage, shiny black, including the head and neck; (2) an all-brown or rusty, nondescript stage, due to wear, fading, and gradual replacement of the juvenal plumage; (3) a slightly variable grayish brown mature plumage, with the lighter (sometimes whitish) head and neck. It is possible, but by no means certain, that the head and neck become whiter with increasing age. Relatively slight individual variation, coupled with the considerably greater effect of wear and fading, are sufficient to account for the range among the "brownish" and "grayish" adults.

There is a correlation of skin colors to the extent that blackish young birds usually have dark legs, feet, and claws, and always brown eyes. Among lighter adults, the feet are often French gray, darker at the edges of the webs, with bluish white claws. The iris is usually gray, whitish, bluish gray, or hazel, though sometimes brown. Every one of a considerable number of white Giant Fulmars I have examined in life has had brown irides, like those of youthful birds, so it appears that the significance of eye color in relation to age, phase, etc., is not yet fully understood. The bills of Giant Fulmars range in hue from yellowish horn-color to brownish or greenish horn-color. Sometimes they show an obvious pinkish cast in life.

Males are uniformly larger than females, a fact which has been made the erroneous basis for the description of a number of supposed geographic races. In general, the maximum size of the bill and feet among females is less than the minimum among males.

12 males from South Georgia, the South Shetlands, coasts of Tierra del Fuego, the Falkland Islands, the South Atlantic, and the Pacific coast of South America: wing, 512–544 (528); tail, 160–192.3 (178); exposed culmen, 94.3–105 (99); depth of closed bill at anterior end of nasal tube, 35–40 (38); tarsus, 89–99.6 (94); middle toe with claw, 132.5–142.6 (137.4) mm.

19 females from the same localities: wing, 490–520 (504); tail, 160–176.4 (168.4); exposed culmen, 83.5–91.5 (87); depth of closed bill, 31.7–34.6 (33); tarsus, 79–90 (85.4); middle toe with claw, 115.5–126.1 (121) mm.

The length in the flesh of a male from South Georgia was 93 cm.; that of a female from Deception Island, 87 cm. Valette (1906, 61) gives 94 and 80 cm. as corresponding average lengths among Giant Fulmars from the South Orkneys. Racovitza (1900, 194) states that the wing-spread of males generally exceeds 2 meters, while that of females is less than that figure. Specific wing-spreads recorded for males from various localities are 207, 209, 211, 213, and 244 cm.; for females 180 and 183 cm.

Weights which, unfortunately, are not correlated with the respective sexes, include recorded figures of 2630, 3288, 3969, and 4535 grams.

Valette found the body temperature at the South Orkneys to be 40.3° C.

The natal down is usually creamy white, but sometimes dark gray among young from the same locality (see discussion below). The mesoptyle down is gray and curly, except in the case of birds destined to have white plumage; among these the down also is white.

The egg of this species is white, thin-shelled, and of highly variable form. I have seen both rounded-ovate and elongate-ovate examples. Their musky odor appears to be confined to the shell, and to be derived from the incubating bird. The shell is usually finely pitted and papillated, sometimes being extremely rough. Four collected by Beck at Sea Lion Island, Falklands, measure 94.5 x 64.5, 100.5 x 66, 103.7 x 65.5, and 108.1 x 62.6 mm. Many recorded Falkland measurements fall within the same range. Two from South Georgia measure 106 x 65 and 100 x 66 mm. The average of 80 from the South Orkneys was 103.8 x 65.7 mm. (Clarke, 1913, 237).

Distribution: Of pan-antarctic breeding range, nesting at many islands of the Antarctic Archipelago southward to latitude 65° S. or beyond, and also on several parts of the coast of the antarctic continent such as Coats Land, Kaiser Wilhelm II Land, and Cape Adare; likewise at the South Shetlands, South Orkneys, Falklands, South Georgia, Gough, Bouvet, the Prince Edward and Kerguelen, Heard, Macquarie, Auckland, Campbell, Antipodes, and other pan-antarctic islands. Its breeding grounds nowhere extend northward to the Sub-Tropical Convergence unless, as reported by Oliver (1930, 107) upon the authority of Travers, the species formerly nested at the Chatham Islands. Breeding records for Tristan da Cunha seem to be erroneous. The flight-range extends northward across the Sub-Tropical Zone (roughly to latitude 30° S.), and much nearer the equator in cool-current regions such as those of the western coasts of the southern continents; in the Humboldt Current the bird migrates regularly to northern Peru.

The Giant Fulmar, more generally known by a variety of opprobrious or derisive names, is scarcely more popular as a bird than a shark is as a fish. Its appearance and habits are alike unprepossessing, and in the tender yet prejudiced breasts of seafaring men it arouses no trace of the kindly sentiments of which albatrosses and Mother Carey's chickens are often the beneficiaries. A bird of prey, it is, nevertheless, ungainly and uncouth, lacking the beauty and dash which win admiration for even the most bloodthirsty of falcons and eagles. More appropriately, of course, it should be compared with a vulture rather than a hawk, and I have heard a Peruvian fisherman call it a "gallinazo marino" or sea-vulture. To English-speaking sailors, which means nine out of ten sailors regardless of nationality, it is most commonly known as the "Stinker," or an equivalent thereof.

The Giant Fulmar is a sea bird of protean appearances, and yet a slight understanding of the plumage sequences, and of the constant sexual dimorphism as regards size, will serve to clear up much of the current confusion. Lowe and Kinnear (1930, 151) are quite incorrect in stating that "there is no difference, certainly none which could be noted at sea, between the juvenile and fully adult plumage of *Macronectes*." On the contrary, the first plumage following the down (except among the relatively rare white birds) is of a type never found at a later stage. It is practically uniform shiny black, the head and neck being as dark as the remainder of the body. With wear and fading this plumage becomes somewhat threadbare and rusty, but it is still distinguishable from that of mature birds, even at long range, up to the time of the moult that converts a yearling into an adult. This fact has been observed before, notably by so excellent an observer as Captain George Comer (Verrill, 1895, 447), but it has been generally ignored.

I have inspected a very large number of fledgling Giant Fulmars in their nests at South Georgia, and have examined specimens from breeding stations in many other parts of the southern hemisphere. With the exception of a few white individuals—which are always white, from egg to grave—every one was black. The same holds for specimens collected at sea and determined by dissection to be young birds. For example, I once shot a small, shiny black male under the cliffs of Mazorca Island, Peru. The minuteness of its gonads and the relative softness of the bones of its skull both proclaimed it to be a youngster not long out of the nest—although, like a foul-bottomed ship, it had been at sea weeks enough to acquire three or four goose-barnacles on the feathers of its belly. Its bill and its wing-spread were still small, the latter dimension being exactly two meters.

In the extraordinarily large and well-selected series of Giant Fulmars possessed by the American Museum are many similar juvenal stages taken at sea as well as at breeding grounds. The former include Brewster-Sanford specimens from Mar del Plata, the Strait of Magellan, Chiloé Island, Corral, and Valparaiso, shot mostly during the southern-hemisphere winter and spring. A series of 18 such blackish young birds demonstrates as well as adults the size discrepancy between the sexes, and I have found it possible to separate the males and females with certainty by a mere glance at the bills, subsequently confirming the matter by reference to the labels. The same series illustrates also how the uniform blackish plumage gradually bleaches, producing a rusty mottling accompanied by extreme fraying of the tips of the young quills. A female taken at Magallanes on March 6 is in this worn condition, and is beginning to moult from juvenal plumage into a garb characterized by brownish gray feathers with lighter gray margins. A male taken at Mar del Plata on October 5 has very nearly completed this post-juvenal moult, and is equipped with new quills. All such yearling or younger birds are marked as being brown-eyed, and all have blackish legs and feet. I suspect that a certain proportion of such examples breed as yearlings before they have lost all the youthful plumage characteristics. On the South Georgia nesting grounds, at any rate, there are always a few dark, worn, messy-looking, brown-eyed Giant Fulmars nesting among the much larger number of light-eyed, gray, whitish-headed birds.

It is likely that careful examination of the limy encrustation at the base of the Giant Fulmar's beak may yield further information concerning age and growth. In most blackish young specimens this shows as a brittle integumentary layer, which looks as though it may have been somewhat soft in life. Among older, light-headed birds it is usually heavy and more extensive, though still rather variable.

Fifty or more skins in our collection illustrate the mature phases of plumage which, as hinted in the description above, are less puzzling than is commonly believed. Wear and fading are sufficient to account for many of the facies. True variation, which may be individual or may be correlated with age, shows in the relative lightness of the head and neck; it is at least possible that for a time these become whiter with successive moults, especially since nearly all the light-headed birds seem also to be gray- or blue-eyed.

There remains the problem of the white Giant Fulmars, which is both genetic and geographic, and which cannot be solved in full with the data at hand. It seems to be established that the curly mesoptyle down of such birds is white instead of gray, and that their first contour plumage is as close to wholly white as it will ever become. The four white adults I examined on their nests at South Georgia had brown eyes, but this may have indicated merely the coincidence that they were youthful, for one of our two white females collected by Mr. A. G. Bennett at Deception Island had light gray irides. Bennett (1926, 315), by the way, dissected ten adult and young white examples in the field at the South Shetlands and found every one to be a female! Here would be statistical grounds for an inference, were it not for the fact that both Beck and I have collected white males. Furthermore, the members of the German Expedition at South Georgia found that each of "several" white nesting birds was a male, and each mated with a normal, gray female.

Numerous authors have published evidence to show that the proportion of white Giant Fulmars increases with latitude, the white birds becoming both absolutely and relatively most abundant in the pack-ice. Wilson (1907, 94) estimated from his pelagic observations that between latitudes 33° and 66° S., dark birds outnumber white ones by at least 500 to 1, while between 66° and 78° S., a watcher may see only 3 or 4 dark examples to each white one. Bennett (1920, 28; 1926, 315) found that in West Antarctic breeding colonies white birds made up from 5 to 12½ per cent of the population. Wilkins (1923, 479) estimated the proportion at South Georgia to be two per cent, which is the same figure given by the 'Scotia' naturalists for the South Orkneys.

It seems clear that in no part of the world do the white birds make up more than a small fraction of the breeding population. The high proportion of white Giant Fulmars in the pack-ice zone therefore probably illustrates a very important zoögeographic principle, namely, that of selection of a particular environment by a particular type of organism. So many naturalists have been concerned, as Wilson himself was, with an assumed *effect* of environment upon organism that the more logical significance of the observed facts has been missed.

On the other hand, white Giant Fulmars are not, as some authors would have us believe, practically non-existent in the lower latitudes of the Sub-Antarctic Zone. Beck collected examples off Tierra del Fuego; Loranchet (1915, 207) observed one close to Tristan da Cunha; I saw two in the Humboldt Current off the Peruvian coast, and MacFarlane (1887, 208) reports one in July off Paita, only five degrees from the equator. Gould (1865, 443) writes of one that followed a ship for three weeks on the run between the Cape of Good Hope and Tasmania.

I have yet to learn of a nesting population of Giant Fulmars among which white birds do not occasionally appear. While their genetic significance is highly interesting, we may account their taxonomic meaning as zero. So far as can be judged from the writings of many of the authors already cited, as well as Hall (1900, 27) at Kerguelen, and others, the status of the *Macronectes* population is rather similar at all of the pan-antarctic islands. By way of recapitulation, I may transcribe from my notes regarding a hundred occupied Giant Fulmars' nests at Albatross Islet, Bay of Isles, South Georgia. Of 100 birds in attendance on the afternoon of January 9, 1913, 93 were "white-headed," and all but 3 or 4 of these were definitely "blue-eyed." Five of the nesters were wholly dark-feathered and brown-eyed and, in my opinion, less than two years old. Two were white, both of these being likewise brown-eyed, perhaps because they were young. On the same date I saw 10 or 12 additional white birds in flight over the bay.

Before leaving the subject of variation, it will be well to add a few words about the chicks. Mathews (1932, 37) is quite wrong in stating that the dark Giant Fulmars start life in dark down. The protoptyles are white, slightly grayish on the back, in nearly all newly hatched young. However, there are individual differences which might lay a pitfall for the systematist who mistook them for geographic differences. For instance, I have before me a number of chicks taken on the first day of their lives at South Georgia and the Falkland Islands. Two collected at Sea Lion Islet, Falklands, on December 17, 1915, are covered with creamy white down, somewhat grayish as well as longer and of looser texture on the back. Several South Georgia specimens exactly resemble these, but another which I picked up an hour after it had hatched, on December 1, 1912, is entirely gray dorsally, except on the forehead and the post-ocular region. Its throat is also gray and its whole appearance is unlike that of the other chicks. The dense, curly mesoptyles which replace the natal down are apparently always gray, except in the case of the permanently white birds.

Taking into account the variations I have described, and keeping in mind the pronounced sexual difference in size, I am unable to recognize among more than a hundred adults from all parts of the range the criteria for the several subspecies that have been described.

As a breeding bird the Giant Fulmar is entirely confined to islands on the polar side of the Sub-Tropical Convergence. The 'Challenger' naturalists (Moseley, 1879, 134) included it among the residents of Tristan da Cunha, an error which has been repeated by Clarke (1913, 286), Dabbene (1923, 154), Sclater (1924, 15), Alexander (1928, 34), Peters (1931, 46), and others. Numerous references to specimens from Tristan, such as that of Lowe and Kinnear (1930, 159), apparently refer to birds captured in waters about the island, where the species is at times common. It would not be surprising, indeed, if migrants occasionally came ashore in search of sustenance, since the Giant Fulmar is the one Procellariiform bird which feeds in part on *terra firma*. There is no satisfactory record of its nesting at any member of the Tristan group, however, although it is native to Gough Island.

Paessler (1909, 100) infers that it is a resident of Guamblin Island, a little to southward of Chiloé. According to Gould (1841, 139), it formerly bred along the Atlantic coast of Patagonia as, for example, at Sea Lion Islet in the estuary of the Río Santa Cruz. I know of no other alleged breeding stations near the South American continental coast, although they have probably existed among the outer Fuegian islets, as they still do at Staten Island. Formerly the species was widely distributed at the Falklands, but the colonies are now confined to a few localities such as New Island, at the extreme west of the archipelago, the Jasons, at the northwest end, and Sea Lion, which is south of East Falkland. Cobb (1933, 36) writes of a colony of a thousand birds on one of the Jasons which seems to hold its population about the same year after year At Sea Lion Island Beck found an aggregation of 75 pairs toward the end of their incubation period, in mid-December, 1915. The eggs lay in small unlined hollows in the sand, about 150 meters back from the water, on a broad stretch of flat upper beach. The first chicks hatched on December 16, and all the unpipped shells contained young birds ready to come into the world, with the exception of four addled eggs which the old birds continued to cover.

During the Brewster-Sanford Expedition Beck encountered Giant Fulmars at practically all seasons of the year from Chilca, Peru, southward to Cape Horn, and up the east coast to the Gulf of La Plata. They proved surprisingly common in the Strait of Magellan, the Beagle Channel, and other inland waterways. Beck's journal also speaks of numbers running to hundreds, or even thousands, along the Atlantic coast of Patagonia, in the Strait of Le Maire, Falkland Sound, and, on the Pacific side, in the Gulf of Peñas and about the San Carlos whaling station near Corral. To the last place the birds had, of course, been attracted by artificial enrichment of food resources. Mr. Bullock's notes from Mocha Island likewise tell how they throng ashore there each year during the special season of sea-lion slaughter. Matthews (1929, 571) states that when whaling is suspended in winter at the South Georgia stations, plenty of Giant Fulmars die of starvation.

Although this petrel ranges northward to low latitudes, as indicated, many individuals remain in the pack-ice even in winter. Gain (1914, 144) reports that the species was never wholly absent from the region around Petermann Island during the wintering of the 'Pourquoi Pas?'. Near Paulet and Snow Hill Islands, on the Weddell Sea side of the Antarctic Archipelago, Giant Fulmars appeared throughout the winter whenever strong westerly or northwesterly winds raised the temperature and tended to break up the fast ice. At such times they were observed by members of the Swedish Expedition in every month between April and October (Andersson, 1908, 45). At the South Orkneys the status of the species is similar, the population falling off in May and June, but a few birds remaining until the spring migration begins again in September (Valette, 1906, 61; Clarke, 1913, 237).

The supposed courtship of the Giant Fulmars has been described by Racovitza (1900, 228), who observed their amorous behavior on ice-floes during the antarctic spring. Birds which he presumed to be males were at this time raising and spreading their tails, as though they aspired to be peacocks, and dancing a bourrée before the seemingly irresponsive females of their choice. The fact that the creatures were hideously smeared with blood and grease from the man-killed seal carcasses upon which they had been feeding did not in the least dampen their sentimental exhibition.

Von den Steinen (1890, 243) records the behavior of a mated pair which had been robbed of an egg on the preceding day. This was in the latter part of November at South Georgia, and it is possible that the breaking up of the usual reproductive sequence had turned back the reactions of the birds to a stage more or less resembling normal courtship. At any rate, these two faced each other with widely opened beaks and uttered cries like the mewing of a cat. While the one which the observer took to be the female was continuing the mewing, its mate turned the beak sharply downward against the throat, bowed low to left and to right, and then waved the head very rapidly from side to side. Presently this bird again stood erect, opened its mouth, and a double mewing performance was resumed. Subsequently a similar type of behavior was noted among the owners of 55 other robbed nests. Von den Steinen did not learn whether or not a second egg is laid to replace the first.

At South Georgia the Giant Fulmars come to land during September and October. The first nest-building was observed by members of the German Expedition as early as September 8. High ground, particularly the tops of promontories or grassy islands—places from which the birds have a ready take-off for launching into flight—are the favorite sites. The nature of the nest depends upon the character of the soil and the abundance of adjacent vegetation. Szielasko (1907, 597) states that grass is ordinarily pulled up within a round plot, which may reach nearly a meter in diameter. Then the vegetation and the peaty soil are raked inward until, in some instances, a truncated cone half a meter in height may be formed. On stony hilltops, however, a few pebbles and fragments of moss and lichen may suffice. I have already referred to the nestless holes in the sand at the Falklands, while at the South Orkneys and elsewhere in the plantless antarctic the usual nests are platforms of angular stones.

At South Georgia the first actual mating between paired birds has been observed on September 15 (Lönnberg, 1906, 78), and the first eggs about the middle of October. Egg-laying continues, however, until well into November. The period of incubation is recorded as six weeks but this estimate is probably considerably too short. The first young at South Georgia were found by members of the German Expedition on November 19. The entire cycle of the breeding season is therefore considerably earlier than that of the Wandering Albatross, as pointed out by Wilkins (1923, 484). At other localities to northward and southward, the dates for corresponding parts of the reproductive cycle are, respectively, somewhat earlier and somewhat later. Thus, at Gough Island, Verrill (1895, 447) has shown that egg-laying commences in the middle of September. At Laurie Island, South Orkneys, where about five thousand Giant Fulmars nest, the 'Scotia' party found the first eggs on November 4. On the shores of De Gerlache Channel, in the Antarctic Archipelago, first layings may be a little later (Andersson, 1908, 45).

At Cumberland Bay, South Georgia, on December 3, 1912, I found my first Giant Fulmars' nests on hills within sight of the water, at altitudes between 100 and nearly 300 meters above sea level. The nests were of very variable size, as noted above. Some contained well-incubated eggs and others newly hatched chicks, and in nearly all instances the brooding parent bird clung to its charge, although evidently viewing me with blue-eyed alarm. When approached closely, the birds snapped their bills repeatedly, turned about so as always to face the intruder, and finally uttered disgusting, retching noises and ejected a fluid, which looked like molasses, up to a distance of 2 meters. This was followed or accompanied by a rapid shaking of the head. In some instances the squirted material had the ordinary, musky petrel odor, while in others it reeked of rotten carrion.

According to Matthews (1929, 573), chicks are more skilful than adults at hitting their targets, besides which they spill the evil mess all over themselves and their surroundings. I noted that on one occasion a tiny white baby, which I knew to be no more than two hours out of the egg and which had probably not yet been fed, none the less vomited as soon as I knelt to examine it closely. Only a few drops of oil came from its throat and nostrils, but the reaction seemed to be made with definite reference to me. It is extraordinary that an instinctive response of this sort should find expression at such an early age.

As among many other birds, the closeness with which the parent Giant Fulmars sit in the presence of a disturbing stimulus seems to depend upon the stage of the egg or chick. Fresh eggs could usually be obtained in nests from which the parents had fled pell-mell at the approach of a human being. Possibly, however, the sex of the sitter has something to do with this matter. So also has the weather, for the brooders cling more closely to their nests when the snow is falling than they do on clear and sunny days. On several occasions at the Bay of Isles I saw birds completely snowed under, with the exception of their ugly white heads which stuck up through holes like jacks-in-the-box. It is sometimes next to impossible to drive away a brooding parent from a newly hatched chick, whereas the older young, which are large enough to be secure against the attacks of the skua, are abandoned at the slightest provocation. At Albatross Island in the Bay of Isles, where the Giant Fulmars were nesting among Wandering Albatrosses on the grassy hills, the difference in the reactions of the two species was impressive, for the albatrosses remained quiet and serene while the fulmars exploded whenever a man passed near them. In many instances I would not have noticed them in the long tussock grass but for their quite uncalled-for behavior. That this involved not a scrap of intelligence was indicated by the fact that one pair continued to brood for a week over a chick which had been crushed as flat as a pancake.

Wandering Albatrosses were the only sea birds found nesting a few steps from the Giant Fulmars, but at Albatross Islet a South Georgian Pipit (*Anthus antarcticus*) succeeded in rearing a brood within 2 meters of the ogre!

By Christmas time many of the young fulmars were covered with very long, curly, gray down, and were as large as domestic chickens, and at this stage they were left alone by their parents during lengthy periods each day. Although fat and heavy, they were yet very weak, and I learned while skinning specimens that the long bones of the limbs were still cartilaginous at their ends, and the parietal and median sutures of the skull still unclosed. Such chicks are, of course, quite unable to stand up, although they can rotate in the nest to face an intruder by scuffling around on their bellies. On warm afternoons they pant distressedly, their thick down preventing much radiation of heat from the surface of the body. Not until February 23 did I find chicks which had shed nearly all of their down except for tufts on the head. At this age the new plumage is a glistening slaty black and the eyes are invariably dark brown.

The loss of the down in an entire population of young is evidently a prolonged process, correlated with the period of several weeks throughout which eggs are laid. Andersson reports fledglings still showing traces of the down at the Bay of Isles on May 9. The majority of the South Georgia adults apparently cease to return to the nesting sites some time during April, after which the chicks remain unattended and unfed throughout May, or even until as late a date as the middle of June, before hunger coöperates with a desire to wander and to beat the wings, and thus drives the young birds into making their way to the water (von den Steinen, 1890, 243). Loranchet (1915, 207) believes that the majority remain close to the land of their birth throughout their first winter, provided they are natives of the milder belts of pan-antarctic waters. We have, of course, abundant evidence from pelagic collecting that certain of the youngsters wander as far as their parents.

The feeding of the young Giant Fulmar is described by Matthews (1929, 572). The chick lifts its beak toward that of its parent and makes a "curious internal scraping" sound. The adult then regurgitates some of the stomach contents, and the chick takes the food from the mandible. The nestlings also utter from time to time a chirping cry while they are being brooded. The vocal performances of the adults, aside from the nauseated gurgles of their defensive reaction and the "mewing" of courtship, comprise long-drawn, tremulous cries vaguely resembling the neighing or whinnying of a colt. Such calls are particularly characteristic of late afternoon, when numbers of the adults are swiftly cutting back and forth in the air above the breeding ground, preparatory to settling for the night. On the quiet, breezeless mornings with a bright sun, which come very rarely at South Georgia, the Giant Fulmars sometimes mount in the air, as if on ascending currents, and wheel about at altitudes that appear as high as the mountain peaks. The same phenomenon has already been described with references to albatrosses and some of the lesser petrels.

At sea the Giant Fulmar is a "stiff flyer," showing to best advantage only in high winds. It is a far less agile and graceful bird than mollymauks of the same size, and it assumes particularly queer and awkward attitudes when descending to the ocean under the handicap of a light breeze. On such occasions the bird stretches up its neck, with the bill turned downward, throws forward the breast, depresses the tail at a sharp angle, and drops to the surface with its legs widely straddled. When rising again it must beat the air heavily and run for a long distance across the water unless the head wind is strong enough to help it materially. Calm weather is generally adverse to its welfare, and it lives mainly in a world where calms are infrequent. Cobb (1933, 36) once watched a dozen of the birds following a schooner for a long distance in half a gale of wind and observed that they sometimes scaled for nearly ten minutes at a time without an apparent wing stroke. According to Whitlock (1931, 264), this petrel is a common victim of heavy gales along the western coast of Australia, the bodies of such waifs showing the usual emaciation. He was a witness when one Giant Fulmar was beaten down by a heavy squall within the line of breakers. It dived through advancing waves in a final effort to keep off the lee shore, but subsequently tottered up to high watermark, collapsed with wings outspread, and died without moving from the spot.

On land the Giant Fulmar is an awkward creature, even though it can walk and run much better than most of its near relatives. The tarsus remains practically perpendicular only when the bird is hurrying; as soon as it stops moving forward it squats down on the heel. When a group is surprised while feeding upon a seal carcass, the birds will hobble off with a curious, sidewise, crab-like gait, holding their wings high, wiggling their upturned tails, emptying themselves as rapidly as possible—as though tossing out ballast—and consequently leaving a horrible line of carrion in their wake. I have seen more than six hundred running along together in this way across a flat glacial moraine, all galloping helter-skelter, colliding with one another and, as a result, tumbling down in greasy, bloody heaps. Under such circumstances they are very rarely able to launch into the air; rather, they prefer to make for the nearest water, from which they can subsequently take flight after the customary run along the surface. One night at South Georgia I startled a sleeping bevy on top of a promontory, whereupon the birds floundered off in confusion and all tumbled down the steep to the sea, like the swine of the Gadarenes. Whenever they rise in a flock from the water, they bump into each other quite as much as on the land, and drop with a great splash. Wilkins (1923, 484) has even observed a head-on crash between two of them.

The feeding habits of the Giant Fulmar are far more diversified than those of any other petrel. Afloat and ashore it is always on the lookout for animal food, dead or alive. It is a combination fisherman, bird of prey, and scavenger. It is in some places a fearful scourge to the penguin colonies, eating both eggs and chicks, and appearing to have a diabolical knowledge that the bellies and intestines of the rotund young penguins are filled with crustaceans quite as acceptable in secondhand condition as though scooped up at the surface of the ocean. It is equally willing to give chase to the introduced rats at South Georgia or the rabbits at Kerguelen. On the ocean it catches squids and pelagic crustaceans, and it is always ready to take advantage of a helpless or unwary smaller bird, or to tackle the floating carcass of a whale. Unlike any other Procellariiform species, the Giant Fulmar will climb out of water to tear its way through the epidermis of a dead whale or seal, and will then thrust a crimsoned head again and again through a small hole. After filling to repletion, it will wash itself while afloat, leaping slightly upward before plunging, bobbing like a cork, and allowing the water to run off its back.

Its eyes are as keen as those of a vulture, and unquestionably the rapid assembling of Giant Fulmars is due in part to the fact that they spy on one another's movements at a great distance. Very likely it also has a keen sense of smell, as Travers (1873, 219) believed. At South Georgia I placed seal blubber in perforated cardboard boxes beside two incubating birds, and the material remained undisturbed for weeks. However, it must be remembered that Giant Fulmars do not ordinarily feed at the nest, which may be why the family of pipits, mentioned above, lived in safety. The sealers insist that the "Stinkers" will find buried sea-elephant blubber, even if it is cached at night, and Beck's notes are full of references to Giant Fulmars supposedly attracted by the odor of birds he had skinned. The 'Scotia' naturalists observed on the sea-ice near the South Orkneys that Giant Fulmars appeared as if by magic in September, when the placentas of new-born Weddell seals offered a fresh food supply.

Buller (1873, 298) tells of watching a Giant Fulmar catch a whale-bird at sea, after which it held its prey by one wing and battered it against the water. Wetmore (1923, 171) quotes an observation by Fagan describing the similar capture of a tern. This happened under the stern of an anchored steamer in the harbor of Arica. A sailor threw a bolt at the marauder and killed it, and from its stomach Fagan took the remains of a diving petrel. Off Corral on September 10, 1913, Beck shot a Giant Fulmar which he allowed to lie upon the water for some minutes. Then, while he had his eye upon other birds, a second member of the species swam up and ripped open the dead one to such an extent that it was ruined for skinning. The approach, by the way, is characteristic. I have never seen Giant Fulmars stoop directly at food in the water. Rather, they alight near-by, and swim up with a somewhat quizzical bearing. For this reason the smaller and more alert petrels steal many tidbits from under their noses.

Werth (1925, 584) reports that a Giant Fulmar confined in an enclosure at Kerguelen Island attacked all of its fellow prisoners, and promptly slew two Sheath-bills and a Kelp Gull. Buller (1888, 225) states that a captive kept by him obstinately declined to eat fish of any sort, although it would devour all other flesh without exception, including that of its own kind. In this connection it would be interesting to learn whether fishes have been found in a Giant Fulmar's stomach. Those of two I collected on the coast of Peru, close to the cliffs of guano islands, contained the mandibles of squids (*Loligo*) and remains of cormorants (*Phalacrocorax bougainvillii*). The fact that the latter were downy young makes it seem very likely that the fulmars had taken them from their nests on the islands. Since the cormorants breed on broad, flat surfaces, there would be very little chance of a chick falling into the sea. Squid beaks, small stones, seaweed, rope yarns, crustaceans, and a variety of birds and bird feathers have been found in Giant Fulmar stomachs examined in pan-antarctic latitudes.

Green (1887, 25) believes that this species is responsible for most of the tales that have to do with "albatrosses" attacking men in the water. McCormick (1884, 98) states that on the southward voyage of the 'Erebus,' during the southern winter of 1840, the boatswain fell overboard and was lost before the ship could come about. Giant Fulmars swooped at the man as he struggled to keep afloat, and appeared to strike him with their bills. The truth of the matter was never learned, for the victim sank suddenly while several of the birds were whirling above his head. Guillemard tells of a rescued sailor whose arms had been badly lacerated through defending his head from the attacks of an "albatross," which Saunders (1901, 231) believes may have been a Giant Fulmar. That the beak of this bird, which resembles carved fossil ivory, could inflict such wounds is beyond question. I still have a patch on my old sea boots covering a spot where a Giant Fulmar nipped through the heavy leather, and another individual laid open the shoulder of our ship's fox terrier as though it had been done with shears.

Has the killer no enemies, other than the sailors who harbor a perpetual grudge against it? We know little about the answer. Man, of course, unconsciously increases the abundance or changes the concentration of the species by slaughtering whales and dumping ship's garbage. The last, in all probability, has drawn the Giant Fulmars to the Chilean ports. Then, in turn, man starves these birds by ceasing whaling operations, or spreads a fatal flypaper for them by pumping out crude-oil residuum from steamers along the west coast of South America (Wetmore, 1926, 50). The only natural enemy of which I know is the skua. At South Georgia, and doubtless elsewhere, the skuas devour an especially large proportion of Giant Fulmar eggs for the simple reason that the big petrels are so slow and clumsy, and so apparently stupid, that their eggs are liable to be exposed for a few dangerous seconds longer than those of other native birds. If it has once run the gantlet of perils as far as maturity, however, the Giant Fulmar is in a position to scorn any fowl it is likely to encounter.

SILVER-GRAY FULMAR

Priocella antarctica

Fulmarus antarcticus Stephens, 1826, in Shaw's Gen. Zoöl. 13, pt. 1, p. 236 ("Antarctic Ocean pretty far to the South").

Names: Slender-billed or Antarctic Fulmar; Cape Dove. Synonyms of the specific name include *glacialoides*, *garnotii*, *polaris*, *tenuirostris*, and *glacialina*.

Characters: A pale gray or whitish bird, closely resembling its relative, the Fulmar of northern oceans.

Adults (sexes alike): General color of the dorsal surface from crown to tail, including the wing coverts, pearly gray, which inclines to be darkest on the back; primary coverts dusky, very narrowly margined with grayish; primaries dusky black on their outer webs and terminally, largely white or ashy white on the inner webs, the shafts dark except basally; secondaries dusky gray on the outer, whitish on the inner webs, the innermost and the tertials being pearly gray, marked by the dark hair lines of the feather shafts; under surface of wing white, with gray mottlings close to the edge; central rectrices like the back, the outer ones somewhat lighter, and all with white shafts; forehead, lores, fore part of face, throat, and entire ventral surface white, shaded with pearly gray on the cheeks, auriculars, sides of breast and flanks; an indistinct blackish semilunar mark in front of the eye. Iris brown; bill pink, light blue basally and on the naricorn, the tip brownish black; legs and feet pale blue, with more or less of a pink wash like the hue of the bill, a few yellow, brown, or blackish scales, a brownish outer toe, and blackish claws.

10 males from the South Shetland Islands and southern South America: wing, 330–351 (348); tail, 114–135.5 (124); exposed culmen, 41.3–46.5 (44.2); tarsus, 48.8–52 (50.3); middle toe and claw, 62.7–70 (66.1) mm.

10 females from the same regions: wing, 325–341 (332); tail, 114–127 (121.7); exposed culmen, 39.3–44 (42); tarsus, 46.3–49.2 (48); middle toe and claw, 61–66.7 (63.7) mm.

The length in the flesh of a male and a female from Deception Island was, respectively, 48 and 52 cm.

A male I shot off North Chincha Island, Peru, on October 27, 1919, weighed 490 grams, and had a wing-spread of 145 cm.

I find no description of the downy young. Eggs have been collected, as noted in the following text, but the only published description seems to be the incomplete one of Andersson (1908, 43), who describes an egg taken at Cape Roquemaurel, Kerguelen Island, as white and 76 mm. in length.

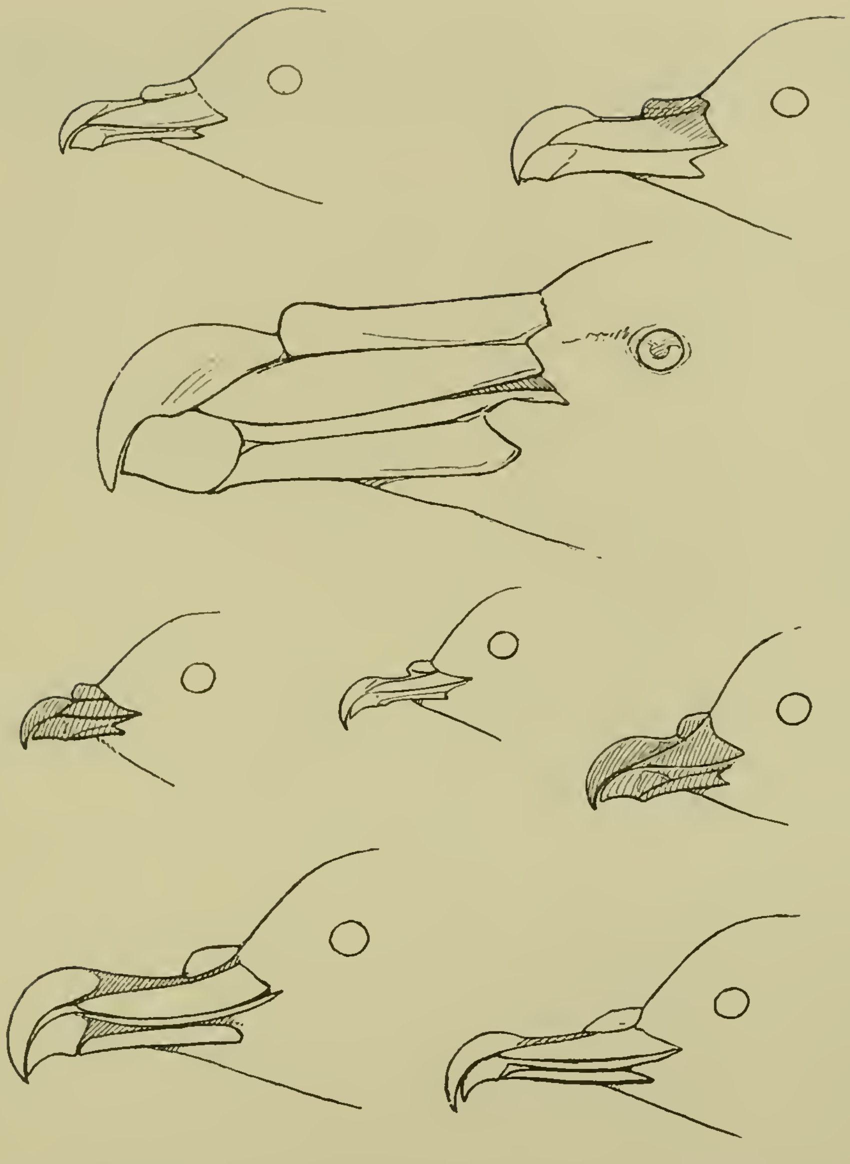


Fig. 57. Beaks of various genera of petrels, drawn to the same scale. All represent males.

Reading from left to right: Top row, *Daption capensis*, *Priocella antarctica;* second, *Macronectes giganteus;* third, *Pagodroma nivea*, *Halobaena caerulea*, *Pterodroma phaeopygia;* bottom, *Procellaria aequinoctialis*, *Puffinus gravis*.

Distribution: Circumpolar in the Antarctic Zone, breeding in the Antarctic Archipelago, Adélie Land, Queen Mary Land, and probably at the South Orkneys, South Georgia (?), Bouvet, Heard Island, the Balleny Islands, and other outlying antarctic islands. Ranges regularly northward in the southern oceans across the Sub-Tropical Convergence; on the east coast of South America to Cape Frio, and on the west coast to the northern end of the Humboldt Current or about latitude 6° S.

Except for the Snow Petrel, the Silver-gray Fulmar is the commonest bird in pack-ice throughout the whole circumpolar belt. Here, however, the distributional resemblance ends, for the present species is scarcely less abundant in the Sub-Antarctic Zone, besides which, during the season of southern winter, it ranges far northward into tropical latitudes wherever cool currents bathe the continental coasts. For this reason, it is a familiar bird in the littoral waters of western South America, following up through the Humboldt Current to the northern end of Peru. At times it apparently goes still farther, even crossing the equator and passing over the gap of warm water, to reappear in the temperate oceans of the northern hemisphere. There are, at any rate, a larger number of records of this species in the North Pacific Ocean than of any of the other petrels ordinarily associated with the far south.

The naturalists of both the 'Challenger' and the 'Quest' expeditions found it not uncommon on the ocean around the islands of the Tristan da Cunha group, which is, of course, very far northward of its breeding grounds. Meliss (1875, 96) states that it is occasionally seen in the waters about St. Helena, where, during October, 1868, two examples were caught on fishing-lines. There can be no doubt, however, that the concentration in numbers of this bird, except in high latitudes, takes place principally in ocean waters kept cool by upwelling phenomena close to continental shores. Belcher (1914, 591) states that on an eastward voyage across the South Pacific during mid-November, he found the Silver-gray Fulmars increasingly numerous as the vessel approached the Chilean coast, and most abundant of all in the harbor of Valparaiso. Lönnberg (1921, 12) records one example taken off Santa Clara Islet, Juan Fernández, which is well to the northward for a locality so far from the continent.

During the Brewster-Sanford Expedition, and during my own work on the coast of Peru, Beck and I respectively found this handsome and conspicuous species to be common throughout the length of the Humboldt Current, where we have recorded examples from ten or twelve localities between Mazorca Island, Peru, and Corral, Chile, during the southern-hemisphere winter and spring period. While I was spending several weeks at or about the Chincha Islands, in October and November, 1919, Silver-gray Fulmars were frequent visitors to the coasts of these islands, and were often observed sitting singly upon the water, feeding on mangled carcasses of birds such as boobies or pelicans which had, of course, first died from some other cause.

While conducting his field work near the southern tip of South America, Beck found this petrel extraordinarily numerous on all the outer coasts of Tierra del Fuego. Occasionally he encountered great numbers in the mouths of the channels or in the larger bays, and on April 13, 1915, during a snowsquall, he collected a series of thirty specimens at False Cape Horn. Even in the landlocked waters of Beagle Channel and the Strait of Magellan, the Silver-gray Fulmar proved common, as attested by specimens from Ushuaia, Magallanes, and elsewhere. Additional examples in the Museum collection come from waters between Patagonia and the Falklands, Deception Island of the South Shetlands, and South Georgia, in the fiords of which the bird is at times abundant.

Whether or not the species nests at South Georgia is still uncertain, though highly probable. At many other islands of the Scotia Arc, and in the Antarctic Archipelago, it is a widespread resident. It has been recorded at Bouvet Island during November (Vanhöffen, 1901, 310; Reichenow, 1904, 348), and is known to nest in eastern Antarctica as well as at Kerguelen, the latter island marking the lowest latitudinal limit of its breeding range.

The Silver-gray Fulmar everywhere seeks inaccessible situations for its home. Gain (1914, 133) reports the inability of the French naturalists to reach supposed nesting sites in various parts of West Antarctica. At Cape Roquemaurel, Kerguelen, Andersson (1908, 43) could make his way to only one of a number of nests he saw on small ledges of the dizzy peak, far above the water and the penguin colonies. Here the single eggs were deposited in slight hollows of the sand or stone-chips. He took one well-incubated example on December 27, 1902, the sitting parent regurgitating in the usual petrel manner at the human intruder. During late November, the members of the Australasian Antarctic Expedition found these petrels mating at Haswell Island, Queen Mary Land. At this time two fresh eggs were taken, but most of the birds were still engaged in courtship, pairs of them billing and cooing in small grottoes which they themselves seemed to have excavated in the snowdrifts (Mawson, 1915, 2, 118).

Motion-picture films made during Mawson's antarctic work offer interesting and illuminating glimpses of the behavior of this and other species of marine birds inhabiting these remote and little-known breeding grounds. Such data are, indeed, far more valuable than the few word descriptions which have yet found their way into ornithological texts. The Silver-gray Fulmars, for example, may be seen sitting upon the rocks or snow during the courtship season, the birds of prospective or mated pairs either side by side or face to face. One of them will presently open the bill widely, point it skyward, and wave the head from side to side in a gesture suggestive of violent choking. The second bird will then respond with similar movements, which presently works each of the pair into a frenzy, causing them to display simultaneously in the same fashion. This performance may be followed by a mutual nibbling at the neck or wings, after which the head-wagging may be resumed with the head turned completely upside down and the bill stretched along the back—a complicated reaction which is highly reminiscent of certain courtship antics of cormorants and frigate-birds, and which, as I have hinted elsewhere in this work, may be a more significant indication of fundamental relationships between these birds and the Procellariiformes than any shown by anatomical characteristics retained by both. In the ultimate stages of the courtship performance of the Silver-gray Fulmars, the tail begins to move in sympathy with the swaying of the head, the rate increasing until it becomes a rapid vibration. Sometimes a great enlargement of the neck, produced either by a puffing out of the feathers or by inflation, or both, is a marked accompaniment of the love-making.

On the open sea the rapacity of this petrel enables it to be taken readily on a hook, perhaps more easily than any species except the Shoemaker and the Cape Pigeon. However, Lucas (1887, 4) found that its very quarrelsomeness may save it from capture, for it sometimes devotes its energy so completely to driving away rivals that it finds no time to seize the trailing bait itself! It apparently has the ability to settle upon and take flight from open water with great freedom, even in the absence of a breeze. Consequently groups of Silver-gray Fulmars are quick to alight about an anchored or becalmed vessel, and for the same reason they are prone to descend and swim in open leads of the pack-ice. I believe that the bird can take wing with more agility than the Arctic Fulmar, and it certainly flies somewhat less steadily and evenly. Pennell speaks of its light, twisting movements in the air, "like the start of a snipe's flight" (Lowe and Kinnear, 1930, 134). In the hand it much resembles the Arctic Fulmar, except in the form of the bill. The *Fulmarus* beak is substantially a miniature of that of *Macronectes*, showing the same pronounced sculpturing. That of *Priocella* is presumably less specialized from the primitive petrel type, and is much longer in proportion to the length of the nasal tubes. The color of the plumage, and the general behavior, would make it difficult to believe, nevertheless, that *Priocella* and *Fulmarus* are not very closely related. Ecologically, one replaces the other—at opposite ends of the globe.

Specimens in the Museum collected by Mr. A. G. Bennett at Deception Island, during March, 1922, show a post-nuptial moult of the quills exactly resembling that of *Thalassoica* and *Daption*. Other specimens from the Magellanic region illustrate the continuation of feather replacement through April and into May. Many such birds have extraordinarily abbreviated wings, or wings with short new inner remiges, and one or two long but frayed external primaries. The hypothesis of a skipped moult among senile or sterile birds is supported by a non-breeding male I collected at the Chincha Islands, Peru, on November 23, 1919. In this example the plumage is faded and tattered to the last degree, and the tips of the quills are little more than stringy tufts. Yet the bird could fly.

Progression on the land is, of course, reduced to a minimum. The Silver-gray Fulmar rarely attempts to walk but merely tumbles into or out of the air, appearing rather to sideslip to its ledge or rock rather than to come down upon its feet. The ordinary terrestrial attitude is a squat, with the flat tarsus extended along the surface and the belly touching. Under conditions of excitement the bird can walk for a few steps, but even then the tarsus is held at a sharp angle, instead of perpendicular to the ground, and continued pedestrian efforts always end in a quadrupedal shuffle in which the wings furnish at least as much support as the legs.

Human operations in the antarctic seem to have had a considerable effect upon the distribution or local concentration of the Silver-gray Fulmar, and since the beginning of modern whaling operations it has tended to gather in vastly increased numbers about such stations as Deception Island, attracted by the carcasses or fragments floating along the beach. So far as I know, it has not taken to the shores in its search for food, the Giant Fulmar being apparently the only member of the whole order of petrels and albatrosses which forages otherwise than afloat. In its aggressiveness and voracity, however, the Silver-gray Fulmar shares many of the traits of its big relative. In fact, all of the petrels of the fulmarine group seem to be particularly carnivorous and bloodthirsty, and always ready to attack a disabled bird, even though it belong to their own species. Doubtless, the bulk of the Silver-gray Fulmar's food, in the southerly parts of its range, is made up of pelagic crustaceans. In such places as the coastal and inland waters of the Magellanic region, small herring-like fishes have been found in stomachs examined; other contents have shown the remains of cuttlefish. Three examples I shot on the coast of Peru contained, in the aggregate, the following foodstuffs: feathers, trachea, and entrails of a cormorant; vertebrae of a fish; squid mandibles (*Polypus*); barnacles (*Balanus*); sand-bugs (*Emerita analoga*); traces of seaweed. In harbors such as those of Callao and Valparaiso, garbage seems to enter largely into the food of this petrel. It would be interesting to learn whether its elongate alimentary tract is correlated with any special food habit; the intestine measures nearly two meters in length, or almost twice that of the Cape Pigeon (Cunningham, 1871, 224).

CAPE PIGEON

Daption capensis

Procellaria capensis Linnaeus, 1758, Syst. Nat. edit. 10, 1, p. 132 (Cape of Good Hope).

Names: Cape Petrel, Speckled Haglet, Albatross-jackal; Pintado Petrel, which is of Spanish origin; other Spanish names are "Paloma del Cabo," "Damero," and "Tablero"; in Brazilian literature "Pombra do Cabo" and "Fradinho" have been used. A synonym of the specific name is *punctata*.

Characters: An entirely black and white petrel, with a checkered back which is responsible for many of the common names of the species in several languages.

Adults (sexes alike): General dorsal color black, with a strong slaty or plumbeous gloss in fresh plumage; head and mantle black, except for the more or less speckled throat, the feathers of the mantle with concealed whitish bases; scapulars, back, and upper tail coverts white, the feathers, however, bearing conspicuous, black, wedge-shaped terminal spots, producing a speckled appearance which varies with moult and wear; rectrices white, with the terminal third black, forming a broad band; lesser and marginal wing coverts black, the median and inner greater coverts white, with black terminal spots like those of the scapulars; bastard wing and primary coverts black; primaries black, with a large extent of white on the inner web, this increasing inward from the outermost quill; third primary showing a patch of white on the base of the outer web, this feature likewise increasing in extent toward the innermost primaries, which are entirely white except for their black tips; secondaries white, with black tips; sides of face and neck black like the head, except for a short white line below the lower eyelid; ventral surface of body white, with the chin black; black-tipped feathers appear also at the sides of the neck and chest, and on the lower flanks and thighs; under tail coverts white, with blackish terminal spots or bands; under wing coverts white, with a pronounced black band around the edge of the wing; lower primary coverts white, the outer ones black with white bases; axillaries white, more or less spotted with black tips. Iris dark brown; eyelids black; bare interramal skin dusky red; bill black; legs and feet black, sometimes with whitish spots on the inner sides of the toes.

20 males from the South Shetlands, South Georgia, the Crozet Islands, Tierra del Fuego, pelagic localities in the South Atlantic, and the coasts of Chile and Peru; wing, 249–273 (260); tail, 89–103 (95); exposed culmen, 29.3–32.7 (31.1); width of bill at base, 15–16.3 (15.5); tarsus, 33.6–47 (44); middle toe and claw, 53.1–60.6 (57) mm.

15 females, from many of the same localities: wing, 255–272 (264); tail, 90–100.6 (94.8); exposed culmen, 28–33.5 (30.5); width of bill at base, 12.5–16.3 (14.7); tarsus, 42–45.5 (43.6); middle toe and claw, 53–57.6 (55.1) mm.

Length in the flesh (based upon four American Museum specimens and three records in the literature), 38–40.6 cm.; wing-spread, 81–91.4 cm.

A male I shot off North Chincha Island, Peru, October 21, 1919, weighed 300 grams; a female taken next day weighed but 255 grams.

A five-day-old chick, taken at the South Orkney Islands on January 18, was clad in slate gray down, paler on the ventral surface. One with the wing quills sprouted, collected on February 4, had a sooty head and was much paler ventrally (Clarke, 1913, 239).

Eggs are white and of highly variable shape. Eight from Deception Island ranged in weight between 53 and 80 grams, the average being 63, the longest and broadest eggs in this series measuring, respectively, 68 x 44.5 and 67 x 47 mm. (Gain, 1914, 147). The average of "many" from the South Orkneys, according to Clarke, was 62.35 x 43.1 mm., the shortest and longest measuring 56.5 x 43 and 67.2 x 43.3. Hartert and Venturi (1909, 255) give the following dimensions for four eggs from the South Orkney Islands: 60.3 x 43.5, 61.4 x 40.5, 59.6 x 41.4, 63.3 x 43 mm.

Distribution: Breeds at several localities on the shores of the antarctic continent, and also at outlying antarctic islands such as the South Shetlands, South Orkneys, South Georgia, probably Bouvet, the Crozets (?) and Kerguelen. Ranges widely in the southern oceans, penetrating farthest north in cool-current regions, regularly reaching northern Peru, and at times even crossing the equator on the west coast of South America.

Best known of sea birds in the southern hemisphere, mentioned in the account of practically every voyage since the earliest days of exploration, is the Cape Pigeon. Its name is truly vernacular, and I have small patience with the pedantry that would alter it to "Cape Petrel." At times I have heard the bird called Cape Horn Pigeon, even by seamen, but this, too, is a misnomer, for in the tradition of the ocean only the Cape of Good Hope is "the Cape," while Cape Horn is "the Horn." The English name of this petrel, which is so well explained by its appearance, has been taken over into Spanish in southern and western South America, and into Portuguese by the fishermen of southern Brazil, to whom the species is well known. The French name is "Damier," because—as explained by Frezier (1717, 29)—this petrel is so regularly marked with black and white, "like the furbelow scarves of second mourning," that it reminded his sailors of a checkerboard. The Spanish names "Damero," as used in Argentina, and "Tablero" in Chile, have the same significance. Friedmann (1927, 145) writes that he recorded his first impression of Cape Pigeons in his notebook as "flying dominoes."

As a breeding bird the Cape Pigeon is confined entirely to regions lying within the Antarctic Zone of surface water. Various older records of nesting stations in lower latitudes, such as Moseley's reference to Tristan da Cunha, von Tschudi's to islands near Callao, and Vanhöffen's to South Africa, are now known to be erroneous. Nevertheless, despite its polar proclivities, the species has one of the most extensive flight-ranges of any sea bird in the southern hemisphere. In the middle parts of the great oceans it migrates northward to the neighborhood of latitude 20° S. Near the continental coasts, particularly where cool surface waters are produced by upwelling or other causes, its northward distribution is extended. Milne-Edwards (1882, 2) was a pioneer in giving a clear explanation, in oceanographic terms, as to why the Cape Pigeon ranges so much farther north in the eastern Pacific than it does in the Atlantic. As a matter of fact, the species is one of the commonest migrants from the far south throughout the length and breadth of the Humboldt Current. Beck and I observed and collected specimens at many points along the coasts of Peru and Chile during both winter and summer seasons. Captain Thomas Dick, who worked with me at Talara, Peru, and demonstrated his ability to identify this and other conspicuous sea birds of the region, assured me that he had seen Cape Pigeons off Salinas, Ecuador, during February, 1924, and as close to the equator as Manta on an earlier occasion. Lucas (1887, 4) reports that examples of the species once followed the ship 'Calhoun' northward across the line to a point near Acapulco, in latitude 16° N., and in the American Museum there is an old specimen from Monterey, California. Some of these records are, of course, exceptional, but each winter season finds Cape Pigeons in numbers at least as far north as Point Pariñas. During July and August they frequently invade the harbor of Talara, and MacFarlane (1887, 208) found them plentiful off Paita at the same time of year.

Near the southern tip of South America, Beck found the Cape Pigeon abundant along nearly every open coast, as well as throughout his several passages between the continent and the Falkland Islands. A few localities and dates at which he noted the species as numerous are the following: off Cape Tres Montes and in the Gulf of Peñas, Chile, July 4; about Cape Horn and the Wollaston Islands, April and July; eastern Tierra del Fuego, Strait of Le Maire, and waters off Staten Island, May, August, September; around the Falkland Islands, August and September; Mar del Plata, Argentina, October 5. His many specimens agree completely in appearance and dimensions with a series which he subsequently collected for the American Museum in New Zealand seas.

It would not be worth while to note many low-latitude records in the Atlantic. In winter, however, Cape Pigeons are common as far north as Cape Frio on the Brazilian coast, and Friedmann first met them in late August still farther northward, or in the neighborhood of the Abrolhos Islands. Hutton (1865, 287) refers to seeing together in this same part of the South Atlantic such an extraordinary mixture as Cape Pigeons, tropic-birds, and flying fish. The mouths of great streams, such as the Río de la Plata, are favorite points of concentration. Likewise the Cape Pigeons often tend to gather about islands remote from their breeding grounds. I frequently saw them on the water under the granite cliffs of various Peruvian guano islands, and they have been collected close to San Ambrosio, Juan Fernández, and the several islands of Tristan da Cunha. When the 'Quest' was northbound through the Atlantic from the pack-ice, numbers of Cape Pigeons followed her to a point within sight of St. Helena (Wilkins, 1923, 487).

The last record leads to a consideration of the influence that ships may exert in extending the pelagic ranges of sea birds. Cape Pigeons are eager devourers of garbage, and it would not be unnatural if bands of the birds sometimes pursued vessels a considerable distance beyond the normal borders of their range. That the same individuals may actually remain with a vessel for many days on end; we have a certain measure of evidence. Green (1887, 32), an accurate and factual observer, refers to a Cape Pigeon with a red stain, which followed his ship southward "for days and days together." Hutton (1865, 292) speaks of one freed with a red ribbon around its neck which followed a vessel thereafter for 1500 miles, and King (1839, 54) states that a surgeon of the Royal Navy observed one from day to day along a passage of 5000 miles after the petrel had been similarly marked and set free. With modern steamships the case may be somewhat different from that of the windjammers of old.

The numerous casual records of the Cape Pigeon in the North Atlantic and other extralimital regions may be due in large part to the capture of birds previously liberated by seamen. Certainly many are caught on fishhooks or bent nails by ships' hands off duty, and all such victims are not eaten at once. The birds may be kept alive in a tub and fed by the crew, under the misapprehension that they can be fattened for a feast. One sailor told Hutton (1867, 188) that he had freed six Cape Pigeons at once in the entrance to the English Channel. Such a type of introduction may account for many records of southern sea birds in the northern hemisphere, including sundry examples mentioned in the life histories of the albatrosses.

Although the Cape Pigeons are likely to be encountered at sea during any time of year, Hutton's long experience led him to the conclusion that their pelagic movements were obviously reduced during rhe nesting season. On occasion he had been unable to find a single example during the month of March in regions where the birds were abundant at other seasons. There is more or less evidence that many of the Procellariiformes may not breed until at least their second year of life, and that 20 per cent or more of the population may remain in the pelagic range throughout the nesting season (Wynne-Edwards, 1935, 274). But most of the non-breeding Cape Pigeons doubtless retreat toward the zone of melting sea-ice during the summer, besides which the whaling operations at South Georgia and elsewhere now serve as a magnet to draw hundreds of thousands of such birds from the oceanic trade routes. The Museum has many specimens taken at South Georgia and lower latitudes, between September and December, which are marked as birds with small gonads.

Although the Cape Pigeons make up a sort of vanguard of the pack-ice, they penetrate toward the heart of it much less than any of their three south-polar relatives, the Snow Petrel, Antarctic Petrel, and Silver-gray Fulmar. In all parts of the polar region, moreover, they move toward the outer fringes early during the antarctic autumn, thereafter tending to oscillate more or less in accordance with the weather and the state of the sea-ice. While members of the Swedish Expedition were wintering at Paulet Island, they observed a few Cape Pigeons on mild days following storms in April, after which no more were seen until the ice had thoroughly cracked up, about the middle of the following October (Andersson, 1908, 46). The experiences of the French naturalists, on the opposite side of the West Antarctic Archipelago, were similar (Gain, 1914, 147). In early November, during the cruise of the 'Deutschland,' Filchner (1922, 117) found the species abundant about the northerly isles of the South Sandwich group which, no doubt, are breeding stations. At the same season the Cape Pigeons flock to the South Shetlands, but at South Georgia they are present in great force all the year round.

Although it is said that no nest of the Cape Pigeon has yet been found at South Georgia, there is little reason to doubt that this island, like the more southerly members of the Scotia Arc, forms part of the breeding range. The birds were common at all seasons before the beginning of modern whaling, and von den Steinen (1890, 251) collected an example with a bare brood-patch on its belly. Furthermore, South Georgia is climatically within the breeding range, which includes Bouvet, the Crozets (?), Kerguelen, and Heard Island, as well as the more southerly islands of West Antarctica.

At the South Orkney Islands the Cape Pigeons return to their nesting grounds by the middle of October (Valette, 1906, 63). Their courtship lasts a month or more, during which period they coo and cluck to each other continuously About ten days before the appearance of the eggs, the birds abandon the nesting haunts for a time and depart on a "honeymoon." A similar habit of disappearing somewhere at sea during the same stage of the reproductive process has been at least vaguely reported of certain shearwaters and storm petrels, and the matter deserves intensive investigation.

In all parts of the breeding range the nesting sites, which are niches and projections of more or less inaccessible cliffs not far from the sea, seem to be chosen at the same season. Numerous accounts from West Antarctica agree, furthermore, with those of Hall (1900, 28) at Kerguelen Island, and Mawson (1915, 2, 117), that the Cape Pigeons everywhere make a paved platform of small fragments of stone, and upon this lay the single egg. Clarke (1913, 239) reports that the members of the Scottish Expedition found the first eggs at the South Orkneys on December 2 and 3 of two successive years. Within a few days thereafter, eggs became common on exposed ledges of the cliffs at Laurie Island, at heights from 6 to 30 meters above sea level. Eggs taken from the nests were apparently never replaced by new ones. The period of incubation proved to be not less than 42 days, a fresh egg marked December 2 hatching on January 13. Young birds were still covered with blackish down on February 5. Chicks in the same stage have been reported at Kerguelen Island on February 7. In defending their eggs and young, the brooding Cape Pigeons squirt their oily stomach contents, in which Clarke found semi-digested euphausians, to a distance of more than 2 meters.

The moult of the quill feathers takes place during the rearing of the chicks, and Borchgrevink believed that he saw adults partially incapacitated for flight during this process (Sharpe, 1902, 156). A male in the Museum collection, taken at Deception Island on February 14, shows a complete set of new, short primaries, the wing-length being reduced to 202 millimeters, or less than 80 per

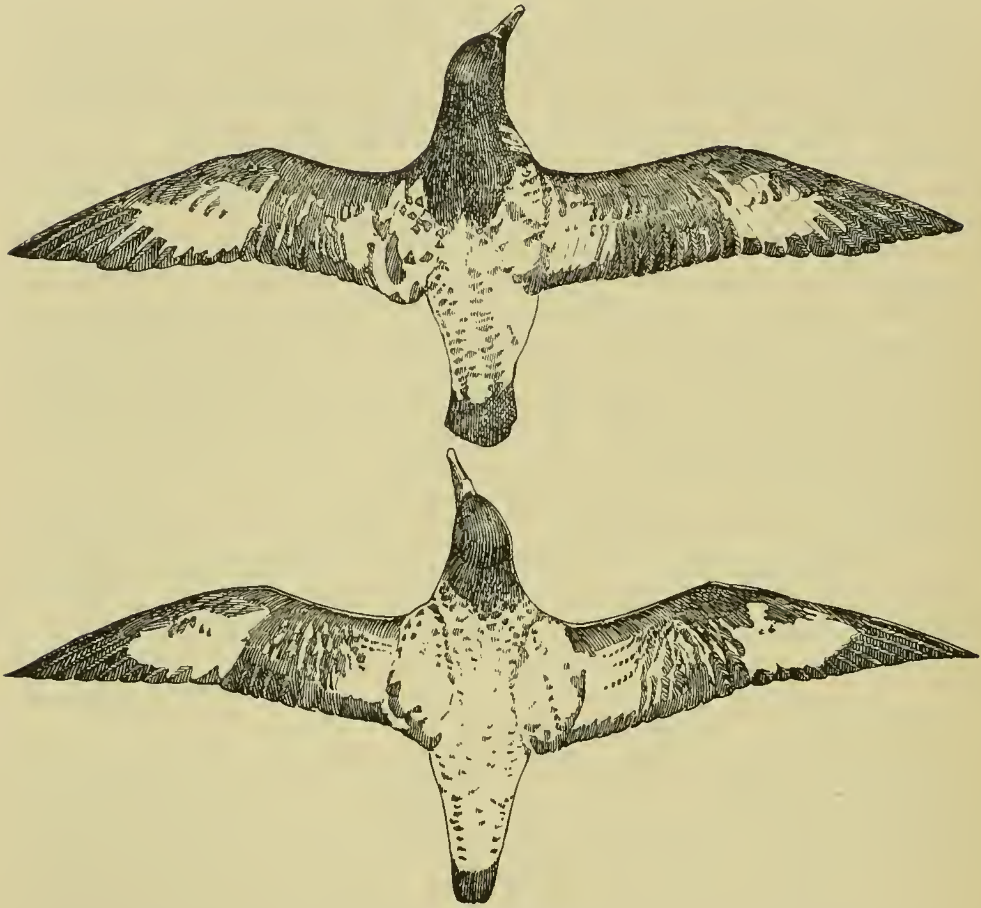


Fig. 58. Effects of wear and moult upon the plumage-pattern of the Cape Pigeon.

Upper drawing, fresh body plumage, new and not yet full-grown quills (♀, Cumberland Bay, South Georgia, July 19, 1914); *lower drawing*, worn plumage, with much of the black feather-tipping abraded away (♀, latitude 36° 16′ S., longitude 46° 35′ W., South Atlantic, November 8, 1912).

cent of the mean. Replacement is in the usual order, beginning at the wrist. An adult female collected at the same locality on March 9 has such short new rectrices that the under tail coverts project far beyond their tips. Other adults, from the South Shetlands and New Zealand waters, retain only one or two pairs of the old outer primaries, and demonstrate that the replacement process may continue until April or May.

Moult of the body plumage is apparently less regular or more prolonged, and is complicated by the probability of its not infrequent suppression among non-breeding, non-migrating birds which remain in low latitudes during the normal reproductive period. Thus the extreme of wear and fraying is illustrated by November specimens from Valparaiso and the coast of Peru. Many pelagic Cape Pigeons have strikingly white backs, which are so different from the heavily speckled condition of fresh plumage that examples representing the two stages have been mistaken for different races or species. Considerable confusion in the literature, indeed, has resulted from the inability of certain authors to recognize fresh plumage, which has a very different appearance from worn plumage. Study of our large series shows that the black lunulas of the dorsal feathers gradually wear away after the moult until only faint spots remain. The course is exactly the opposite of the interpretation given by Godman (1909, 280) to the effect "it is possible . . . that the black spots, at first minute, and occupying the tip of the feather, gradually spread until the whole of it is black." It is not difficult to see what actually takes place, provided large numbers of specimens are laid out in an order correlated with season, though the body plumage shows a less consistent progression than the quills.

Cape Pigeons rest freely on the water, even in mid-ocean. In the harbor of Deception Island they frequently cover the surface, and have constituted a difficulty, or rather a menace, to the landing and taking-off of sea planes by Wilkins, Ellsworth, and other explorers. During blizzards at South Georgia, I often saw the birds sitting firmly on the fiords when the surface was lifted in sheets by the gale and spray was flying all around them. They appear to float so lightly that one would expect to see them picked up and whisked away by the wind.

Hutton (1865, 287) states that the Cape Pigeon cannot rise from a deck and that its terrestrial progress is a hobbling on all fours. I have never seen it ashore in any other attitude than squatting on the full length of the tarsus. It is probably one of the most helpless of petrels when out of the air or off the water. Except under conditions beyond their control, these birds alight only upon ledges of cliffs or steeply sloping surfaces, such as snowbanks, from which they can easily spring into the air. After the Cape Pigeons had gorged themselves in front of the whale-slips at Cumberland Bay, South Georgia, I often saw them fly to snowbanks along the adjacent shore, where they sunned themselves. Campbell (1877, 115) reports that when the 'Challenger' passed an iceberg to southeastward of Heard Island, large numbers of Cape Pigeons were resting in the soft snow on a steep slope of the ice.

Except in the teeth of a strong wind, the Cape Pigeons run foot after foot along the water when launching into flight. Sometimes when following a ship they will keep up this hydroplane style of progression for long distances, instead of mounting into the air. By this I mean that they set their wings as gliders and, keeping the breast barely above the surface of a quiet sea, they propel themselves with rapid, alternate, running strokes of the feet. In this manner I have seen them trail my baits for an hour at a time. Darwin noted that the Cape Pigeons dive quite beneath the surface in pursuit of offal thrown from a ship (Gould, 1841, 140), and Turquet reports that he has seen them submerge themselves to a depth of at least a meter without, however, attempting to swallow food until they had returned to the surface (Menegaux, 1907, 63). According to Green (1887, 32), they are especially easy to catch on hooks after a storm, when sea birds seem particularly ravenous, as though their natural food had been difficult to obtain during the period of rugged water. I doubt, however, whether the Cape Pigeons need the stimulus of a storm to make them hungry, for they are notoriously voracious birds. Scouler (1826, 203) tells of catching 200 of them on fishhooks baited with suet, one October day off the Patagonian coast. These were all eaten by the sailors of his ship.

The food of the Cape Pigeon is as varied as its voracity is incredible. It may be called a glutton, in the human meaning of the word, not only because of its appetite but equally because each Cape Pigeon seems to dislike to see another eating as much as it enjoys the process itself! At South Georgia I saw a good deal of sea-elephant slaughter by Yankee sealers, and at the Bay of Isles I witnessed frequently the division of spoil arranged by nature between the hungry hordes of the land and those of the sea. Thus, when an unfortunate seal had been shot or clubbed to death on the beach, the skuas would congregate to "assist" in the blubber-stripping process, and to feast upon the steaming red flesh of the abandoned carcass. After the departure of the bloody-handed humans, the Giant Fulmars, less bold or impudent than the skuas, would assemble to reduce the victim to a skeleton.

While such deeds were going on ashore, the Cape Pigeons would congregate in the water just below the beach and wait expectantly, floating as high and lightly as corks, with their wing-tips much overlapped above the tail. Not one of them would be tempted to leave the sea for the outlawed regions of the shore. Rather, they would all watch and hope, killing time by turning the head and preening their plumage, an act that made them look for all the world like black and white pigeons afloat. As soon as the blocks of sea-elephant blubber had been carried or dragged to the water's edge, and attached to loops of ropes called raft-tails so that they might be towed by the whaleboats to the ship, the orgy of the Cape Pigeons would commence. With a continuous clamor, and with vicious, uninterrupted fighting among themselves, they would fall to and peck at the blubber almost as rapidly as a woodpecker drums his tree. The custom of the sealers was to allow the blubber to soak overnight alongside their anchored vessel, in order to wash out the blood corpuscles which tend to discolor the oil. This process assured a night-long feast for the Cape Pigeons, despite everything that one or two members of the watch could do to drive them off. The temperaments of the dainty, inoffensive-looking little birds never showed to better, or rather to worse, advantage, for even when their numbers had been temporarily reduced to four or five, along a line of blubber stretching a ship's length, there was still never room for these few to eat without battling. At times, when noisy hordes were crowded along the whole length of the hawser, I have seen one champion berserker among them run amuck and dart pugnaciously along the blubber-line from one end to the other, driving off every bird in the mob. Of course, all the dispossessed closed in immediately in the rear, so that nothing was accomplished by the maneuver except a satisfaction of the ego. Bennett (1927, 259) has well said that one whale carcass is too small a morsel for two Cape Pigeons to divide in peace!

Nor is the predaciousness of the Cape Pigeons confined merely to a show of force among their own kind. Their violence goes, in fact, to bloodthirsty and cannibalistic limits. On the whaling banks off South Georgia I once saw several of the Antarctic Whale-birds (*Pachyptila desolata*), which at the time filled the air like snowflakes, killed by the discharge of the gun of a Norwegian whale-chaser. The petrels were not hit by the harpoon but were stunned by the gas, or perhaps struck by fragments of the wad. At any rate, the helpless birds had scarcely struck the water, where they lay feebly struggling, before they were attacked by Cape Pigeons, which quickly succeeded in tearing open their body cavities. At later dates I had additional opportunity to observe the bird-eating proclivities of this species, for, near the Chincha Islands, Peru, I shot two which were engaged in devouring the entrails of floating cormorant and booby carcasses.

At the conclusion of such a garrulous and cantankerous banquet upon blubber as I have described above, the Cape Pigeons temporarily leave the source of supply, cease the hubbub which, as Hutton says, is like the sound made by scraping the teeth of a coarse steel comb, and proceed to bathe scrupulously. They flatten their spread wings upon the water, dip, erect their feathers, shake violently, and subsequently prink.

Vallentin (1924, 297) relates that he was once on board a whaling ship when a kill was made off the Falkland Islands. Within a short time, Cape Pigeons, which had not been seen before, seemed to spring from nowhere to settle about the carcass for the sake of the small crustaceans (*Munida*) thrown up by the dying whale. It is hard to say whether in this instance sight alone was the sense that had guided the birds to the scene of slaughter but, as related in my biography of the Wandering Albatross, Mr. Beck made a discovery which would indicate rather strongly that the Cape Pigeon is gifted with a well-developed "nose." On the ocean east of the Falkland Islands he had been engaged in baiting sea birds within range of his gun and camera when, on September 20, 1915, he discovered that Cape Pigeons, albatrosses, and Giant Fulmars responded much more quickly to fat and oil that had been heated on the galley stove than they did to cold bait. He subsequently found that the technique was one to be relied upon, for it evidently attracted at least some of the Procellariiform birds from afar.

Fish, crustaceans, and remains of squids have all been found in the stomachs of Cape Pigeons taken at a distance from man-made sources of whale or seal blubber. Birds with anything in their stomachs are usually found to be well packed with a single type of organism, as though they had encountered a concentration of suitable food and had lost no time in filling up. The stomachs of two I collected off the Peruvian coast each contained more than 500 small hippas (*Emerita analoga*), which is the more surprising since these crustaceans, in the adult stage at least, are creatures of the wave-wash of sandy beaches, rather than of the waters beyond. A third bird from the same region contained a considerable mass of laminar seaweed, some of it with red spots, and also squid mandibles. There were likewise a few bits of gravel. King (1839, 541) found fragments of granite in the stomach of a Cape Pigeon captured at the entrance of the Río de la Plata, and he concluded that the bird was a long way in both space and time from any locality at which stone of such composition might be obtained.

The Cape Pigeon has a curious mouth-structure, pouch-like as in *Pachyptila*, and with a fleshy, bifid tongue, which is attached for most of its length to the skin beneath the gnathidea. Further details, as correlated with method of feeding, are as follows:

> If the bill of a fresh specimen is examined it will be found to have a series of fine serrations on the inner side of each margin of the maxilla, which overlaps the mandible of each side when the bill is closed. The skin between the rami of the mandibles is naked and thrown into folds and can be depressed to form a small pouch. The whole apparatus is very similar to the beak of the Whale Birds (*Prion*), though not so highly developed. In feeding, the minute particles are hooked up by the tip of the maxilla, with a few drops of water, in rapid succession into the mouth, and the pouch is quickly expanded and contracted so that the water is strained off at the sides of the bill and the food particles are retained on the serrations. When feeding in this manner the bird keeps vigorously paddling to each side with the feet, so that it only moves forward slowly and a current of water is drawn in towards it from the front (Matthews, 1929, 576).

The greasy matter ejected by Cape Pigeons is highly varied in color and consistency. Frequently it is bright red, which I suspect may sometimes be due to a pigment derived from *Munida* or one of the other crustaceans responsible for so-called "red seas." I have seen Cape Pigeons with their breasts stained red or pink, presumably from this same discharge. Scouler (1826, 203), who was a surgeon, reports that the source of the stomach oil is in thickly set glandular follicles of the large and membranous anterior stomach. Although considerable attention has been given to the chemical characteristics of petrel stomach oil, as related in my introduction to the Procellariiformes, there seems to be little or no recent work concerning the anatomy and physiology of its secretion.

The Whale-Birds of the Genus Pachyptila

The whale-birds or small blue petrels of the genus *Pachyptila*, formerly called *Prion* and more recently endowed with separate generic names for each species, are represented by four specific groups, each of which is easily distinguishable from the others. There is a strong possibility, however, that one of the forms commonly treated as a subspecies of *Pachyptila turtur* should be recognized as a full species, making five in all.

In the whole order Procellariiformes there is probably no other aggregation of closely related species which has been so confused in the literature as these petrels. Not only are there several synonyms for most of the specific names now believed to have prior claims over others but, moreover, these names, through misinterpretation or misidentification, have become transposed from one species to the next in a manner which is bewildering if not altogether hopeless. I believe it safe to say that about half of the older Museum specimens of these birds which I have examined have at one time or another been incorrectly identified, as indicated by the name or names written upon the labels. Furthermore, most of the observers responsible for the "log of the birds" kept on scientific expeditions in the southern oceans have either been unaware that there is more than one species of whale-bird, or have at any rate failed to discriminate among them as they were noted in life. It is doubtful, in fact, whether the several species of *Pachyptila* are certainly determinable, as they may be seen over the ocean, except under the most extraordinarily favorable circumstances. Clarke (1913, 264) admits that under the collective term "blue petrels" two or more species of *Pachyptila*, together with *Halobaena caerulea*, were confounded by the Scottish antarctic explorers, as they had been during many other expeditions of the preceding hundred years and more. Fortunately, the error of the 'Scotia' naturalists has done no harm, because the final records were limited to determinations based upon specimens actually collected. This scientific candor does not, however, apply generally. Scores, if not hundreds, of records of whale-birds sighted at numerous parts of the southern oceans have been based upon no certainty extending beyond the identification of the genus. Specific names have been applied in large measure as a result of assumed geographic probability, derived by subsequent consultation of books of reference. I think it not too much to say that in a very large number of records of voyages, and in local lists of birds based partly upon compiled data, the references to whale-birds of the genus *Pachyptila* are practically worthless, and that even in many standard faunal accounts, the data are misleading because of incorrect identification or the acceptance of transposed specific names from the literature.

Recent systematic work has tended to complicate the situation still further, rather than to clarify it, because an amazing number of subspecies of the whale-birds have been designated upon no adequate grounds. That one or all of the four recognizable species may break up into geographic races I have not the slightest doubt. My complaint is merely that the characters which may actually serve to differentiate such races have never been properly pointed out, and that synonyms have been dumped into the ornithological record in advance of any systematic study even approaching accuracy or thoroughness. As a result, the zoögeographic facts have become as sadly mixed as the names.

The four species of this natural group of petrels are, as I have said above, readily determinable. They show in most dimensions a regular sequence in size, with at most a very slight overlapping in certain measurements between any one of them and the next one higher or lower in the scale. In the size or shape of the bill each one stands out clearly as a distinct entity, without exhibiting a degree of variation which might be interpreted as intergradation. The bills of the four species are, indeed, so different that each species has not unreasonably been made the basis of a distinct genus.

In this book I prefer to follow Peters (1931, 48) and other recent reviewers in treating all of the whale-birds as members of a single genus. This gives the best indication of their obviously close relationship. Furthermore, as I shall show later, the length, depth, and breadth of the bill in the several members, together with important differences in the internal structure of this organ, offer beautiful examples of the phenomena of differential growth, which is alone sufficient to account for the evolution of what I regard as four species of the single genus.

Below, in the left-hand column, are the names of the species certainly determinable from the extensive series of specimens I have studied. After each I have attempted to list the true generic and specific synonyms (omitting names which seem merely to have been wrongly applied). In the last column are the subspecific names which have been so copiously and irresponsibly conjured out of nothing. Most of the last are taxonomically worthless, for the reasons given above; only one or two have been accompanied by an adequate description.

Species	Generic Synonyms	Specific Synonyms	Named Subspecies
Pachyptila forsteri	Prion Priamphus	australis latirostris magnirostris vittata	gouldi keyteli macgillivrayi missa salvini
Pachyptila desolata	Prion Heteroprion Pseudoprion Attaprion	banksi dispar fasciata rossii	alexanderi altera banksi macquariensis mattingleyi peringueyi georgica
Pachyptila belcheri	Heteroprion		
Pachyptila turtur	Prion Pseudoprion Fulmariprion	ariel brevirostris typica	brevirostris crassirostris eatoni fallai huttoni nova solanderi

One reason why I have confidence in the classification of the whale-birds here adopted is that it matches the type of geographic distribution exhibited by the forms of these petrels and by numerous other groups within the order Procellariiformes. The four species of *Pachyptila* show definite zonal correlations which have not previously been recognized and which have, indeed, been obscured through confusion of names. Although many details remain to be worked out, the following broad conclusions seem to be well established by factual evidence.

1. *Pachyptila forsteri:* breeding range confined to lower latitudes of the Sub-Antarctic Zone of surface water; at Tristan da Cunha, in fact, the nesting grounds lie practically on the Sub-Tropical Convergence. The record of this species as a resident of South Georgia (Dabbene, 1923, 134) is based upon erroneous identification, as I shall demonstrate below. There is no evidence that it reaches even the much milder Falklands, or Kerguelen Island. For this reason the record of a form of *forsteri* from the Crozet and Marion Islands (Mathews, 1912, 212) is open to serious doubt; indeed, Mathews's figure of the bill of "*Pachyptila vittata salvini*," on page 213 of his work, proves that the Crozet Island resident

bird is an out-and-out example of *Pachyptila desolata*, as long since pointed out by Godman (1910, 286).

The following list of localities tells approximately all that we have learned regarding the breeding range of *Pachyptila forsteri*, and sufficienrly indicates its faunal status: islands in Foveaux Strait and in Hauraki Gulf, New Zealand; Auckland Islands; the Chatham Islands; Gough Island and Tristan da Cunha in the South Atlantic; St. Paul and Amsterdam (?) Islands in the Indian Ocean.

From this it appears that *P. forsteri* reaches its southernmost breeding outpost just beyond latitude 50° S. in the exceptionally temperate region of the New Zealand Sub-Antarctic Zone. Numerous pelagic records for this species as far south as "70° south latitude" (Oliver, 1930, 111) mean little or nothing, and may be discounted.

2. *Pachyptila desolata:* breeding range confined to the Antarctic Zone, or to islands close ro the convergence between the Antarctic and Sub-Antarctic Zones of surface water. This is rhe only resident *Pachyptila* of South Georgia, the South Orkneys and other islands in rhe American antarctic quadrant. It probably breeds also in the South Sandwich group (Kemp and Nelson, 1931, 156), at Bouvet, rhe Prince Edward and Crozet Islands, Kerguelen and Heard Islands, Macquarie, and possibly the Auckland Islands, though the status of the form attributed to the last locality needs further investigation. It is quite possible, to be sure, that rhe breeding range of *desolata* overlaps that of *forsteri* at the Aucklands, just as it does that of *turtur* at Kerguelen. In most parts of its generally icy breeding range, however, it is the sole representative of its genus, and is undoubtedly the species which has so frequently been reported in pack-ice beyond the antarctic circle, in Weddell Sea, the Indian Ocean quadrant of Antarctica, etc.

3. *Pachyptila belcheri:* breeding grounds probably restricted to the colder parts of the Sub-Antarctic Zone of surface water, close to the polar fronr. Pelagic birds have been captured in the Australasian region, and in the Atlantic and Pacific oceans close to the southern tip of South America. An almost certain breeding ground is among the Jason Islands, at the northwest corner of the Falklands. This is the least known member of the genus, and details of its range, which is doubrless more or less sub-polar, remain to be worked out.

4. *Pachyptila turtur:* breeding range sub-antarctic, confined so far as yet known to the Australasian and Indian Ocean areas, where it nests at the Chathams, Bounty, and Antipodes Islands, islands in Bass Strait, and at Kerguelen. Oliver (1930, 115) records it also from islands in the Gulf of Hauraki, and other localities close to both North and South Islands of New Zealand. He indicates, furthermore, rhat at least two subspecies show valid correspondence with different latitudinal belts in the New Zealand area. This fact is confirmed by excellent series of specimens in the American Museum, collected during the Whitney South Sea Expedition. It is, indeed, not unlikely that the so-called southern race of *Pachyptila turtur*, which is known as *crassirostris*, should be regarded as a distincr species. In fact, Mathews's generic name, *Fulmariprion*, created for *P. t. crassirostris*, has in my opinion a better claim to recognition than any other genus proposed for the birds here comprised within *Pachyptila*.

In any event, so few examples of the species *turtur* have been found in the oceans adjacent to South America that the existing records may well be based upon rare stragglers from the Indian Ocean or elsewhere. It is certain, at least, that no breeding grounds have yet been discovered in the South Atlantic or the eastern South Pacific. For this reason I shall leave the status of the races or species now encompassed within the name *turtur* to be worked out in future.

It remains only to diagnose the several species just discussed. As shown in the accompanying drawing, the names *turtur*, *belcheri*, *desolata*, and *forsteri* correspond with an increasing sequence in the size of the bill. *Pachyptila turtur* has perhaps the most distinctive bill of the four, for the three others represent what resembles a true evolutionary series, the bill of *belcheri* being of a type that is structurally ancestral to that of *desolata*, while the bill of *forsteri* is merely an exaggeration of that of *desolata*. Furthermore, the bill of *belcheri* resembles the immature or larval condition in *desolata*. While the maxilla is never as broad as in even fledglings of *desolata*, the general morphology of each element, including every line and curve, is remarkably similar.

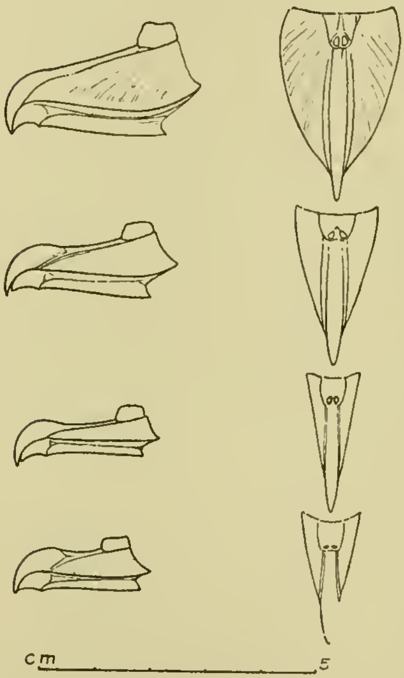


FIG. 59. Lateral and superior aspects of the bills of four species of Whale-birds. All represent males.
Reading downward: *Pachyptila forsteri*, *P. desolata*, *P. belcheri*, *P. turtur*.

In the bill of the smallest-billed member of the group (*turtur*), and in the slightly longer but even narrower and more slender bill of *belcheri*, the lateral border of the palate is marked by a series of transverse rugosities which run more or less at right angles to the cutting edge of the maxilla. In *desolata*, which has a much wider and heavier bill than either of the preceding species, these structures have both broadened and lengthened, so as to form a row of definite lamellae. The latter rise to a height of about 1 millimeter from the plane of the palate, and between their inner ends and the cutting edge of the maxilla is a groove into which the opposing edge of the mandible fits. In the species *turtur* and *belcheri*, it would be hard to believe that the faint striations could have any function whatsoever, unless they might serve to increase the grip of the bill slightly. In *desolata*, however, the lamellae are developed to such a degree that they can evidently function as a sieve or strainer.

In *Pachyptila forsteri*, in turn, these lamellae have grown enormously beyond the stage exhibited by *desolata*, and form a curved fringe of 150 or more transparent keratose plates on each side, which attain a length of 3.5 millimeters in the proximal half of the mouth and decrease in length toward the tip of the bill. Each plate is shaped like a shark's fin, with a curved stiffening rod on the inner side. The comb-like row of these closely appressed lamellae fits inside the tomium of the mandible when the mouth is closed, while the edge of the maxilla closes down outside it. The entire apparatus, in which a large, fleshy tongue is also involved, appears to be analogous with the mouth-parts of a whalebone whale. It would be hard to imagine, moreover, that the palatal screen of *P. forsteri* does not function in straining food from the water very much in the same manner as baleen.

Thus the sequence of mouth-structure in the *Pachyptila* group as a whole represents an excellent example of what might formerly have been termed orthogenesis, but which gains meaning if it is understood as a result of disharmonic growth of a single organ (the bill) in relation to the remainder of the animal. The fringe of plate-like lamellae, which doubtless develops during the ontogeny of *Pachyptila forsteri* from a series of minute striations such as remain in the adult stage of *Pachyptila belcheri*, is also an example of what is sometimes called an aristogene.

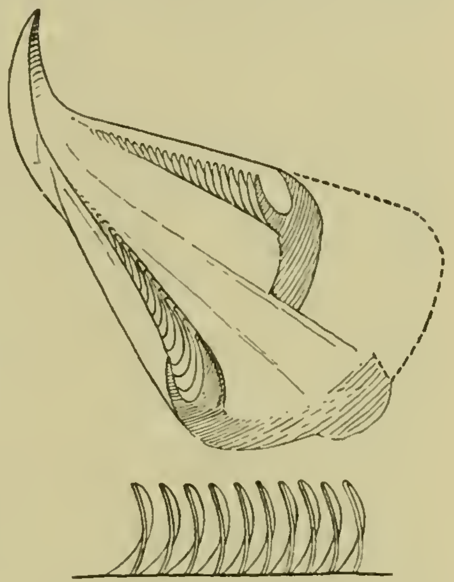


FIG. 60. Maxillary lamellae of *Pachyptila forsteri* (much enlarged).

The upper drawing is a palatal view; the lower shows a series of ten plates on the right side, as seen from the mid-line.

BROAD-BILLED WHALE-BIRD

Pachyptila forsteri

Procellaria Forsteri Latham, 1790, Ind. Orn. 2, p. 827 (New Zealand).

The following has been described as a South Atlantic subspecies:

Prion vittatus keyteli, Mathews, 1912, Birds Australia, 2, p. 210 (Tristan da Cunha).

Names: Broad-billed Prion; Scooper, Blue-Billy, and Right-whale Bird are vernacular names long used by whalemen and the sailors in the southern Atlantic and Indian Oceans, the last name being due to the resemblance between the laminations of the bird's bill and the plates within the mouth of a right-whale; "Petrel de las Ballenas" is a translation of this which appears in some South American Spanish texts, and "Faigão" is the Brazilian name; Night-bird is one of the local names at Tristan da Cunha, but it may not be applied exclusively to this petrel. The many specific and subspecific names which have been used for this species are cited on page 612.

Characters: An exceedingly broad-billed or "frog-mouthed" species of whale-bird, the maximum width of the upper mandible ranging usually between 21 and 23 mm., and apparently never being less than about 18 mm. in adults from any part of the world. The long strainers or baleen-like plates inside the cutting edge of the maxilla are also diagnostic. Furthermore, this is in all dimensions the largest member of the genus, with a minimum wing-length of about 200 mm.

Adults (sexes alike): General color of dorsal surface and sides of neck and breast blue-gray, definitely bluer than the deep gull-gray of Ridgway; crown darker than back, owing to brownish terminal margins on many feathers from forehead to nape; base of forehead, greater part of lores, and a narrow area below the gape mottled whitish; feathering around eyelids narrowly black, and from the inner canthus of the eye a broad blackish infraorbital stripe extends caudad toward the auricular region; above this and forking nearly around the eye is a white though slightly mottled ocular stripe which extends caudad as far as the dark infraorbital stripe beneath it; a small dusky spot on the rump; lesser wing coverts dusky brown, becoming darker and inclining toward black on the outer primary coverts, the latter being very narrowly edged with whitish at their tips; outermost primary sooty black on outer web and the adjacent part of inner web, rest of inner web white; in the next three the sooty black is confined to the outer webs, the remainder showing less and less white and inclining toward gray; inner primaries and secondaries slate-gray, less blue than the back, with a slightly darker wash on the inner webs; the long scapulars are subterminally dusky black and tipped with whitish; tail-feathers gull-gray with broad (30–40 mm.) blackish tips on the central feathers, these becoming obsolete on the outer feathers; the long upper tail coverts, which are the color of the back, give the tail a blue, blackish-tipped aspect; throat, breast, abdomen, crissum and sides of body, axillaries and under wing coverts, white, the flanks washed with a delicate bluish gray tinge on the tips of the long feathers; under tail coverts basally white, the longer ones broadly tipped with dusky black, the shorter feathers terminally blue-gray like the lower flank feathers, or mottled with the same hue. Iris dark brown; bill light blue or bluish gray, the nostrils, culmen, and a line between the lateral plates of the lower mandible black, the unguis yellowish or horny; legs and toes pale blue, the webs flesh colored with the free borders gray.

10 specimens from the Chatham Islands (5 of each sex): wing, 199–213 (205.2); tail, 92.3–113.2 (101.5); exposed culmen, 31.9–36.6 (34.1); greatest width of bill, 20.1–22.7 (21.2); tarsus, 33–36.2 (35); middle toe and claw, 39.8–49.3 (41.5) mm.

5 specimens from Tristan da Cunha and Gough Island which I have measured in the British Museum, show the following comparative dimensions: wing, 203–217; tail, 96–104; exposed culmen, 34–37; greatest width of bill, 20–22; tarsus, 35–37; middle toe and claw, 40–44 mm.

Nestlings, according to Oliver (1930, 111), are covered with smoky gray down, lighrest on the ventral surface, and the maxillary lamellae are only slightly developed.

Two eggs from Tristan da Cunha are described as white, smooth, and of typically oval form. They measure, respectively, 52.5 x 35 and 51.5 x 35 mm. These do not differ materially from numerous eggs recorded from the New Zealand region.

Distribution: Certainly known to breed within our region only at the islands of the Tristan da Cunha group and at Gough Island. The general distribution of the species is sub-antarctic and barely sub-tropical, and has been sufficiently discussed on page 612.

The Right-whale Bird, says Green (1887, 33), is always looked for by sailors in the neighborhood of Tristan da Cunha. This author of an astute and useful book on oceanic birds, though one now rare and little known, employed the name *turtur* for this species but at the same time made it clear that he referred to the Broad-billed Prion, thus illustrating the only too familiar experience that a vernacular name may prove more stable and practical than a technical one.

At Tristan the Night-bird, as the inhabitants call the Broad-billed Prion, nested in vast numbers before man and the vermin which he transports had made a great change in the pristine ecological balance of the island. More than a century ago Carmichael (1818, 487) could write that the soil above the fern-belt of Tristan

. . . is perforated in all directions by the various species of Petrel, which resort in myriads to the island during the season of incubation, and burrow in the earth. The weaker tribes of these birds are devoured in vast numbers by the Skua gulls.

Since Tristan da Cunha has been overrun with rats, this petrel and many others have become scarce, and it is not even certain that the Night-bird still nests at Tristan itself, though it is numbered among the surviving residents of the neighboring islands of Nightingale and Inaccessible, which may have been spared rats even though one or both of them are thoroughly rooted over by ornithophagous hogs!

This whale-bird, which comes to land at the Tristan group in July and lays its egg in September (Barrow, 1910, 275), formerly nested not only in burrows of the island slopes but also in caves. Not far from the Tristan settlement of "Edinburgh" are a number of spacious caverns close to sea level which are known respectively as Freshwater Cave, Dry or Guano Cave, etc. Some of these penetrate the rock to a length of a hundred meters or more, and the whale-birds are said to have nested near the inner ends. They were formerly caught by the people of the island through the expedient of lighting fires within the caves, which drew the birds toward the glare. Both birds and eggs were regarded as excellent eating.

At Gough Island, Wilkins (1923, 508) dug four examples of this species (which I have examined in the British Museum) from deep burrows on slopes near the beach, between May 28 and June 1. The birds were betrayed by the noise they were making, and many others were in the vicinity. Dissection of the specimens showed no sign of proximity to the breeding season, and the time of year was, of course, close to the beginning of winter. Wilkins inferred from this and other data that many Tristan and Gough Island petrels either make use of their burrows during the non-breeding period or else anticipate the normal date of courtship by an extraordinary number of weeks. Since his specimens were taken at the end of May, it would be natural to infer that they were full-grown fledglings, at the point of departing from the island. However, Wilkins's statement that the birds were in pairs in the burrows puts this out of the question.

Mathews (1912, 210) bases his discrimination of a Tristan subspecies of the Broad-billed Whale-bird upon the allegation that examples "are noticeably lighter in upper coloration" than New Zealand birds. After comparing five specimens from Tristan da Cunha and Gough with fifty or more from the New Zealand region, I can only conclude that color differences are inconstant and are probably due merely to stage or state of plumage. Since measurements offer no added criteria, it seems that valid subspecific distinctions have not yet been pointed out.

Around the world in the southern oceans, the Broad-billed Whale-bird seems to be a petrel of the lower sub-antarctic latitudes and adjacent parts of the Sub-Tropical Zone. Godman (1910, 286) corrects the often-repeated statement that *Pachyptila forsteri* belongs to the avifauna of Kerguelen Island, and the 'Challenger' specimen from Marion Island, many times referred to as of this species, proves to be just what it should be on geographic grounds, namely, an example of *Pachyptila desolata*. In the Indian Ocean the southernmost breeding ground of the broad-billed species seems to be at St. Paul Island.

Doubtless various records of whale-birds cast up after winter storms at Porto Seguro, Santos, Bahia, and other points on the Brazilian coast apply to this species (Wied, 1833, 846; von Ihering, 1907, 38). Although Tristan and Gough are the only certainly known nesting grounds in the South American region, we have the somewhat problematical story told to Darwin of another possible station in the western part of the Magellanic archipelago. The species referred to is, of course, open to question because although Gould uses the specific name *vittatus*, the bird might prove to be *Pachyptila belcheri*, which has only recently been described. At any rate, according to Darwin, a species of prion has long been known to breed on the western outliers of Tierra del Fuego, and has also been taken at a number of different points off the coast of Patagonia. He writes:

> I did not procure a specimen of this bird, although I saw numbers on both sides of the Continent from about lat. 35° S. to Cape Horn. It is a wild solitary bird, appears always to be on the wing: flight extremely rapid. Mr. Stokes (Assistant Surveyor of the Beagle) informs me that they build in great numbers on Landfall Island [south of Desolation Island and the entrance of the Strait of Magellan], on the west coast of Tierra del Fuego. Their burrows are about a yard deep: they are excavated on the hill-sides, at a distance even of half a mile from the sea shore. If a person stamps on the ground over their nests, many fly out of the same hole. Mr. Stokes says the eggs are white, elongated, and of the size of those of a pigeon (Gould, 1841, 141).

The possibility that *Pachyptila forsteri* actually does breed in this region is heightened by the testimony of the naturalists who took part in the cruise of the 'Magenta.' Godman (1910, 287) quotes Giglioli to the effect that on December 6, 1867, one day after leaving the western end of the Strait of Magellan, several large prions with exceedingly broad bills were seen following the Italian vessel for several hours.

Mathews (1912, 206) quotes from the journal of the second voyage of the great circumnavigator, Captain James Cook, incidents and descriptions connected with the capture of the first specimens of whale-birds ever examined by scientific men. He neglects, however, to note the oceanic positions of Cook's entries and, from examination of the original, I am convinced that Mathews combines accounts referring to two distinct species of prions. The first reference appears on October 16, 1772, close to latitude 35° S., longitude 7° E., or midway between southern Africa and Tristan da Cunha. Captain Cook (1777, 12) writes that the 'Resolution' was

> . . . now accompanied by albatrosses, pintadoes, sheerwaters, etc., and a small grey petrel, less than a pigeon. It has a whitish belly, and grey back, with a black stroke across from the tip of one wing to the tip of the other. These birds sometimes visited us in great flights. They are, as well as the pintadoes, Southern birds; and are, I believe, never seen within the tropics, or North of the Line.

The last species mentioned may well have been *Pachyptila forsteri*, though no specimen appears to have been taken in this region. But the remainder of Mathews's quotation undoubtedly refers to *P. desolata*. When Captain Cook speaks of the broad bill, he is evidently comparing the latter with the bill of *Halobaena caerulea*, which is described on an adjacent page. The broadest-billed species was not captured until the expedition reached the New Zealand region.

Wilson (1907, 105), the best of all ornithologists who have worked in the southern oceans, states that while the various whale-birds are not readily distinguishable upon the wing, this species can occasionally be certified at close quarters by the enormous width of the bill. He continues:

> We obtained one or two specimens on the 'Discovery,' and were much interested to find that the floor of the mouth was very extensile, enabling it to take up a much larger quantity of water and small crustaceans than would otherwise be possible. Darwin, in his "Origin of Species," makes rhe following remark: "In the genus *Prion* the upper mandible alone is furnished with lamellae, which are well developed and project beneath the margin; so that the beak of this bird resembles in this respect the mouth of a whale." If the lower bill of a dried skin is examined, more than this would hardly be noticed; for the loose blue skin between the rami of the lower jaw will be found dry and folded to form a hard level floor to the mouth. But if the tip of the little finger is inserted into the mouth of a freshly killed specimen, it will be found that the neatly folded skin can be quite easily distended into the form of a bag, or sac, something like that of the pelican, which is obviously of use to a bird that has developed lamellae on the upper bill which act like the baleen plates of a whale. The rongue is bright orange-pink in colour, smooth and fleshy, and of a suitable muscular character to assist in expelling the fluid from a mouthful of minute crustaceans and the water in which they were taken up.

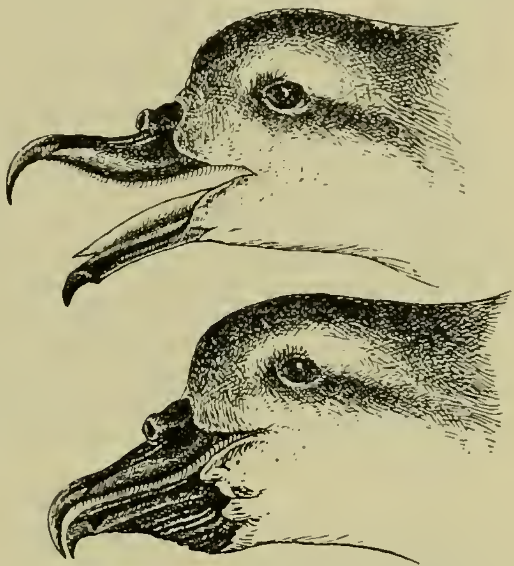


Fig. 61. Head of Broad-billed Whale-bird, showing the baleen-like lamellae, the fleshy tongue, and the expansible pouch.

From Wilson (1907).

Wilson further notes the restless, untiring flight of these birds and the manner in which they constantly rock and twist on the wing, showing first the white under parts and then the blue-gray backs with the dark V-shaped mark. Giglioli calls attention to the fact that prion flight is quite different from that of petrels of the genus *Pterodroma*, being equally swift but more irregular. The wings of whale-birds seem to be opened and shut very frequently and very rapidly; the motions reminded Giglioli of those of turtle doves. Doubtless the peculiar wing-formula has much to do with their erratic gyrations. Although Mathews (1912, 199) states that the outermost primary is longest, as among most petrels, I find by examination of a hundred specimens, representing four species of *Pachyptila*, that the second primary slightly exceeds all the others in length.

The V-mark on the dorsal surface of these birds is an extraordinarily interesting pattern, less because of its distinctive shape than because of the manner in which the tip of the V is formed. Bands composed of terminal markings on various series of wing feathers are common among birds of many sorts. In *Pachyptila*, however, the stripes which converge when the wings are spread are then joined together by a superficial daub of the same pigment on the blue feathers of the rump. Why there should be such an odd pattern-nexus between wings and lower back, and how the diverse units of pigmentation evolved to form an undeniable whole, is an interesting and puzzling biological problem.

Throughout the circumpolar range of *Pachyptila forsteri* the habits, and the correlation between season and physiological rhythm, seem to be similar. Eggs were found in a dark cave at Inaccessible Island, Tristan group, on September 10, 1917. At the Chatham Islands, east of New Zealand, the birds likewise lay in September, and nest in both niches of the cliffs and in burrows excavated in the soil (Travers, 1873, 221). On islets close to New Zealand this variability as regards nesting site also crops out. Burrows are described as being a meter, more or less, in length, with a slight nest of twigs and leaves in the terminal chamber (Oliver, 1930, 112). At St. Paul Island, Indian Ocean, the birds have been found in the burrows during November (Pelzeln, 1869, 147).

The principal natural enemy of this and other whale-birds is the skua, the relation to which will be discussed more specifically in the next biography. Whitlock (1931, 265) says that among all petrels the prions are also the greatest sufferers from storms on lee shores, as along the west coast of Australia. Hunger and exhaustion precede death, and the bodies he has found have always been greatly wasted. Among the members of the genus which Whitlock describes in admirable detail as beach-waifs, are examples of the broad-billed species. In their stomachs he has found beaks and crystalline lenses of cuttlefish, minute bits of shell (crustaceans?), and sometimes fragments of seaweed mingled with grit. Buller also reports very small cephalopod beaks in the stomachs of windblown birds of this species found on New Zealand beaches.

ANTARCTIC WHALE-BIRD

Pachyptila desolata

Procellaria desolata Gmelin, 1789, Syst. Nat., 1, pt. 2, p. 562 (Kerguelen Island).

Names: Ice-bird; Scooper; Dove Prion; "Petrel Paloma" in Argentina. The alternative technical names are listed on page 612.

Characters: Generally similar to *Pachyptila forsteri*, but with a much narrower bill, the latericorn of which is only slightly tumescent. The greatest width of the maxilla is in the neighborhood of 15 mm., as against a minimum of 20 mm. or thereabouts for *P. forsteri;* the average difference in width, as derived from measurements of 20 specimens of these two species, is 7 mm. In the ventral aspect of the bill the difference is even more evident, the mandible of *desolata* being not more than half as wide as that of *forsteri*. Furthermore, the maxillary lamellae of *desolata* are greatly reduced, as noted above. In the general appearance of the dorsal surface, *P. desolata* may average a very slightly paler and clearer blue than *forsteri*, but the difference is extremely subtle. An optical analysis of this color is given below. In size, *desolata* is smaller in all dimensions than *forsteri*, but larger than the succeeding species of the genus. Iris brown; maxilla pale cobalt blue, the narial tube and the culmen blackish; mandible blue save for a narrow black line dividing the plates of each ramus; legs and toes blue, the webs flesh color with gray terminal borders.

10 specimens (5 of each sex) from South Georgia: wing, 182–194 (188.9); tail, 87.5–97.6 (92.7); exposed culmen, 26.7–29.6 (27.8); greatest width of bill, 13.6–15.4 (14.4); tarsus, 31.6–34.3 (32.9); middle toe and claw, 35.7–39.7 (37.8) mm. These measurements are from a series in the American Museum collection. Measurements of 10 random South Georgia specimens measured in other museums give the following closely similar averages: wing, 187; tail, 94; culmen, 27.4; tarsus, 33.2; middle toe and claw, 39 mm.

In nestlings, the protoptyle down is smoky gray, slightly lighter on the ventral surface than elsewhere. The face and throat remain practically bare. The second down is slightly bluer than the first, with a general tendency toward whitish on the belly. Fledgling young are distinguishable from adults only by their bright unworn plumage and by the relative slenderness of the bill which, however, could not readily be mistaken for the bill of any of the other three species.

An egg taken at the Bay of Isles, South Georgia, is white but heavily stained with brown mud, and measures 48.3 x 36.4 mm. The dimensions agree well with those of examples from Macquarie Island (Oliver, 1930, 113).

Distribution: A species of the Antarctic Zone, breeding in our region at South Georgia, and ranging southward beyond the antarctic circle. The distribution in other parts of the world has been sufficiently discussed on page 613.

On the southward voyage of the brig 'Daisy,' in 1912, I had no sure way of determining the species of whale-birds seen continuously in the South Atlantic after the date of their first appearance. Three examples were logged on November 11, and next day, when the noon reckoning gave latitude 39° 41′ S., longitude approximately 45° W., very large numbers were about. Thereafter, until we reached South Georgia on November 23, we found ourselves practically always in the midst of these birds, which sometimes filled the air like snowflakes for hours on end. On November 18, 19, and 20, we encountered a protracted gale from the southwest, with frequent squalls, and throughout this period the whale-birds were more abundant than at any other time. On the 19th, in latitude 50° S., longitude 36° W., a point four degrees due north of South Georgia, we were suddenly surrounded by whale-birds about five o'clock in the afternoon while the vessel was lying-to before very violent southwesterly puffs. Several hundred of the petrels settled on the water near the stern of the 'Daisy,' and for a quarter of an hour I had an opportunity of watching the birds feed while many of them were within 20 meters of where I stood on the quarterdeck. From an examination through glasses, I am confident that they were of the present species, which I subsequently reported upon under the specific name *banksi* (Murphy, 1914, 449). In view of the unbroken series of observations day after day, in waters close to South Georgia, it is probable that the bulk of my Atlantic field notes on whale-birds relate to this species.

On the special occasion referred to, the whale-birds that had come down to the water close to my vessel were progressing in the manner which I have called "hydroplaning" in the preceding general account of the Procellariiformes. The birds worked along with an odd creeping motion, resting their bodies lightly upon the surface but holding the wings just above it, the feet apparently furnishing all of the motive power. Then, as they scurried forward quite rapidly, their heads would be thrust under water and the laminated bills would scoop for food. This, as the captain of the vessel explained to me, was why the Yankee seafarers called these birds "Scoopers." It was impossible at the time to determine upon what organisms the birds were feeding. Groups of the creatures recalled a human swimming-race, for the bodies of the birds were stretched out along the water in the attitude of the "crawl stroke." Frequently, however, each one would dive out of sight, to emerge quickly a meter or less ahead. They stayed below the surface not more than a fraction of a second except, perhaps, when they shot through the crest of a wave, but in a definite field on the water the birds disappeared and reappeared with such rapidity that the area fairly twinkled. About as many were below as above most of the time. When the prey had dispersed, the whale-birds would rise like a school of flying fish, and dart off over the ocean on another quest. There was, as I have said, a very rugged sea running at the time, with wide troughs between the waves, and whenever a great roller with a white and broken crest hurtled along, the birds would not attempt to dive through it but would lift themselves daintily from the water at the last moment, fly through the spume of the comber, and settle immediately on the downward slope beyond.

This species of whale-bird is the only member of the genus native to the Antarctic Zone of surface water, notwithstanding the fact that many other specific names have been applied in the literature to birds taken or observed in the far south. The following record of the taking of specimens was made by Captain Cook among icebergs of the southwestern Indian Ocean, latitude 55° 20′ S., longitude 31° 30′ E., on December 23, 1772. It is worth noting that the latitude is close to that of South Georgia, Bouvet, Heard and Kerguelen Islands, at all of which the Antarctic Whale-bird either certainly or presumably nests. Mathews (1912, 206) quotes this same incident in his account of *Pachyptila forsteri*.

Mr. Forster, who went in the boat, shot some of the small grey birds before mentioned, which were of the peterel tribe, and about the size of a small pigeon. Their back, and upper side of their wings, their feet and bills, are of a blue-grey colour. Their bellies, and under side of their wings, are white, a little tinged with blue. The upper side of their quill feathers is a dark blue tinged with black. A streak is formed by feathers nearly of this colour, along the upper parts of the wings, and crossing the back a little above the tail. The end of the tail feathers is also of the same colour. Their bills are much broader than any I have seen of the same tribe, and their tongues are remarkably broad. These blue peterels, as I shall call them, are seen nowhere but in the southern hemisphere (Cook, 1777, 29).

This is doubtless also the "blue peterel" which Weddell (1825, 35) saw in many places literally covering the surface of the sea that now bears his name. Ross (1847, 1, 315) likewise observed south of Australia and beyond the 57th parallel, on March 28, 1841, flocks of whale-birds estimated "to be from six to ten miles in length, two or three miles broad, and very densely crowded together, literally darkening the sky during the two or three hours they were passing over and about us." During the 'Challenger' expedition, specimens of this species now in the British Museum were obtained at the edge of the ice barrier on February 14, 1874. Wilson (1907, 106) carefully avoids unjustified sight determination of blue petrels seen during the 'Discovery' expedition. He states that, between New Zealand and the ice of Ross Sea, birds, presumably of this species, were abundant in December and that they flew by night as well as by day. Vanhöffen (1901, 315) states that the southward range of the Antarctic Prion is limited only by pack-ice, and he reports it as following the 'Gauss' in numbers southeast of Bouvet Island on December 6. Andersson (1908, 48) cites many records southward almost to latitude 66° S., though it is likely that some of his more northerly references are to other species. Gain (1914, 154) states that the French Expedition saw this species daily throughout the summer in the Bransfield Strait region, and southward to latitude 65° S.

in the Pacific in a sea well dotted with bergs. Menegaux (1907, 66) also reports specimens taken and observed off the coast of the Palmer Archipelago on January 20, 1905, at about latitude 65° S. On this occasion some of the birds came aboard the expedition vessel during a period of very rough water. By the 'Scotia' naturalists the species was seen off Coronation Island of the South Orkneys, November 27, 1903, and examples were subsequently collected at sea between these islands and Southern Thule, of the South Sandwich group, as well as southward practically to latitude 66° S. in Weddell Sea (Clarke, 1913, 240, 266). Godman (1910, 290) refers to a specimen in the Liverpool Museum procured by Sir Joseph Hooker, during the voyage of the 'Erebus' and 'Terror,' off Victoria Land in latitude 74° S. Finally, Bennett (1920, 30; 1926, 316) states that this species nests at the South Orkneys in latitude 61° S.

Dabbene (1923, 134) has confused this petrel's identity, and has listed the breeding whale-bird of South Georgia under the name *Pachyptila vittata keyteli*. Unfortunately, his misapprehension has been carried on by others through subsequent quotation from his excellent paper on the petrels and albatrosses of the South Atlantic. Since, however, Dabbene publishes the following measurements for South Georgian specimens: wing, 183–189; tail, 93–95; culmen, 26–27; greatest width of bill, 14–15; tarsus, 32–33; middle toe and claw, 39 millimeters, he proves that he was dealing with typical examples of *desolata*, the only resident species.

Turning eastward through the southern oceans, the Antarctic Whale-bird presumably breeds at Bouvet Island, and certainly at Heard and Kerguelen Islands. In the Berlin Museum I have had the privilege of examining specimens taken during 1902 and 1903 by the staff of the German South Polar Expedition. Heard Island specimens are absolutely indistinguishable from South Georgia birds, both in measurements and in the appearance of the bill. This is entirely in accord with principles of sea-bird distribution expressed by Murphy and Harper (1921, 550), when we pointed out that in many instances island breeding grounds a long distance apart, but lying on the same parallels of latitude, have proved to be the homes of indistinguishable races of petrels.

As regards the species to be found nesting at the Crozet Islands, Godman (1910, 286) states that although the broad-billed *P. forsteri* has been said to be a resident, the only specimen he had seen from the group represented *P. banksi* (= *desolata*). He adds that Layard identified other examples from the Crozets as this species. Godman continues that the Marion Island specimen collected during the 'Challenger' expedition is, in his opinion, also an example of *desolata* and not *forsteri*. All of this is what might be assumed upon zoögeographic grounds, because both the groups of islands mentioned lie very slightly to northward of the Antarctic Convergence, and should be inhabited by the species of whale-bird common to Kerguelen Island.

The whale-birds from Kerguelen Island, judging by the few specimens I have measured and compared, may possibly have slightly smaller bills than those of South Georgia and Heard Island, and may prove to be a distinct subspecies. If so, no difficulty should be experienced in finding a name, as one might well judge from a consideration of the seven proposed subspecific divisions of this species listed on page 612. In fact, Mathews's (1912, 230) discrimination of six subspecies is to my mind one of the best examples in the whole range of ornithological literature of how systematic work should not be done. He ends his discussion with the following statement: "I am convinced that almost each breeding-place of *Prions* shelters a distinct subspecies, and all the blundering has been simply due to confusion of well-defined races through study (!) of sea-killed specimens."

More recently Mathews has created the generic name *Attaprion* for this species, on the grounds that its interramal space is feathered and not distensible like that of *P. forsteri*. The assumption is incorrect, for the pouch-like membrane between the branches of the mandible can be drawn down in life as in all the fulmarine petrels. Mathews's notes on the feathering of the pouch among the various species are, indeed, quite unsatisfactory. In South Georgia examples of *P. desolata* the pouch is feathered to scarcely any greater extent than in examples of *P. forsteri* from the Tristan group, and it also has a distensible membrane despite its lesser size. Even in the very narrow-billed *P. belcheri*, in which the feathering of the pouch is carried farther forward along the mid-line, the rami of the mandible are capable of being spread apart in life and the connecting membrane, representing the floor of the mouth, is highly elastic.

During the course of the Brewster-Sanford Expedition Mr. Beck did not at any time enter the Antarctic Zone, nor did he encounter this species of whale-bird. The American Museum series of about fifty specimens and the bulk of the field observations are derived chiefly from my own work in South Georgia, supplemented by that of Mr. J. G. Correia. In the following chronological record I shall endeavor to correlate my own notes with data on the life history drawn from other sources.

On the whaling banks off the northeasterly coast of South Georgia, on November 6, 1912, I saw incredible numbers of sea fowl between dawn and dark, and among these there were surely hundreds of thousands if not millions of Antarctic Whale-birds, mingled on and above the water with albatrosses of four species and also with petrels and fulmars representing the genera *Procellaria*, *Daption*, *Macronectes*, *Oceanites*, *Fregetta*, and others. At times the whale-birds were distributed so thickly in the air about the whale-chasing steamers at work on the banks that I saw numbers of the birds accidentally killed by the harpoon or wads of a whale-gun fired at a sharp downward angle from the prow of one of the little vessels. Such stunned or wounded birds at once fell victims to the Cape Pigeons, which immediately swam up to peck at them as they lay afloat, feebly struggling.

The observations of Wilkins (1923, 490) suggest a somewhat similar picture of abundance, when he speaks of thousands of whale-birds, off the southeasterly tip of South Georgia, engaged in feeding upon the myriad crustaceans that colored the surface of the ocean a dark olive-green.

On November 30, I found on the eastern shores of Cumberland Bay a grassy slope where there were many whale-bird burrows. This was at no great distance from the oldest whaling station at South Georgia, and most of the burrows opened contained only the cleanly picked bones of adult whale-birds, which had evidently been devoured by the ubiquitous and murderous rats. These dangerous mammals have been resident at the island for upwards of a century, and their effect upon native bird life has probably been very serious. Above ground, on this same hillside, were remains of many orher whale-birds which had been eaten by their more natural hereditary foes, the skuas. Close to nests of the latter, the tussock grass and other vegetation was littered thickly with whale-bird feathers and bones. Upon first witnessing the extent of this destruction, as well as on many subsequent occasions, I was forced to wonder how the unfortunate whale-birds, which lay but a single egg and which suffer so heavily from their enemies, can still exist in such incalculable numbers as are to be seen over the adjacent ocean.

Some weeks later, during December and in January, 1913, I visited other colonies of the South Georgian Whale-birds on grassy islands in the Bay of Isles, where there were no rats to disturb them. Here, however, they had not escaped the skuas, and their disrupted carcasses were freely scattered about, sometimes forming windrows in the hollows. Whenever we dug into whale-bird nests, the skuas would hurry to the scene of activity, and would stand about expectantly, in their customarily bold manner, which seldom fails to arouse a feeling of admiration even in human beings who most decry plunder and ravin. On January 6 I liberated three whale-birds taken from burrows near the summit of Albatross Island, in the Bay of Isles, fully expecting to see them seized and dismembered at once. To my great surprise, however, the skuas on this occasion proved no match for the speedy petrels, which fled before their pursuers down the slope, dodging erratically, and apparently reaching ultimate safety out at sea. The whale-birds faded from sight long before the large, dark-colored skuas became invisible, and the latter eventually gave up the chase and returned to the island without their meal, but in search of another chance. From this experience I infer that the skuas rarely capture their victims in full flight, but that they rather watch for whale-birds that come home too early in the evening or are a few fatal moments late in getting away at daybreak.

I have just spoken of the rapidity with which whale-birds become lost to the eye, when putting distance between themselves and an observer. Their obliterative coloration is, indeed, remarkable against a marine background. When their flocks of enormous magnitude go "fluttering up and down like a cloud of silvery butterflies, and glittering like the silver tree when its leaves are shaken by the wind," to use the words of Green (1887, 33), the individual birds have a way of vanishing from sight like "the gay motes that people the sunbeams." They seem even to be proof against camera records, for I have shot my Graflex when whale-birds filled the air like autumn leaves, only to have the resulting photographs show chiefly a scattering of albatrosses, Giant Fulmars, Shoemakers and other petrels which I had not even noticed because of the storm of pale prions.

My experience in this respect, which has been shared by other naturalists, had an interesting sequel shortly after the United States entered the European

War, when the naval authorities were concerned with hues possessing low visibility against a background of ocean and sky. This was during the period in which it was thought that low visibility, obtained through the use of a monochrome pigment, might be more important in the protection of vessels against enemy submarines than the "dazzle" type of camouflage which was subsequently adopted. At that time I pointed out that the gray-blue whale-birds of the southern oceans met the requirements extraordinarily well, and that they probably blended with the background at a lesser distance than any other pelagic birds. Their natural obliteration in an environment of sea and sky is due, of course, not entirely to the prevailing color of their upper surface, but also to the principle of countershading, and to the presence of a slight pattern of both light and dark bands. Nevertheless, the beautiful blue-gray of the whale-birds, which seems not different in tone from the "horizon blue" of the poilu's uniform, must have a large part in the extraordinary result.

The naval authorities were little moved by the general impressions of a mere naturalist, and they set about to determine by methods of optical experiment a color which would have the lowest general visibility under marine atmospheric conditions. In due course—meaning several months—they produced the hue known as "Omega gray" which was determined to have a combination of the best characteristics for low visibility in the northern war zone. A physical description of Omega gray is as follows: wave length, 486 millimicrons; saturation (per cent of white), 90; reflecting power, 45 per cent. After learning of this, I requested the naval authorities to make a similar analysis of the dorsal surface of specimens of *Pachyptila desolata* from South Georgia, as a result of which they courteously supplied me with the following data: wave length, 485 millimicrons; saturation, 85; reflecting power, 30 per cent; texture, mat; reflection, diffuse. In view of such close concordance between the color of the petrel and Omega gray, the low visibility of the whale-birds over the open South Atlantic proves to be more than an unfounded impression.

Will (1884, 137), Pagenstecher (1885, 23), von den Steinen (1890, 254), and Lönnberg (1906 75), have all written authoritatively regarding the nesting habits of this whale-bird at South Georgia. The birds first come to land, according to Pagenstecher, along with the large black petrel (*Procellaria*) about the beginning of October, and commence to dig their burrows at night in the cold and peaty earth, retiring to sea again before dawn. As soon as the hole is deep enough to conceal them, the paired birds remain in it throughout the daylight hours. The burrows are in colonies which sometimes suggest rabbit warrens, and on tussocky ground there is likely to be one under each pedestal of grass. The tunnel rarely exceeds about a meter and a half in length and is often very crooked. In cross-section it is likely to be somewhat wider than high, but the longest diameter is hardly more than 12 centimeters. The excavation terminates in an enlarged chamber which usually lies 20 to 30 centimeters below the surface, and in it the egg is laid directly upon the ground. The adults in the nest-chamber make low grunting and cooing noises, and they fight and scratch vigorously when they are pulled out.

The first recorded egg date at South Georgia seems to be November 14, but many eggs do not appear until well into December or even until after the first of January. The young birds hatch mostly during January and February and, although by the end of April they may have lost their down, they are mostly not yet ready to leave the burrows. The general exodus takes place some time in May, usually long after the nesting grounds have been covered deeply by a blanket of snow.

At the Bay of Isles members of the 'Daisy's' crew, who did a good deal of scouting on my behalf, found the first whale-bird eggs on December 19; even as late as January 2, I dug into numerous burrows of these birds only to find them uncompleted and empty. Possibly in such cases the parents had been accounted for by skuas, for on the same date I found three fresh eggs in as many burrows, which were being incubated, respectively, by two males and one female. These birds all had large bare brood-patches on their abdomens. On January 6 I found a small colony surrounding several occupied nests of Wandering Albatrosses on the highest point of one of the larger islands in the Bay of Isles. Here, then, was an example of multiple use of the same territory, with tenants on the surface and others in the cellar. Another small colony of whale-birds on this same islet was at the grassy brink of a tall cliff, from where the occupants of the burrows could spring into space at a distance of only a length or two from the entrance of their homes.

On February 28, 1913, I found the first young whale-birds. This was at Possession Bay, South Georgia, and here the burrows were not only on high slopes, intermingled with those of diving petrels, but also in soft sand-banks just above the level of the bay. Most of these holes contained the strange-looking chicks, fluffy balls of gray down, which showed no members whatsoever when their heads were drawn down into the fluff and their feet tucked forward beneath the powder-puff bodies. Various dead chicks in the burrows had doubtless been orphaned by the skuas. Even at this late date, one adult whale-bird was still incubating an egg which contained a live embryo. Finally, on March 3, among the hills between Possession and Antarctic Bays, I found one adult in a burrow containing neither egg nor chick. I have no evidence, however, that this individual was destined still to produce offspring so late in the year.

Observations in other parts of the world confirm the general substance of these made at South Georgia, and also add a little to our store of information. At Kerguelen Island their relation to the skua is exactly the same, according to Loranchet (1916, 209), who was also fortunate enough to watch the paired birds at work at night, and to see them tunneling in the ground with their beaks, and then kicking the earth out of the burrows with their feet. The same author tells us that flocks of this species have a penchant for following whales in the shore waters around Kerguelen, and both he and Moseley (1879, 207) say that they do so for the sake of feeding upon droppings from the whales' mouths. Hall (1900, 29) has described their flocks heading toward home at evening in Royal Sound, Kerguelen, and has also observed vast hordes of the birds resting on the glassy surface of the neighboring ocean during a calm succeeding a storm of several days' duration. Hall reports, furthermore, that these prions sometimes utilize at Kerguelen the abandoned burrows of introduced European rabbits, and that they make use of nest material, such as seaweed and stalks of grass.

Vanhöffen (1905, 505) describes the nesting of the species in burrows at Heard Island, while Bennett (1920, 30) states that at the South Orkneys the egg is laid in a feather-lined natural niche of the rocks. At these islands he found unfledged young at the end of March, and the numerous dead chicks, he believed, testified to the stringent effect of the antarctic climate at the extreme southerly limit of this whale-bird's breeding range.

At South Georgia I found that the whale-birds, like many other small petrels, as well as albatrosses, came into the fiords mostly during days when a gale was blowing. At such times they seemed to be free from molestation by the skuas, which fact may not, however, have had any bearing upon a custom shared also by the completely immune albatrosses and Giant Fulmars. On five occasions when the storms were most terrific, and particularly when the air was filled with driving, cutting snow, the whale-birds crowded into the Bay of Isles, and on January 18 one flew on board our anchored brig and was captured.

In the soil of the burrows of South Georgia whale-birds I collected examples of a flea (*Notiopsylla kerguelenensis*) which had been previously known only from Kerguelen Island, where it was first found on diving petrels.

As regards the food of this species, we can only infer that the crustaceans which teem in the surface water of the Antarctic Zone make up the bulk of it. Every observer agrees with Kidder (1875, 32) that all the whale-birds disregard waste from a ship's galley, which forms such an attraction to many other Procellariiformes. A stomach from a bird identified as "Banks's Prion" by the sea captain who captured it in latitude 49° 30′ S., has been examined at the American Museum. It contained chiefly remains of small Macrura and Schizopoda, probably with larval stages of other crustaceans. There were also bones and fragments of bones of very small fishes.

The voice of this whale-bird seems to be more variable and more pronounced than is indicated in the foregoing notes. Buller (1873, 309) speaks of a rapid twittering to which his captive examples always gave utterance as they awakened to activity toward the approach of evening, and began to clamber over his armchairs and other furniture! Eaton (in Sharpe, 1879, 137) found that when nesting birds at Kerguelen were disturbed during the daytime they commenced to coo. Their flight-note, however, Eaton describes as "u-u, u-u, u-u." On calm nights at the end of October and beginning of November their mingled cries, and the rustling of their wings as they flew, produced a low continuous murmur like the sound of distant street traffic in a large town.

Will likened the courtship calls at South Georgia to the cooing of turtle-doves, while Waite (1909, 505) described sounds issuing from the burrows as a "groaning." In my own recollections, I doubtless confuse the voice of the whale-bird more or less with that of other petrels. Nevertheless, since this species is the most abundant bird at South Georgia, its song must have a large part in the nightly chorus. Several times during my visit a calm summer evening lengthened into night without the rising of a wind. Then, from every isle and headland through the still darkness would come a distant, sweet, bell-like piping—the singing of numberless whale-birds and other petrels in their burrowed nests. It was a nostalgic sound, which I can still hear. At South Georgia it took the place of the katydids, the whippoorwills, and the frog choruses of summer nights at home.

SLENDER-BILLED WHALE-BIRD

Pachyptila belcheri

Heteroprion belcheri Mathews, 1912, Birds Australia, 2, p. 224, and figures 2 and 5, p. 215 (the beach southwest of Port Phillip Bay, Victoria, Australia).

Names: Thin-billed Prion. This species was first described only in 1912, and it is not known under what other names specimens taken before that date may have been listed.

Characters: Very similar in general aspect to the two preceding species, *forsteri* and *desolata*, but smaller than either except in the length of the tarsus and foot in which it equals or slightly exceeds *Pachyptila desolata*. Bill characters at once distinguish it because the whole structure is slenderer, the latericorn without lateral swelling, and the maximum width of the lower mandible little more than half that in *P. desolata*. In greatest width of maxilla, 10 examples of *P. belcheri* from the neighborhood of the Falkland Islands show a maximum of 11.4 mm., while 10 specimens of *P. desolata* from South Georgia show a minimum of 13.6 mm.; the average difference amounts to about 4 mm. Iris brown; bill blue, with the nares and ridge of the culmen black; feet blue, with whitish or flesh-colored webs (Beck's labels).

10 specimens (five of each sex) from the South Atlantic between the Falkland Islands and the coast of Argentina: wing, 180–191 (186.5); tail, 86.2–96.5 (92.1); exposed culmen, 23.7–28.3 (25.9); greatest width of bill, 9.8–11.4 (10.6); tarsus, 31.2–34 (32.6); middle toe and claw, 38.2–42.2 (40.1) mm.

Distribution: A species of cooler parts of the Sub-Antarctic Zone, breeding in all probability at the Falkland Islands and ranging northward to the Río de la Plata; reported also from the western coast of southern South America. The type locality represents a point at which examples had been driven ashore by a storm. Australasian breeding grounds are still unknown, and the eggs and young have never been described.

It is strange to consider that the Slender-billed Whale-bird, which appears so different in the hand from either of the preceding species, has been observed, and doubtless collected, in waters off southern South America for well over a hundred and fifty years without being recognized as a distinct form. An attempt to pick out many of the probable references to it would be futile, but the following four are worth noting:

Off Cape Horn, on February 1, 1769, Sir Joseph Banks, who accompanied Captain Cook, wrote about a petrel

> . . . of a light silvery blue upon the back, which shines beautifully as the bird flies. Its flight is very swift and it remains generally near the surface of the water. More or less of these birds have been seen very often since we left the latitude of Falkland's Island, where in a gale of wind we saw immense quantities of them (Banks, in Hooker, 1896, 63).

Paessler (1913, 42) records many whale-birds in latitude 44° S., longitude 75° 45′ W. on April 29; in 36° S., 73° W. on May 12; and off the western entrance of the Strait of Magellan on May 17 and August 27. He calls them *Prion desolatus*, preceded by a question mark.

Under the name *Puffinus turtur*, Philippi (1902, 94, pl. 43) describes and clearly figures an example of *Pachyptila belcheri* from Chile, but the exact locality is unknown.

Bennett (1931, 12), using the name *belcheri*, states that there are local specimens in the Stanley Museum, Falkland Islands, and that the species breeds on the same islands with *Halobaena*, with which it had long been confounded. In an earlier publication (1926, 317) Bennett evidently referred to one of these same specimens as *Pseudoprion turtur brevirostris*.

Dabbene (1923, 136) regarded *P. belcheri* as difficult to distinguish from *P. desolata*, which meant merely, as I have shown elsewhere, that he confused typical examples of the latter species with *P. forsteri*, and was probably comparing conspecific birds.

The above meager record is all I can find regarding the status of the Slender-billed Whale-bird in the American part of its range, except that Mathews once called attention to certain alleged differences between Neozelanic and Falkland specimens but, with exceptional restraint, failed to give a new name to the latter (Mathews and Iredale, 1921, 41).

In the American Museum Collection are 66 specimens of *Pachyptila belcheri* from southern South America. One of these was collected off the coast of Uruguay on August 10, 1918, and another found dead on the beach at Mar del Plata, Argentina, on October 27, 1915. The others were obtained by Mr. Beck during the Brewster-Sanford Expedition in waters between the Falkland Islands, Staten Island, and the coast of Patagonia. Positions and dates in 1915 covering the entire series are as follows:

East of Cape Vírjenes, May 26
51° S., 68° W., Sept. 10
52° 50′ S., 58° 30′ W., Sept. 20
51° 37′ S., 66° 20′ W., Oct. 1

Beck's notes also refer to remains of "blue petrels" seen at Deceit Island, near Cape Horn, on January 4, 1915, and to many hundreds observed outside the eastern entrance of the Strait of Magellan on May 25, 1915. Next day he succeeded in shooting one bird, which was of this species. Also, on August 6 and 7 of the same year he saw many along the eastern coast of Tierra del Fuego, the birds feeding in flocks, frequently diving below the surface, and rising a few lengths ahead.

On September 10, he lowered a boat on the ocean northeast of Río Gallegos, laid out a trail of bait, and collected many of these petrels along with other sea fowl. At this time hundreds of the whale-birds were sitting on the water during a midday calm. When disturbed, they would fly only a few gunshots' length in the light air and descend again to the water. Thereafter he saw the birds all along a cruise toward the Jason Islands, of the Falkland group, where they no doubt nest.

Beck was informed that New Island, off West Falkland, is also a favored breeding ground of whale-birds. On January 25, 1916, he accordingly set out for this locality, but war-time prohibitions prevented him from landing. Off Bleaker Island, and elsewhere, he saw a few of the birds in flight. His notes refer, incidenrally, to the disastrous effect that both mice and rats have had upon many of the small petrels at the Falklands. Some islets, once well populated by certain species, no longer have a trace of petrels, and Beck found that most such are now overrun with either rats or mice.

Details relating to the nesting habits of the Slender-billed Whale-bird remain to be learned. The specimens taken at sea during September and October were in breeding condition, bur Beck judged that none of the females had yet reached the poinr of laying.

It seems likely that Staten Island and parts of Tierra del Fuego are within the breeding range of this species. Quire possibly the whale-birds of Landfall Island, referred to in the biography of *P. forsteri*, belong here.

FAIRY PRION

Pachyptila turtur

Procellaria turtur Kuhl, 1820, Beitr. Zoöl., p. 143 (Bass Strait).

The following are descriptions of forms of this species attributed to the Atlantic Ocean and the eastern South Pacific:

Prion brevirostris Gould, 1855, Proc. Zoöl. Soc., London, p. 88, pl. 93 ("Madeira," which is probably erroneous).

Pseudoprion turtur solanderi Mathews, 1912, Birds Australia, 2, p. 220 ("west coast of South America").

Names: Snow-bird, not from the weather of the range, but from the resemblance of the flocks to snow flurries. The various specific names for this species have been sufficiently discussed on page 612.

Characters: Smallest species of the genus; similar in general coloration to each of the foregoing, though in fresh plumage perhaps the "bluest" and palest of all the whale-birds. Bill characters are diagnostic. The bill is short, and both the unguis and the dertrum are relatively very large; the distance between unguicorn and nasal tubes is, in consequence, little more than half as long as in any other member of the genus. Weight of Australian examples of this species, "five ounces," or 142 grams (Gould, 1865, 472).

10 specimens (5 of each sex) taken at sea east of the northern end of New Zealand: wing, 174–187 (180.3); tail, 81.5–93.4 (85.7); exposed culmen, 21.8–24.2 (23.3); greatest width of bill, 10–11.8 (10.9); tarsus, 29.4–31.9 (30.7); middle toe and claw, 35–39.3 (36.7) mm.

The above figures probably represent the typical race (*P. t. turtur*). Another supposed subspecies, with a stouter bill and much wider unguis, inhabits Bounty Island, about thirteen degrees of latitude south of the pelagic locality in which the measured specimens were collected. I strongly suspect, however, that two full species of whale-birds may be hidden under the name *turtur*. One of these is represented by the typical form, the other by the form described as *crassirostris*. These belong to distinct zones, the latter form inhabiting the higher and colder latitudes. If the Kerguelen bird were shown to be of the "*crassirostris*" type, the question might be regarded as settled.

The nestling, according to published descriptions, does not differ in general appearance from that of other species of *Pachyptila*. Eggs from the Chatham Islands measure 44 x 31 and 45 x 34 mm. (Oliver, 1930, 114).

Distribution: The general distribution has been discussed upon page 613. Nothing is known of this species in oceans adjacent to South America, except for the vague record of Gould, cited above, and the fact that there are said to be in the British Museum specimens from the west coast of South America and from near the Cape of Good Hope. The latter suggests, at least, that a form of the species enters the South Atlantic.

At present we have no way of judging as to which form of *Pachyptila turtur* claims a tenuous place in the South American avifauna. Von Ihering (1907, 38) reports that certain whale-birds from Iguapé and São Paulo, Brazil, were identified by von Berlepsch in London as *Prion ariel*, which would be this species. In view of past confusion of all the forms, however, a re-identification of such specimens is needed.

Apropos of whale-birds on the west coast of South America, Belcher (1914, 593) speaks of "innumerable millions of Prions" between latitudes 35° and 48° S., all the way across the Pacific to Valparaiso. Again we are left in doubt as to the species.

In Mathews's account of *Pachyptila desolata* (1912, 226), he quotes some highly interesting details concerning the life history of a species of whale-bird, as recorded by Mattingley (1908, 12). The locality referred to is Lawrence Rocks, just outside the harbor of Portland, southwest Victoria, Australia, and reference to an excellent photograph accompanying Mattingley's original article shows a whale-bird with a short bill and the proximal end of the unguis almost in contact with the nasal tubes, which could therefore be no other species than *Pachyptila turtur*.

Mattingley states that these whale-birds occupy the borders of a soil-covered neck of land that connects two great masses of rock at the islets. The earthy covering has a growth of pig-face weed (*Mesembryanthemum*) and mallow (*Lavatera plebeja*), together with a species of moss and one of lichen. The spot is a little oasis in a wilderness of rock and wave. He writes of the whale-birds as he found them at Christmas time.

At Portland this prion is vernacularly known as Snow-bird. Because of competition with a burrowing penguin at Lawrence Rocks, it utilizes only the fringes of the soil-covered area. The earth is here so friable that strong winds sometimes tear away the edges of the rookery, destroying the burrows or plugging them up with earth and suffocating the occupants.

Mattingley remained on the lonely rocks overnight, and observed that the first Snow-birds arrived from sea after nine o'clock in the evening. They fluttered about silently, as if to get their bearings, and then entered their tunnels, from which they kicked out the earth that had drifted into the mouths. A faint "coo-coo-coo" seemed to represent a hail to the exceedingly fat chick within. Just before dawn next morning, the adults departed, seeming to have no difficulty in springing into the air from the rocks. Their only enemies at this islet were a resident family of Black-cheeked Falcons which had captured and dismembered a number of the Snow-birds.

Falla (1934, 248) has recently published a study of this species, and the measurements he gives entirely agree with those above. He states that the Fairy Prion of the islets off northern New Zealand is the same as the bird of the Chatham Islands. He found new burrows on November 17, heavily incubated eggs on December 3, and well-grown young at the end of January. By February, continues Falla, countless numbers of prions of several species congregate in the waters about northern New Zealand, so that it becomes impossible to trace the movements of local birds. Most examples of this species driven ashore by gales are immature, as revealed by their bright blue coloration, and their smaller bills which acquire a shrunken appearance after death.

Buller (1888, 209) kept several storm-blown waifs of this petrel for a number of days, and found that they were content to lie low during the hours of light but that they became active at dusk. Whenever he held one of the birds and inserted its bill in a glass of water, it at once commenced to kick its feet in the swimming reaction.

On another occasion, when nearly thirty miles from land [off New Zealand], about sundown, just as the sky had become overcast, I observed large flights of the Dove Petrel [*Prion ariel* = *turtur*]—sometimes in close communities, sometimes more widely scattered—all coming in the same direction and taking a south-west course. This constant stream of passengers was kept up till dark, and probably much later; but during the time they were visible some tens of thousands must have passed by us. . . . Long after dark, I noticed a flock of them hunting in company and very near the surface of the water (Buller, *l. c.*, 213).

Kirk (in Buller, 1905, 125) is also describing this species when he writes:

In 1891 I visited the Snares, and was filled with amazement at the number of Petrels that made their appearance on the approach of evening. From the surface of the sea to the greatest height at which it was possible to distinguish them they were to be seen in myriads, and gave me such an idea of their vast numbers as I had never before been able to realise; while their rapid but graceful evolutions were a never-ending source of pleasure. The scene reminded one of the countless vistas of stars opened to the eye of the observer through a good telescope, or, perhaps better still, of the ever advancing and receding hosts of bacteria to be seen in infusions under a high power of the microscope.

Other accounts of the Fairy Prions, their numbers, nocturnal predilections, the extraordinary volume of a sound sometimes produced by their flocks, etc., are numerous. They nest later than the Broad-billed Whale-bird (*P. forsteri*) at islands in which the ranges of the two coincide, as at the Chathams. Like the latter species, too, they are content to lay the egg on ledges protected by overhanging rock in localities where soil is wanting.

Small crustaceans have been found in the stomachs of Fairy Prions from Bounty Island (Oliver, 1930, 115).

SNOW PETREL

Pagodroma nivea

Procellaria nivea Forster, 1777, Voy. Round World, 1, pp. 96, 98 (Latitude 52° S., longitude 20° E.).

Names: "Petrel de Nieve" and "Petrel Blanco" are recorded South American names. Synonyms of the specific name include *novaegeorgica*, *candida*, and *confusa*.

Characters: Plumage of the adult entirely white, except for a black spot in front of and above the eye and the creamy or yellowish shafts of the quill feathers. Iris brown; bill black, with a bluish tint on the latericorn, and with the pink lining of the mouth showing along the cutting edge and gape; legs and feet dark bluish gray in life.

7 males from South Georgia: wing, 249–273 (259); tail, 98–109 (105); exposed culmen, 19–21 (20.1); tarsus, 32–36 (34.1); middle toe and claw, 41–46 (43) mm.

3 females from South Georgia: wing, 253–262 (256.7); tail, 104–110 (107); exposed culmen, 18–20.5 (19.5); tarsus, 32–35 (33.3); middle toe and claw, 41–45 (43) mm.

The sexes seem to be of substantially one size. The average dimensions of two males and two females from Ross Sea are: wing, 261; tail, 106.4; exposed culmen, 20; tarsus, 33.4; middle toe and claw, 42 mm. Furthermore, these exactly match our South Georgia birds in appearance. Two specimens from Deception Island, South Shetlands, are slightly larger. For the range in measurements among about 70 specimens Lowe and Kinnear (1930, 144) should be consulted.

Valette (1906, 62) gives the length in the flesh of a South Orkney specimen as 30 cm., its wingspread as 60 cm. He records the body temperature as 37.7° C.

Birds in juvenal or first contour plumage have shadowy, grayish vermiculations on the dorsal surface, and a gray wash or specklings on the tips of the primaries.

The mesoptyle down is long and fluffy, lavender-gray on the back and chest, darker on the head, and dull white on the abdomen.

The egg is white and usually relatively elongate. Examples brought to the American Museum by the Second Byrd Antarctic Expedition, and collected in late December, 1934, in King Edward VII Land, measure 56.5 x 39.5, 56.2 x 38.8, 53 x 37.8, 52.9 x 38 mm. A series of South Orkney eggs measured 50–56 mm. in length by 36–41 in breadth (Mathews, 1928, 103).

Distribution: Breeds in the Antarctic Archipelago, the South Shetland and South Orkney Islands, South Georgia, probably at other antarctic islands, and at Cape Adare and other localities on the antarctic continent, both at the shore and inland. Ranges northward only to the Antarctic Convergence, which in most parts of the southern oceans lies beyond the circle of latitude 50° S.

In appearance, the Snow Petrel harmonizes perfectly with its antarctic environment. Racovitza (1900, 229), with a fine flair for hyperbole, says it is "so white that it forms a contrast with the snow." Whatever germ of truth there may be in this assertion proceeds less from the whiteness of the bird than from the subtle ivory tone in its plumage, which on occasion seems to gleam through the cold antarctic light. At other times, on the contrary, its visibility is extraordinarily low, and it seems to be made still less by the jet-black spots which are the beak, eyes, and feet of the bird. My own memory of this petrel at South Georgia is of a large-eyed wraith gliding through snow blown before williwaws from the upper slopes of the mountains.

Specimens in the hand do not all look as white as the birds in life. Some of them show on their upper surfaces the shadowy vermiculations which are marks of immaturity, as well as a gray wash or fine speckling on the tips of the flight quills.

Snow Petrels vary in size in a somewhat unaccountable manner. Upon the basis of material obtained as long ago as the cruise of the 'Southern Cross,' the existence of two distinct species was suspected (Sharpe, 1902, 148). We also have the later testimony of Wilson that examples shot close to latitude 67° S., longitude 179° W., exhibited an extraordinary discrepancy in weight and in size, including the length of the bill. Such differences have been made the criteria for the naming of two species, a large and a small. After examining a very full series from antarctic localities all around the globe, Lowe and Kinnear (1930, 142) have come to the conclusion that birds of intermediate size apparently connect the well-known extremes, and that any attempt at systematic subdivision is inadvisable until a worker has studied adequate material from a large proportion of the nesting grounds.

The Snow Petrel is one of the few southern-hemisphere birds invariably associated with ice. Loomis (1918, 13, 15) refers to it as a member of a small group of species unknown to northward of the atmospheric isotherm of 15° C.

for January, the warmest month of the year. Such limits are, however, considerably too liberal for this petrel, besides which Loomis suggests no interpretation of what he calls "temperature control." Food supply has been shown by Jespersen (1930, 12) to be the principal factor in regulating the range and abundance of plankton-eating birds, and the remarks of Rustad (1930, 5) seem directly applicable to the case of the Snow Petrel. The latter author states that the isotherm of 12° C. of the surface water, which corresponds better than Loomis's datum with the outer limits of this petrel's range, also bounds the distribution of the opossum-shrimp known as *Euphausia superba*, the most abundant antarctic member of its family and the only species recorded from almost all the stomach contents of whales, seals, and birds taken within the area. At times, indeed, it makes up the exclusive food of these various creatures.

The Snow Petrel is as essentially antarctic as the Adélie Penguin or the South Polar Fulmar (*Thalassoica*). Snow and ice make up its Promised Land (Vanhöffen, 1901, 311). Its distribution is circumpolar and, although it has been rarely captured as far north as the Falkland Islands (Wace, 1921, 196), as well as in latitude 52° S., longitude 20° E., south of Africa, it apparently never occurs regularly or in numbers north of the parallel of about 60° S., except in the neighborhood of an ice-covered island (Saunders, 1901, 229). It is very commonly encountered in the proximity of bergs or heavy pack-ice, and is consequently of great interest to navigators as an augury of ice conditions on their course. Sharpe (1902, 148) writes that on several British antarctic expeditions the Snow Petrels were not seen until the edge of pack was reached, after which they became abundant as if by magic. Bennett (1920, 28) tells us that the species is more numerous at the South Orkney Islands than at the South Shetlands. This, too, accords with theory, because the relations of Weddell Sea to the general west-wind drift cause the South Orkneys to be beset by bergs, and floes, and frozen ocean to a greater extent than the more southerly South Shetland group. At the latter islands the Snow Petrel is chiefly a visitor which comes to take advantage of the rich food resources, enhanced in part by whaling operations, but at the South Orkneys it has established a populous nesting ground.

The 'Scotia' naturalists first observed the Snow Petrels at the South Orkneys in November. The birds appeared then to have just come to land, and they were wheeling about in front of the faces of high cliffs, giving voice to calls which sounded like *kaa-kaa*. Valette (1906, 62) reports after long residence, however, that Snow Petrels are to be found at the South Orkneys throughout the year, being in many places most abundant, or at least most in evidence, during September, the month in which courtship begins.

The Swedish Expedition found these birds to be frequent visitors, even during the winter, to Paulet Island. Andersson (1908, 44) states that they were noted daily on the island as late into the antarctic autumn as April and May, and that during the midwinter months of June, July, and August, they reappeared with more or less regularity whenever the weather was slightly milder than usual. During the latter part of September and the first half of October, they again turned up for a time, but after that they gradually became scarce and disappeared, which was attributed to the fact that they do not breed at Paulet Island, and had probably gone elsewhere to seek nesting grounds. Andersson also quotes Ekelöf, who noted a similar seasonal régime at Snow Hill Island.

The naturalists of the French Expedition observed great numbers of southbound Snow Petrels in flight above Booth-Wandel Island during August and September. Throughout the following summer they were abundant along parts of the coast of Adelaide and Alexander Lands, and at Marguerite Bay, though no nesting places were discovered. A northward autumn migration was noted at Petermann Island on April 9. In the enclosed crater-harbor of Deception Island they lingered around the expedition ship throughout the winter, feeding as freely as the Cape Pigeons upon food tossed overboard. They began to disappear southward as spring drew near, and not one was logged after November (Gain, 1914, 137). Numerous other observers, however, have found them at Deception Island all through the summer months.

At South Georgia the Snow Petrel is not uncommon in the fiords and about the drifting ice offshore at all times of year. The German Expedition of 1882–1883 collected seven specimens in Royal Bay during July, and later found five nests with eggs among crevices of the rocks at Mt. Krokisius, which is 470 meters in altitude (Pagenstecher, 1885, 21; von den Steinen, 1890, 250). Filchner (1922, 117) observed many Snow Petrels at South Georgia in November, and Andersson (1908, 44) in May. During my own stay, I made 34 journal entries relating to the species between November 23 and February 10, the localities including the fiords as well as the whaling banks off the northeastern coast. Whenever gales were raging, one or two Snow Petrels were particularly prone to appear with Cape Pigeons, Kelp Gulls, albatrosses, and other sea birds, astern of the brig 'Daisy' as she lay at anchor in the Bay of Isles, and to join in a general squabble for scraps from the galley.

On the cruise of the 'Deutschland,' Filchner found this petrel ubiquitous around the northerly islands of the South Sandwich Archipelago. Both Vanhöffen (1901, 311) and Reichenow (1904, 348) regard it as a resident of Bouvet Island, in the central part of the Atlantic Antarctic Zone, and from the waters about this island it has long been noted as a constant companion of southbound vessels.

Moseley (1879, 253) states that the Snow Petrel remains on the wing exceptionally late at night, after most of the other sea birds have disappeared. This conclusion might be attributed to the greater conspicuousness of its white plumage, except that, as a matter of fact and experience, a white bird is harder to see against the night sky or water than a dark one. At the nesting grounds, too, the Snow Petrels are not only noisy but also restless at night, often flying around the promontories in small groups (Andersson, 1908, 44). They are no less active on sunny antarctic days, however, when flocks of them flit about the hillsides and the floe-ice, twittering like linnets, a whole band acting as though it constituted but a single organism. This concerted movement of the Snow Petrels has been shown very well in films exposed during Sir Douglas

Mawson's field work, as well as by a similar record obtained during the first Byrd Antarctic Expedition.

The nesting Snow Petrels seldom form true colonies, but select individual niches on the peaks and cliffs, or recesses under the stone slabs of a talus slope. Almost invariably the sites are difficult of access, from the human point of view. A cave sufficiently large for a man to enter was an exceptional nesting place discovered by the Scottish naturalists at the South Orkneys. Here, on a guano-covered floor only a few meters above the sea, about a dozen eggs were found (Brown, Mossman, and Pirie, 1906, 215).

As soon as the Snow Petrels alight at their nests, they flatten their tarsi against the rock, and squat upon their bellies. Apparently they do not walk, or even stand for more than a moment at a time, on straight legs. The incubating birds are tame or fearless, like most other petrels, and can easily be caught in the hand, after which, however, they disgorge an orange-colored fluid of the usual petrel odor which leaves an ineffaceable spot wherever it touches the snowy plumage.

The first eggs appear at the South Orkneys at the end of November, and by the middle of December the laying period is over (Valette, 1906, 63). A number of eggs examined on December 7 contained well-developed embryos. Despite the fact that the birds are close sitters, and presumably share the duties of incubation in the manner of other petrels, the German naturalists at South Georgia found that several of the eggs obtained had been rendered sterile by freezing. The dates of nesting in the American quadrant of Antarctica agree with observations made by members of the Australasian Antarctic Expedition in Queen Mary Land. Most original and astonishing is the information supplied to me by Mr. Paul A. Siple with reference to skins and eggs of Snow Petrels collected during the Second Byrd Antarctic Expedition. On December 19, 1934, a rookery was discovered on the very summit of Mount Helen Washington in the Rockefeller Range of King Edward VII Land, at a distance of more than 80 kilometers from the sea. Snow Petrels by hundreds were flying about the peak in company with Antarctic Petrels (*Thalassoica*), but no nests of the latter were discovered. Many Snow Petrels were found crammed or wedged in the corners of interstices among the granite boulders. Egg-laying had apparently just begun, for many niches were empty and the eggs in others were quite fresh. Wilson (1907, 90) once wrote that this "bird is a great wanderer, and was seen by several of our sledge parties on the Great Ice Barrier, some 70 miles to the south of open water." It now appears, however, that it also may retire extraordinarily far from the ocean to nest.

The raucous voice of the Snow Petrel seems incongruous with the exquisite appearance of the bird. Borchgrevink (in Sharpe, 1902, 148) refers to the "original and remarkable half-whistling, half-shrieking" call, and the ordinary caw, referred to above, is usually repeated four or five times at an utterance.

Since the range of the Snow Petrel is in waters prevailingly filled with floe-ice, one would infer that the bulk of its subsistence would be made up of the same crustaceans upon which such animals as the crab-eater seal and pelagic

Adélie Penguins feed. Examination of stomachs confirms the supposition for, as hinted at the beginning of this biography, the remains of euphausians usually fill the alimentary tract to the exclusion of other organisms. During the cracking up of the snout of a glacier at the South Orkneys, flocks of Snow Petrels were observed plunging avidly among the newly opened lanes of water, where they evidently found a rich supply of crustaceans that had been imprisoned underneath the ice. Fish have occasionally been found in their stomachs, and like most other petrels they are not averse to carrion. At South Georgia von den Steinen once came upon three eating the floating carcass of a teal. They will gather about the body of a whale or seal as well, even alongside a vessel filled with men. Instead of tearing at the flesh of such large carcasses, however, as the Cape Pigeons and Giant Fulmars do, they daintily confine their attention mostly to the small scraps that drift away from the tumult in which the more aggressive sea fowl take part.

ANTARCTIC PETREL

Thalassoica antarctica

Procellaria antarctica Gmelin, 1789, Syst. Nat. 1, pt. 2, p. 565 (Latitude 31°–61° S.).

Names: Antarctic Fulmar. There are no synonyms of the specific names.

Characters: A brown and white petrel, with a very broad and conspicuous white bar across the wings.

Adults (sexes alike): General color above mummy brown in fresh plumage, but fading rapidly to a paler or buffy color under the influence of the highly actinic antarctic light; the top and sides of head and neck, the back, scapulars, and rump are of this brown shade, which is more or less mottled on the nape and elsewhere through partial exposure of the concealed grayish white portions of the feathers; lesser wing coverts like back, the median series faintly tipped with ashy white; greater coverts white; primary coverts and tips and outer webs of primaries mummy brown, the primaries white on the inner webs for the greater part of their length; secondaries basally white, with brown tips, which become gradually reduced inward to terminal bands and spots, the innermost secondaries and tertials being entirely white; shafts of the remiges creamy white except distally; rectrices white, broadly tipped with mummy brown, which decreases toward obsolescence on the outer quills; upper tail coverts white; ventral surface white except for a terminal wash of brown, lighter than that of the back, formed by the tips of the feathers on the throat and the sides of the neck and breast, producing on the throat and neck a more or less variable, mottled appearance; under wing coverts and axillaries white; margin of wing brown as far as the most distal under primary covert. Iris brown; bill blackish horn, with the maxillary latericorn lemon-yellow; legs and feet bluish or fleshy gray, with darker shadings on outer toe and web; claws blackish.

12 males and females from the South Shetlands, South Georgia, and Ross Sea: wing, 305–338 (315); tail, 101–125 (112); exposed culmen, 33–40 (36.4); tarsus, 41.6–46.5 (44.5); middle toe and claw, 51.8–62 (58.7) mm.

The length in the flesh of a male from Deception Island was 46 cm. Measurements of Berlin Museum specimens from the Gaussberg region of Antarctica agree with those of birds from the American quadrant.

Although the eggs of this species have been found on the shores of the antarctic continent, as related below, neither they nor the downy young appear to have been yet described in the literature.

Distribution: Circumpolar, but practically confined to the Antarctic Zone of surface water, and scarcely known northward of latitude 50° S. Breeds on the coast of Queen Mary Land, and doubtless along many other south polar mainland and insular shores.

When Wilson (1907, 83) first saw this petrel in the pack-ice, he wrote:

It required much faith to see in the richly piebald bird that appeared to be almost black and white against the icefloes, any semblance to the faded white and buff-brown specimen that was captured in the days of Ross. But the Museum specimen was not, as we found out later, altogether at fault. In life, also, the colours fade. . . .

The clean-moulted *Thalassoeca* is a handsome bird, with head and back and wings deep chocolate brown, . . . and after the autumn moult, when the young birds have gone north to the open ocean away from ice, one sees them in this dark plumage during the winter months between New Zealand and Cape Horn. In November they are still dark, but when the nesting season is over and the summer sun has done its work, the richness goes entirely and a pale buff colour takes its place. Then comes the autumnal moult in January or February, and the birds take on a mottled plumage, as one by one the almost black-brown feathers make their way out amongst the faded feathers.

The American Museum specimens of this petrel include a number from Deception Island, and three brought back from Ross Sea by the first Byrd Antarctic Expedition. I have examined also an example taken by Filchner near South Georgia, as well as the birds in the Berlin Museum collected during the cruises of the 'Valdivia' and the 'Gauss.' All of these make a uniform series, involving no taxonomic problem.

The Antarctic Petrel belongs to the group of four or five species among its order which find their way to breeding grounds on the world's most southerly seacoasts. Its range is to be associated most closely with that of the Snow Petrel. These two species may nest no farther southward than the Silver-gray Fulmar and the Cape Pigeon but, unlike the latter two, they rarely stray far outside the limit of pack-ice. While examples of the Antarctic Petrel have been observed or captured farther northward than those of the Snow Petrel, either bird is to be taken, in general, as an augury of ice floating in the sea. Vanhöffen (1901, 311) states that when the 'Gauss' was southward bound from the vicinity of Bouvet Island, this species was first met in latitude 57° S., on December 1.

Gain (1914, 129) reports that this Petrel was observed by the French Expedition from the antarctic circle southward to Adelaide Land, and that it became most numerous over the pack-ice off Alexander Land. Near winter quarters at Petermann Island, the Antarctic Petrels paid frequent visits from May throughout the winter, whenever a northeasterly storm had broken up and dispersed the sea-ice. Even during July, these birds appeared in flocks under such circumstances, and Menegaux (1907, 53) states that they seemed to come from the south rather than from the shortest route toward open water.

Referring to field experiences on the opposite side of the antarctic regions, Mawson (1930, 541) speaks of entering, during a recent cruise of the 'Discovery,' a region of sea much encumbered with belts of year-old ice, dotted with bergs, in latitude 62° 36′ S., longitude 78° 22′ E., on December 10, 1929. Coincidentally with this, he notes that pan-antarctic bird life gave way somewhat abruptly to exclusively antarctic bird life, in which Snow Petrels and Antarctic Petrels made up a conspicuous element. At the same time, he adds, Adélie Penguins and crab-eater seals began to appear, and the catches of the ship's townet comprised typically antarctic representatives of the marine plankton. All of Mawson's comments combine to picture the inexorable bonds of an environment.

Dr. Wilson, as reported by Lowe and Kinnear (1930, 133), has described and sketched the manner in which the Antarctic Petrels cluster on bergs and floes, squatting rather than standing, their white lower parts so matching the snow that only the brown portions of the plumage remain noticeable.

Sharpe (1902, 143) writes that this species is always a common bird along the edge of oceanic pack-ice and in leads of open waters well within the pack. On fair days at Cape Adare, he continues, groups of these petrels were to be seen sailing about in a gale of wind at a great altitude. According to Bernacchi (1901, 315), the Antarctic Petrels first appeared in the neighborhood of Cape Adare early in November, after which they could be observed in large groups flying southward toward their breeding grounds.

In the peripheral parts of its oceanic range, the Antarctic Petrel has been taken in the neighborhood of Cape Horn, and several times on the southerly coasts, or even within the channels, of Tierra del Fuego (Oustalet, 1891, 162). It is occasionally noted about South Georgia, particularly during the southern winter, but has perhaps never been known to enter the fiords of that island (Lönnberg, 1906, 82). In more open parts of the southern oceans, I observed examples in latitude 48° 39′ S., longitude 36° 40′ W., during November, a position slightly north of the Antarctic Convergence. Wilson has reported the species northward to about latitude 53° S. in the Pacific.

Breeding grounds of the Antarctic Petrel all seem to be close to large bodies of high, heavily glaciated land, such as are found in the West Antarctic Archipelago. Wilkins (1923, 494) believes that the species breeds at Elephant Island of the South Shetlands, because he saw many immature birds during his visit. Although the French Expedition observed several Antarctic Petrels at the shore of Booth-Wandel Island during February, 1904 and 1905, no nests were discovered (Menegaux, 1907, 53). Most of the known or suspected breeding sites, in fact, are on the other side of the antarctic continent, rather than in the American quadrant. At Haswell Island, Queen Mary Land, during late November, Mawson (1915, 2, 117) was the first actually to find the species breeding. The petrels were here occupying steep slopes on the eastern side of the island, laying their eggs on bare soil among clefts and gullies. The birds were crowded close together, and they offered no other resistance to an intruder than to eject pink or green oily fluid from their throats. Incubation was already advanced although their neighbors, the Cape Pigeons, had only just begun to lay. More recently, Mawson (1930, 550) has reported that the northerly face of Mt. Biscoe, which rises steeply to a height of more than 500 meters in latitude 66° 13′ S., longitude 51° 25′ E., is encrusted with guano because of the countless numbers of Antarctic Petrels which resort there, with certain other sea birds, during the nesting season.

Gain (1914, 129) reports that the Antarctic Petrel feeds in part upon large Medusae. Birds captured in Ross Sea during January proved to have eaten small fishes and squids (Wilson, 1907, 84), and beaks of the latter have been found in their stomachs elsewhere. They also devour euphausians, and while feeding in the ice-floes they sometimes remain submerged for several seconds.

Atlantic, or Schlegel's, Petrel, off Tristan da Cunha.

Male (white) and female Kelp Goose,
Chonos Archipelago, Chile.


F L JAQUES

Guano fowl of the Humboldt Current: Peruvian Pelicans, Boobies, and Cormorants.

King Penguins, South Georgia Island.

Peruvian Penguins at the mouth of a sea cave,
Independencia Bay.

Wandering Albatross and Wilson's Petrels, and a double circular rainbow sketched by the author in the South Atlantic.

PLATES

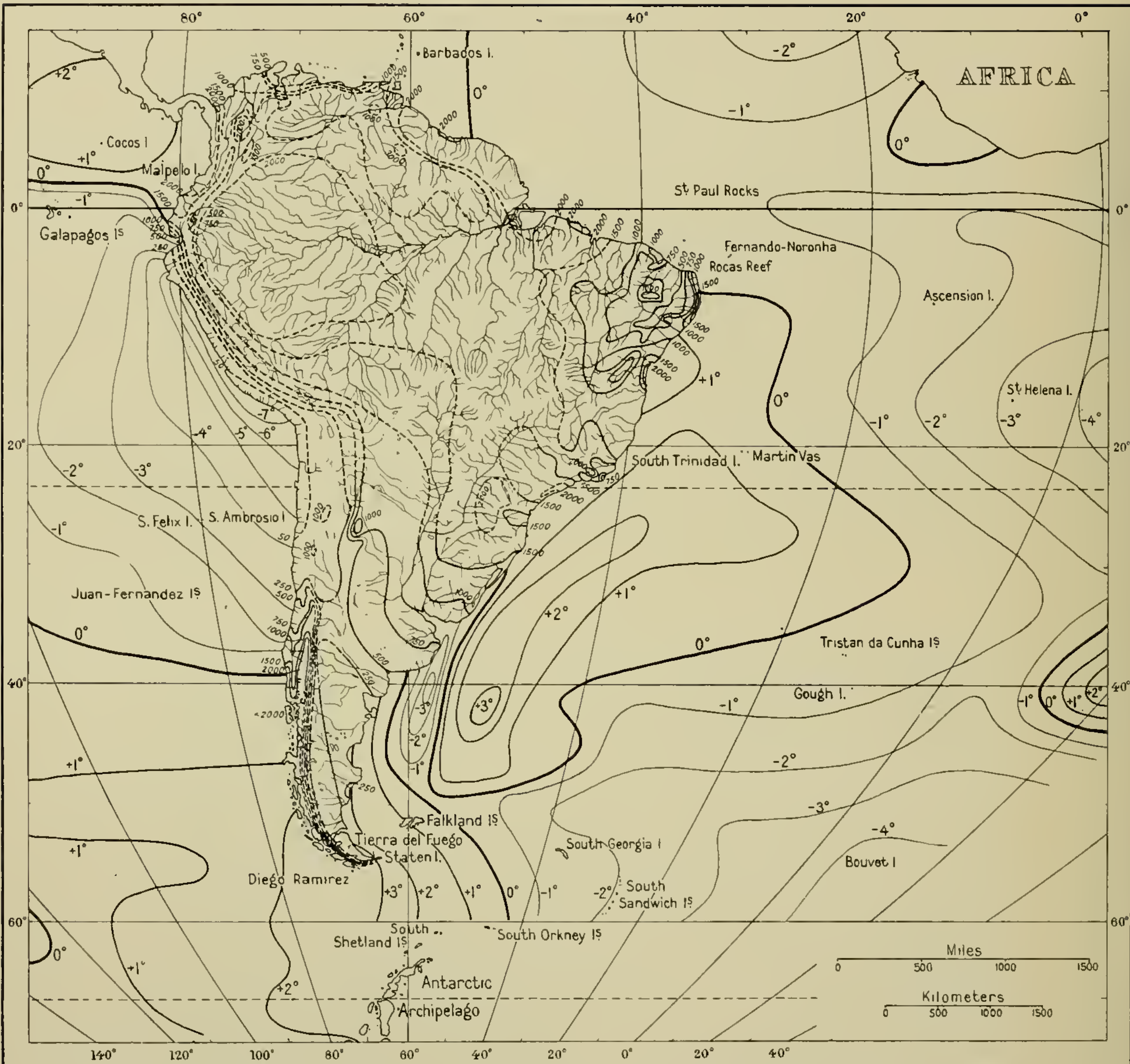
Toshio Asaeda

F. L. Jaques sketching at the Chincha Islands, looking southward toward the Ballestas. February, 1935.

Mrs. R. H. Beck

R. H. Beck preparing specimens between decks on the 'Leguri.' Beagle Channel, December, 1914.

AMERICAN MUSEUM FIELD-WORKERS



South America, the adjacent oceans and their islands, showing the pattern of drainage, the continental precipitation, and isanomalous lines of the surface water-minus-air temperature relationship.

The isohyets, from Franze (1927), express mean annual rainfall in millimeters, solid lines representing the known, and broken lines the conjectural, courses.

The isanomalous oceanic lines, from Schott (1926 and 1935), represent annual means for the Atlantic but midsummer (February) means for the Pacific, the positive or negative thermal departures being expressed in Centigrade degrees. For explanation of the biotic significance of these lines of equal departure, the text on page 297 should be consulted. The extremely marked negative departures off the central west coast are due to conditions discussed on pages 94–98, 102–108, 263, 267–268, 282, 296–297. The sources of the west to east transition from positive to increasingly negative departures in the South Atlantic are considered, directly or indirectly, on pages 48–49, 66, 68–71, 84, 85, 93, 229, 233, 543.

Map drawn and presented by Messrs. Gustav Schweizer and John Forsyth.

A. W. Stevens

Uprooted trees, scattered like matches along mudbanks of the Amazon estuary.

A. W. Stevens

The sea beach in the State of Ceará, Brazil, with habitations on the dunes and arid coastal plains between the ocean and the mountains.

(Both photographs reproduced by special permission from the 'National Geographic Magazine.')

A W Stevens

Drowned valley topography at Victoria (Bay of Espirito Santo), Brazil.

A. W Stevens

Seacoast of the State of Maranhão, Brazil, with extensively flooded forest land between the mountains and the beach, the latter serving both as highway and habitable land.

(Both photographs reproduced by special permission from the 'National Geographic Magazine.')

Toshio Asaeda

Feeble mangrove growth at Conway Bay, Indefatigable Island, Galápagos. Anomalous equatorial district of the Pacific Tropical Zone.

R. H. Beck

Tussock grass (*Poa flabellata*), with nesting Black-browed Albatrosses and Rockhopper Penguins. Ildefonso Island, west of Cape Horn, March, 1914. Sub-Antarctic Zone.

PLATE 6

R. H. Rockwell

South Trinidad from the south, the Ninepin at the left. Sub-Tropical Zone.

J. P. Chapin

Coast of Cocos Island, showing tree ferns and other rain-forest vegetation. Tropical Zone.

PLATE 7

E. S. Riggs

Felton's Harbor, on the northern shore of the estuary of the Río Gallegos, at low tide.

R. C. Murphy

King Edward Cove, Cumberland Bay, South Georgia, with the author's brig, the 'Daisy,' at anchor. November, 1912. Low Antarctic Zone.

The southernmost peak of Powell Island, South Orkneys, with Adélie Penguins in the foreground. High Antarctic Zone.

(Photograph used by courtesy of the British 'Discovery' Committee.)

R. H. Beck

Western end of Gable Island, Beagle Channel, showing effects of erosion by the prevailing winds. Sub-Antarctic Zone.

R. H. Beck

Hacienda Grande, Bertrand Island, the southernmost sheep ranch in the world. Southern coast of Navarino Island in the background. Sub-Antarctic Zone.

F. M. Chapman

Guaitecas landscapes, on an island inhabited by Magellanic Penguins. A humid district of the Sub-Antarctic Zone.

Toshio Asaeda

San Juan Bautista Valley, Mas Atierra, with the peak known as El Yunque in the background. Sub-Tropical Zone, but with numerous sub-antarctic associations.

J. P. Chapin

The coast of the north Chincha Island. Excessively arid coastal belt of the Humboldt Current.

J. P. Chapin

The eastern scarp at an altitude of 700 meters. January, 1935.

Toshio Asaeda

Main gorge and abandoned penal settlement on the east coast, with a landing party from the 'Zaca.'

MAS AFUERA ISLAND

J. P. Chapin

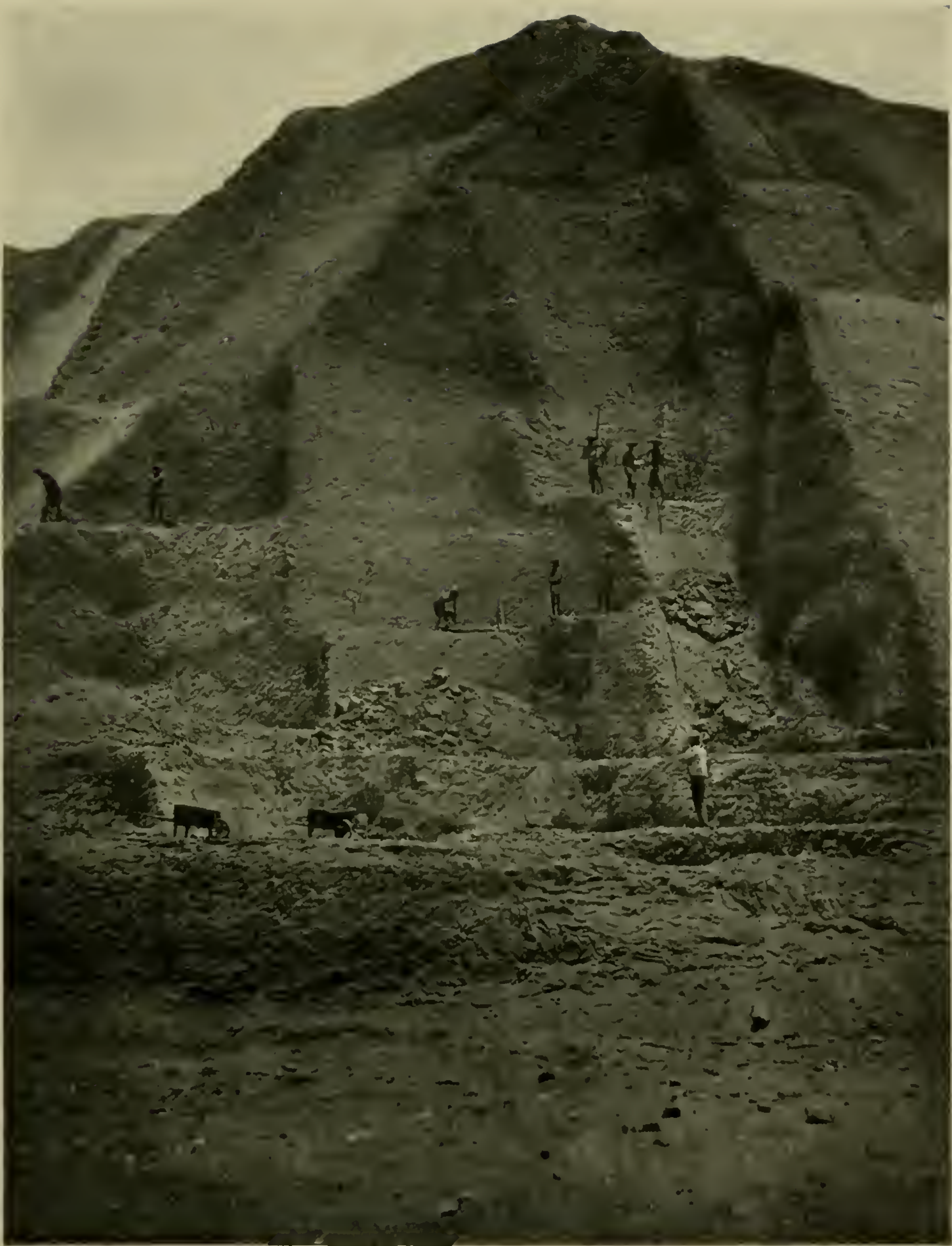
Toshio Asaeda

Two views of San Felix Island, showing the outlier called Gonzales Islet. San Ambrosio, which is much higher than San Felix, can be seen on the easterly horizon in the upper photograph. February, 1935. Sub-Tropical Zone.

J. P. Chapin

Hormigas de Afuera Islets, from the northeast, with boats of Peruvian fishermen at anchor. March, 1935.

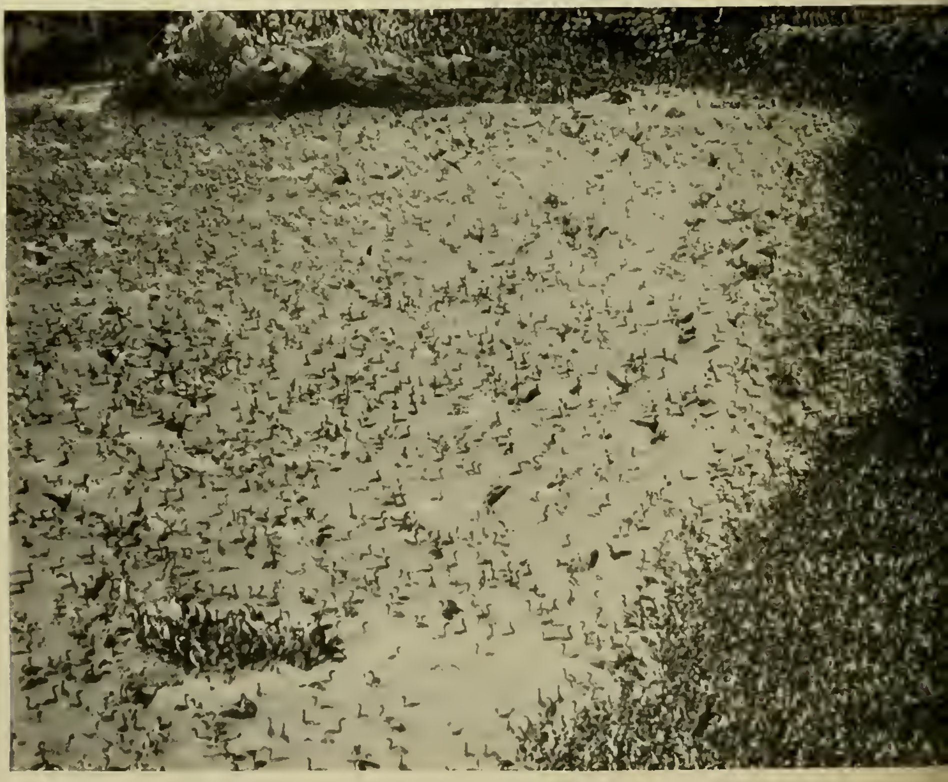
PLATE 13



C. S. Merriman

Guano excavation at the central Chincha Island, about 1860.
The layers are here in excess of 20 meters thick.

Plate 14



Depletion and Restoration. A fleet of guano-carriers in the strait between the central and north Chincha Islands about the year 1860, when most of the guano had been removed. Two

C. S. Merriman

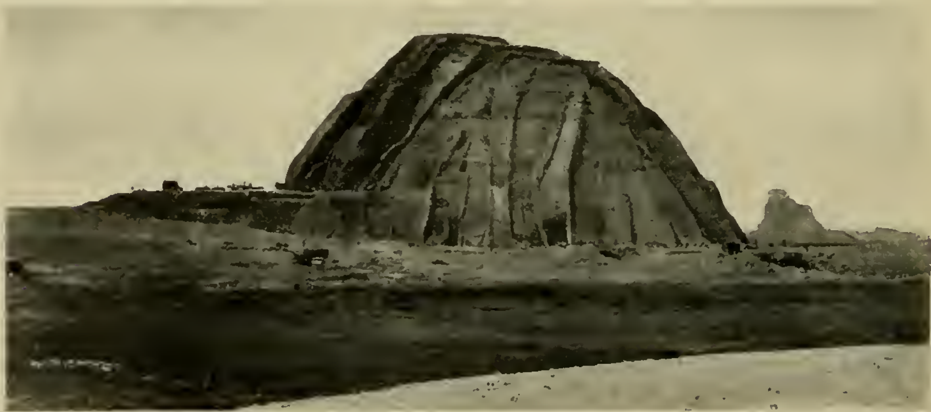
J. P. Chapin

.wer photographs: The "bathing beach" of fledgling Guanays on the north island, as
served during the visit of the 'Zaca,' in February, 1935.

C. S. Merriman

R. C. Murphy

The south Chincha Island, looking southward toward San Gallán, in 1860 and in 1919. The old photograph shows a great lens of accumulated guano, partly excavated. In the modern photograph a flock of Guanays can be seen on the denuded plateau.



C. S. Merriman

Residual guano stacks at the Chincha Islands, about the year 1860.

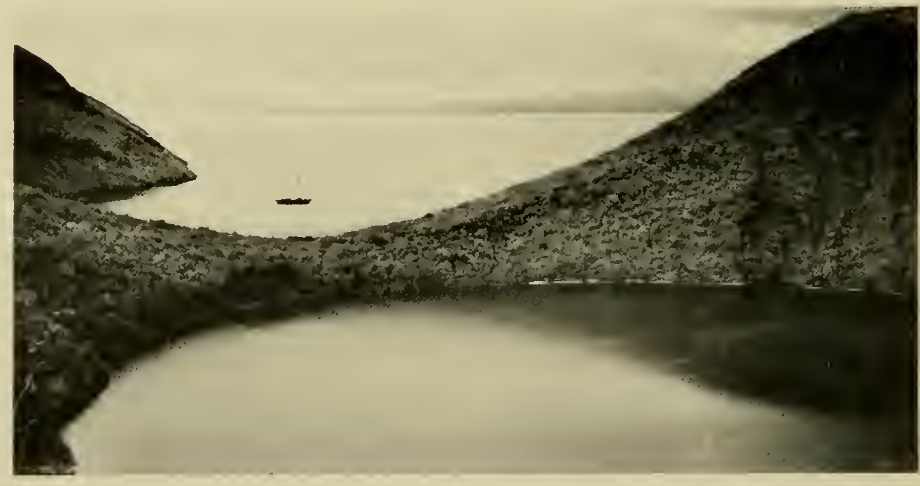
Toshio Asaeda

Central Chincha Island, as seen from the north island of the group, with the 'Zaca' at anchor, and fledgling Guanays in the foreground. February, 1935.

En la costa de la mar desde mas abaxo de Arequepahasta Tarapaca, que son mas de dozientas leguas de costa, no echan otro estiercol sino el de los paxaros marinos, que los ay en toda la costa del Peru grandes, y chicos, y andan en vandas tá grandes, que son increybles si no se veen: crian en vnos islotes despoblados que ay por aquella costa, y es tanta el estiercol que en ellos de xan, que tambien es increyble, de lexos parecen los montones del estiercol puntas de alguna sierra nevada. En tiempo de los Reyes Incas auia tanta vigilancia en guardar aquellas aues, que al tiépo de la cria, a nadie era licito entrar en las islas so pena de la vida: porque no las assombrassen, y echassen de sus nidos. Tan poco era licito matarlas en ningun tiempo, dentro ni fuera de las islas so la misma pena (Garcilasso de la Vega, 1609, folio 102).

J. P. Chapin

Conway Bay, Indefatigable Island, looking northwestward toward Jervis and James Islands. March, 1935.



J. P. Chapin

Tagus Cove, Albemarle Island, from the lake above the anchorage of the 'Zaca.

Toshio Asaeda

Southwestern coast of Albemarle Island, with two small craters close to the sea.

GALÁPAGOS LANDSCAPES

R. C. Murphy

The "head of the corpse," El Muerto Island, showing knife-edge erosion due to the extraordinarily heavy rainfall of February, 1925.

G. R. Johnson

North Guañape Island, with colonies of Guanays showing as dark ameboid areas.

R. C. Murphy

An eroded peninsula of the lowest tablazo, or coastal terrace.

R. C. Murphy

Ephemeral rain vegetation of February, 1935, with characteristic xerophilous growth in the background.

LA PLATA ISLAND. SEMI-ARID COASTAL BELT OF SOUTHWESTERN ECUADOR

Emperor Penguins in juvenal plumage. Bay of Whales, Ross Sea, January, 1935.
(Photograph used by courtesy of the Second Byrd Antarctic Expedition.)

R. C. Murphy

King Penguins incubating and quarreling. Bay of Isles, South Georgia, February, 1913.

R. C. Murphy

King Penguin tucking away its egg.

R. C. Murphy

Galápagos Penguins.

R. C. Murphy

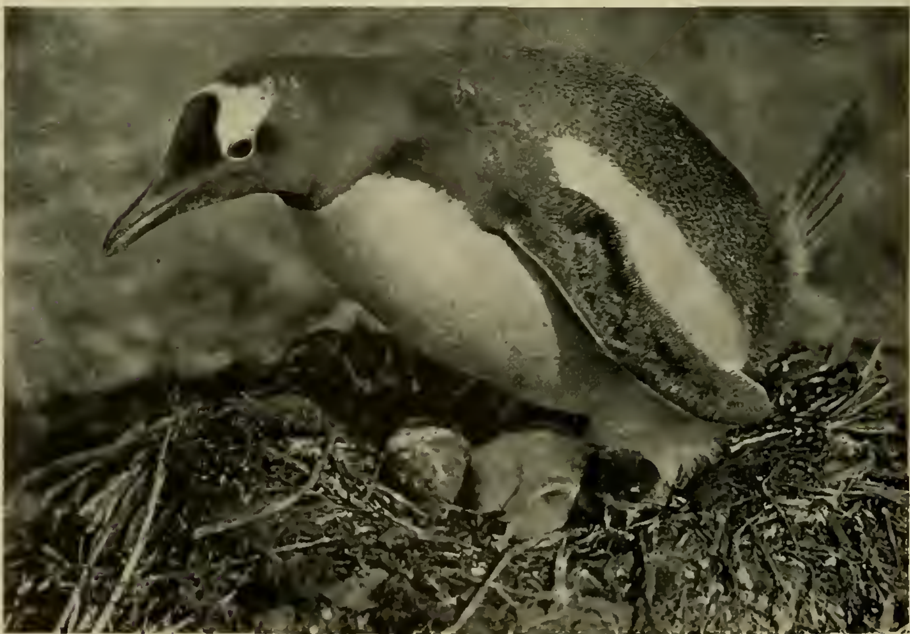
King Penguins entering the Bay of Isles, South Georgia, January, 1913.

R. C. Murphy

Gentoo Penguins. The pathway from the sea to a hilltop colony.
Bay of Isles, South Georgia, January, 1913.

R. C. Murphy

A nursery of young penguins, at the commencement of moult of the down.



R. C. Murphy

Parent, egg, and chick.

GENTOO PENGUINS. SOUTH GEORGIA, JANUARY, 1913

R. H. Beck

A territorial squabble. Bleaker Island.

R. H. Beck

Incubating adult. Cochon Island, November, 1915.

ROCKHOPPER PENGUINS AT THE FALKLANDS

Plate 26

Rockhopper Penguins and King Shags at an early stage of the nesting season. Cochon Island, Falklands, November, 1915.

R. H. Beck

R. H. Beck

Egging in the Rockhopper colony at Kidney Island, Falklands, November, 1915.

R. H. Beck

Rockhopper Penguins on an abandoned nest of the Black-browed Albatross.
West Point Island, Falklands, January, 1916.

R. H. Beck

Landing-place of the Rockhopper Penguins. Kidney Island, Falklands, November, 1914.

R. C. Murphy

Captive fledgling Peruvian Penguins. Chincha Islands, November, 1919.

F. M. Chapman

Fledgling Magellanic Penguins in the nest burrow. Guaitecas Islands, Chile.

R. H. Beck

Magellanic Penguins at York Bay. East Falkland, December, 1915.

J. P. Chapin

Peruvian Penguins on La Goleta, a rock near the south Chincha Island.

R. H. Beck

Magellanic Penguins in a pond at Sea Lion Island. Falklands, December, 1915.

R. C. Murphy

Black-browed Albatrosses. South Atlantic, November, 1912.

R. C. Murphy

Cape Pigeon. South Georgia, November, 1912.

R. H. Beck

Fledgling White-bellied Storm Petrel in its nest crevice.
Santa Clara Island, Juan Fernández, January, 1914.

Plate 32

R. C Murphy

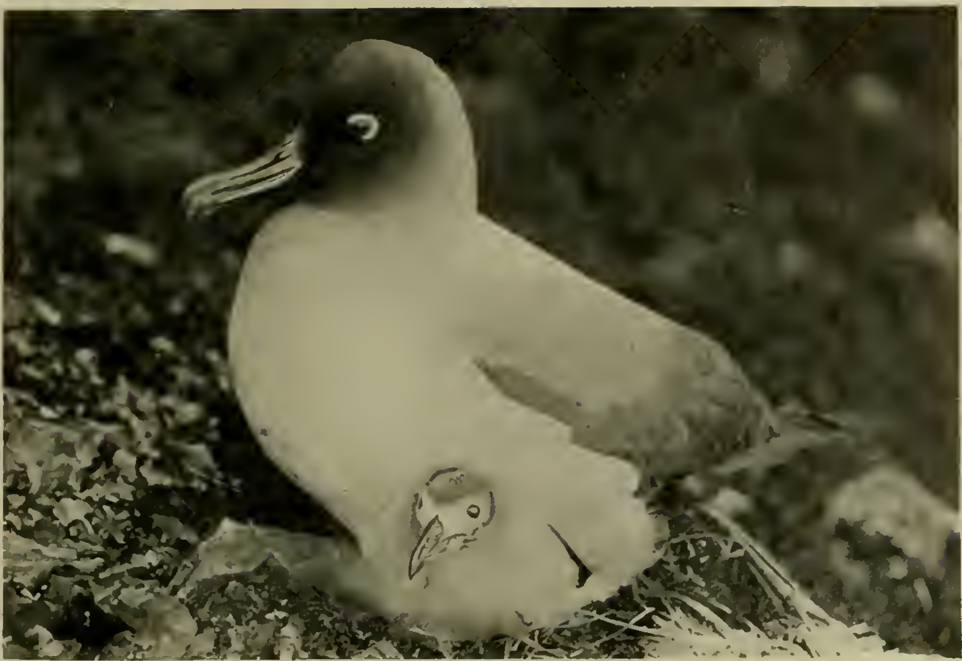
Sooty Albatross. Latitude 48° S., Atlantic, November, 1912.

R. C. Murphy

White Giant Fulmar on the nest. South Georgia, January, 1913.

R. C. Murphy

Giant Fulmar standing guard over its nestling. Bay of Isles, South Georgia, December, 1912.



R. C. Murphy

Male Light-mantled Sooty Albatross brooding its nestling on the ledge of a cliff. Bay of Isles, South Georgia, January, 1913.

R. C. Murphy

Male Wandering Albatross incubating. Albatross Islet, Bay of Isles, South Georgia, December, 1912.

Plate 34

R. H. Beck

Black-browed Albatrosses on their nests at Ildefonso Islet, west of Cape Horn. December, 1914.

PLATE 35

R. C. Murphy

Male (standing) and female Wandering Albatrosses at the nest. Bay of Isles, South Georgia, December, 1912.

R. C. Murphy

Black-browed Albatross crossing the stern of the brig 'Daisy.'
South Atlantic, November, 1912.

R. C. Murphy

Cape Pigeon. South Atlantic, November, 1912.

Incubating Giant Fulmars. A Kelp Gull stands in the center of the colony. Sea Lion Island, Falklands, December, 1915.

R. H. Beck

PLATE 38

Snow Petrel on its nest. Adélie Land.
(Photograph used by courtesy of Sir Douglas Mawson.)