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STUDIES ON THE ECTOPARASITES OF SEALS AND PENGUINS

II. THE ECOLOGY OF THE LOUSE *ANTARCTOPHTHIRUS OGMORHINI* ENDERLEIN ON THE WEDDELL SEAL, *LEPTONYCHOTES WEDDELLI* LESSON

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Summary

The Weddell seal, *Leptonychotes weddelli*, which lives around the shores of Antarctica, is infested with the blood-sucking louse *Antarctophthirus ogmorhini*. Infestations spread solely from female seals to their pups by the transference of adult lice, and are frequent and heaviest on yearling and immature seals but are less frequent and lightest on mature seals. Few mature bulls are infested.

Lice are usually restricted to the tail, ankle, hip, and hind flipper, but the margins of the anal and penile orifices of males may be infested, and occasionally the axilla of the fore flipper. The skin temperature of these sites of infestation varies with the thermoregulatory requirements of the seal, thus providing more opportunities than elsewhere on the body for lice to reproduce when the seal is ashore, and to feed when the seal is at sea. The number of lice is largely determined by the behaviour of the Weddell seal, and numbers are greatest on those age groups which haul out of the sea most frequently throughout the year.

The principal physiological adaptation of *A. ogmorhini* for survival on the Weddell seal is the ability to become active and to reproduce at 5–15°C. Eggs can develop and hatch at constant temperatures as low as 0–4°C.

I. Introduction

The first paper of this series (Murray and Nicholls 1965) described the ecology of the louse *Lepidophthirus macrorhini* Enderlein on the southern elephant seal, *Mirounga leonina* (L.). The southern elephant seal, which breeds in the subantarctic, comes ashore for 3–5 weeks twice a year, and spends the rest of the year at sea. To maintain its numbers, *L. macrorhini* must multiply rapidly whenever the seal is ashore, and feed whenever possible in order to survive when the seal is at sea. For both rapid multiplication and feeding, the habitat temperature must be sufficiently warm; consequently, the lice are found principally on the flippers where the skin temperature fluctuates with the thermoregulatory requirements of the seal and is warm more frequently than elsewhere on the body (Murray and Nicholls 1965).

The Weddell seal, *Leptonychotes weddelli* Lesson, which lives around the coast of Antarctica, is frequently infested with the blood-sucking louse *Antarctophthirus ogmorhini* Enderlein. Apart from living in colder regions than the southern elephant seal, the behaviour of the Weddell seal differs markedly in that it hauls out

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of the sea onto the ice regularly, often daily in the summer. It is likely, therefore, that the detailed ecology of *A. ogmorhini* on the Weddell seal may differ from that of *L. macrorhini* on the southern elephant seal (Murray 1965). However, similarities in the biology of these two species of lice may indicate basic physiological and ecological adaptations to their aquatic existence, which may be common to other seal lice.

Antarctophthirus ogmorhini is a blood-sucking louse of the family Echinophthiriidae of the order Anoplura, a family which is only found on marine carnivores of the suborder Pinnipedia. Lice of the genus *Antarctophthirus* are found on the northern fur seal, the walrus, and the antarctic seals, and *A. ogmorhini* is also found on the leopard seal, *Hydrurga leptonyx* (Blainville). The bodies of the lice of this genus are covered with flattened scale-like setae.

II. Methods

The Weddell seal hauls out onto the ice regularly in close proximity to certain of the scientific stations which have been established in Antarctica. They do not move away if approached quietly but must be captured and restrained if they are to be examined for lice. Pups were restrained manually by two persons, but older animals were immobilized with succinyl choline as described by Flyger *et al.* (1965).

The incidence and distribution of lice was determined mainly by the immediate examination of seals which had been killed during a study of the reproductive physiology of the Weddell seal by one of the authors (M.S.R.S.). The lice could be seen easily if the hair was brushed against its natural lie, and were collected by dry shaving the hair close to the skin with a scalpel. Individual lice were removed by plucking out the hairs to which they were attached to avoid injury.

The Weddell seal does not fast for 3–4 weeks, as does the southern elephant seal, and consequently, as it must be fed, it is not so amenable to laboratory experiments (Murray and Nicholls 1965). It was necessary, therefore, to perform experiments on free-living seals which were individually identified either by placing on the outside web of the hind flipper a monel metal tag of the type used to identify fur seals (Roppel *et al.* 1965), by branding (Smith, unpublished data), or by painting various symbols on their sides (Lugg, unpublished data). These individually identified seals were recaptured for subsequent examinations, and the frequency of re-examination was influenced considerably by the severity of the climatic conditions, particularly as it was necessary for the observer to remove gloves and mittens to examine a seal for lice.

Skin temperatures were measured with Weston thermocouples, which gave comparable results to the more sensitive instrument used by Ray and Smith (unpublished data) to measure skin temperature in their study of thermoregulation of the Weddell seal. Laboratory experiments were carried out at Scott Base (M.S.R.S.) and Wilkes Station (Z.S.) in Antarctica, and in New Zealand (M.D.M.) with live lice and eggs flown from McMurdo Sound, Antarctica.

III. Natural History of the Weddell Seal

The habitat of the Weddell seal, which is the most southerly ranging of mammals apart from man, is the coastal waters of Antarctica. It spends much time in the water but emerges at intervals to lie on the ice or on the beaches. Usually it hauls up onto the ice alongside tide and pressure cracks (Plate 1, Figs. 1 and 2), the abundance of which varies with season and locality. Thus, at McMurdo Sound (77°51′S., 166°40′E.) there are few cracks in thick sea ice from autumn to spring, and the seals keep holes open by "sawing" with their teeth. This is rarely necessary around Wilkes (66°15′S., 110°32′E.) and Davis (68°35′S., 79°59′E.) (Lugg, unpublished data), which are in less southern latitudes, and where there are numerous cracks in the sea ice throughout the year. The descriptions of the annual cycles of the Weddell seal which have been observed in various regions of Antarctica are basically similar, and the following summary is based on observations at McMurdo Sound (Smith 1965).

Pregnant females haul out from mid-October to mid-November to pup, and mothers and pups lie together for many hours until the pup is weaned (Plate 1, Fig. 1; Plate 2, Fig. 1). After 2 weeks the pups commence to shed their birthcoat which is completely lost within 6–7 weeks. They commence swimming at 3 weeks with their mothers' assistance, and are weaned at 6 weeks.

From mid-November to early January the main population of seals hauls out onto ice, and comprises males, non-pregnant females, immature seals (2–3 year old), a few yearlings (pups of the previous year) which are recognizably smaller, and pups. The individuals of these groups are scattered and do not lie touching one another (Plate 1, Fig. 2). They haul out onto the ice daily when the weather is calm, and if it is also warm they may remain there for about 8 hr before returning to the sea to feed. In windy and cold weather they spend much less time ashore, and remain in the sea, the temperature of which is about -2°C. They are rarely seen on the ice in the winter.

The number of seals seen on the ice declines from mid-February to mid-March, and it is considered that they leave the immediate vicinity of the coast of Antarctica which may become covered with thick fast ice, and depart northwards to where the ice is less thick and solid and where cracks are more abundant. A small wintering population of adults usually remains. When the main population returns the following spring few yearlings are seen, and apparently they do not return in numbers to the coast of Antarctica until they are 2–3 years old. Mating is considered to take place in the sea, as it has never been observed on land, and females commence to breed when 3–4 years old.

IV. Habitat of *A. ogmorhini* on the Weddell Seal

(*a*) *General*

The habitat of *A. ogmorhini* is the pelage of the Weddell seal which covers most of the body but is sparse on the webs of the flippers. The pelage is usually only 2–3 mm deep, and consists of hair fibres which are about 10 mm long, and lie parallel and close to the skin. There are stout flattened guard hairs and softer underfur hairs, and, although each hair grows from a separate follicle, one guard hair with several underfur hairs posteriorly emerge from a common orifice. These orifices are at the bases of depressions on the skin surface which is uneven in appearance.

There was no evidence of an air-blanket or air bubbles being maintained in the pelage while the seals were in water.

(b) *Skin Temperature*

A detailed study of thermoregulation of the Weddell seal at McMurdo Sound (Ray and Smith, unpublished data) has shown that the hind flipper, ankle, hip, tail, and to a less extent the fore flipper, are concerned with heat dissipation. The skin temperature of these areas was much more variable than elsewhere on the body, and could rise from 0 to 30°C while that of the rest of the body remained between 0 and 5°C. When exposed to solar radiation the skin temperature of the whole body could rise to 32°C.

(c) *Moult*

The moult is of the usual mammalian type, and hair shedding of all age groups, other than pups, takes place in December and January. The seals continue to feed in the sea and haul out onto the ice during the moult.

V. Stages of the Life Cycle of A. ogmorhini

The stages of the life cycle are the egg, three nymphal instars, and the adult males and females.

The eggs are about 1 mm long and 0·6 mm wide, whitish when newly laid, changing to fawn and brown as the embryo develops. The end of attachment is nearest to the skin, and the posterior of the egg is well covered with cement substance (Plate 2, Fig. 2).

The setae covering the first two nymphal instars are less developed than those of the adults, and scales appear first on the second instar. The three stages may be readily distinguished by their size. Stage I nymphs are about 1·2 mm long and 0·5 mm wide, stage II nymphs are about 1·5 mm long and 0·7 mm wide, and stage III nymphs are 1·9 mm long and 1·2 mm wide. Females are larger than males being on average 3 mm long and 2·1 mm wide compared with 2·5 mm long and 1·5 mm wide, and their abdomens are more rounded than the pear-shaped abdomen of the male (Plate 2, Fig. 2).

VI. Distribution and Number of A. ogmorhini on Weddell Seal

(a) *Distribution on Body*

The distribution of lice on 30 infested seals of various ages was determined. Lice were found on the tail, ankle, hip, and hind flippers of all; adults, but no eggs, were occasionally found on the fore flippers near to the axilla; lice were not uncommon around anal and penile orifices of male seals but rarely were they found elsewhere on the body.

Lice were often found in large numbers on the tail particularly where the hair was densest. Eggs were most commonly found on the hind flippers, particularly on the dorsal surface of the digits.

(b) *Distribution on the Skin*

Eggs were laid in clusters, and each egg was attached to a separate guard hair and its accompanying undercoat hairs (Plate 2, Fig. 2). Solitary females surrounded by a cluster of eggs were found but usually nymphs, adults, and eggs were found together.

Occasional pairs of lice were found on flippers, and all of 22 pairs of lice removed from three seals comprised a male and female.

Nymphs and adults lay on the surface of the skin with their heads resting snugly in the depressions into which the hair follicle groups opened. One or more hairs were grasped by each tarsal claw, and sometimes the pointed tips of the tarsi were embedded in the skin (Plate 2, Fig. 2). When the pelage was dry the lice were quite difficult to remove.

(*c*) *Number of Lice*

The number of lice found on pups 5–7 weeks old was 8–90 with an average infestation of 50–60 lice. On yearlings with typical infestations, it was usual to find about 40 lice easily on the tail and flippers. A complete count was made of the lice on a yearling seal with a typical infestation, and 115 lice were found. Infested adult seals had noticeably fewer lice, and the estimated range of the total number of lice was 1–50. No heavily infested adult seals were found.

(*d*) *Percentage of Weddell Seals Infested*

The infestation rate at McMurdo Sound was 75% of 30 pups, 100% of 15 yearlings, and 5% of 275 mature adults (92 females, 183 males) of which the infested seals were mainly females. At Wilkes all of 12 pups examined in January and February 1962 were infested as were most yearlings and immature seals examined. No lice were found on 21 adult seals examined during the period October–December 1962 but lice were found on all of six yearling seals.

VII. Experimental

(*a*) *Activity of* A. ogmorhini *at Various Temperatures*

In air at *c*. 100% R.H. lice were inactive at 0°C and active at 6–10°C. When exposed to 25°C they were violently active for 5–10 min after which little movement was observed.

(*b*) *Time Required to Feed*

Two thin adult lice were placed on the outer aspect of a digit of the hind flipper of a 5-week-old pup which was restrained manually. The skin temperature of the hind flipper was 10–20°C. The lice completed feeding in 2–3 min when their abdomens were rounded in appearance. Many lice with abdomens similarly rounded have been seen on seals which have been examined within a minute of hauling out of the sea onto the ice.

(*c*) *Rate of Reproduction*

(i) *Oviposition*

The abdomens of 10 females were dissected, and the number of maturing ova visible at ×25 magnification determined. The mean number was 10·5 ova per louse (S.D. ±2·27; range 8–15) of which 3·4 (S.D. ±0·52; range 3–4) were almost fully developed with the chorion present.

A female was observed ovipositing on a hind flipper, the skin temperature of which was 10–12°C. The posterior end of the abdomen of the louse was rubbed up and down the hair fibre several times before the cement substance was excreted, and as the egg was expelled the abdomen contracted.

(ii) *Length of Life Cycle*

All the lice were removed from the outer dorsal surface of a hind flipper of a 5-week-old seal, and the eggs were left. When examined 7 days later no eggs had hatched; after 15 days eggs had hatched and nymphs were present; after 26 days adults only were present. The seal spent most of this period on the ice but it was observed swimming on four occasions. The sequence of the changes in the composition of the louse population indicated that no reinfestation of the flipper from elsewhere had occurred. Thus, the life cycle was completed in 3–4 weeks.

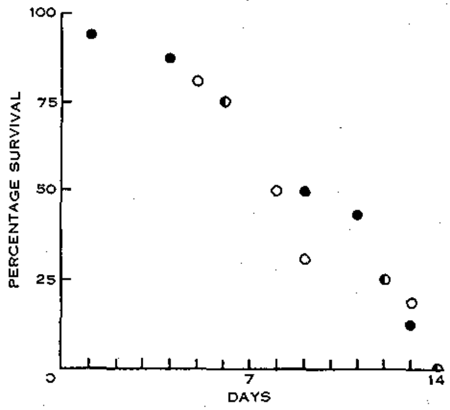

Fig. 1.—Percentage survival of *Antarctophthirus ogmorhini* when exposed to a temperature of 6°C in moist air or seawater. ● Moist air; ○ seawater.

(*d*) *Development of Eggs at Various Temperatures*

Two groups of 20 eggs were exposed to 5 and 10°C in moist air. The eggs continued to develop, and three hatched at 5°C and four at 10°C. A few eggs of other collections even hatched when exposed to 0–4°C but none hatched at 16 or 20°C.

(*e*) *Survival in Water*

(i) *Mode of Respiration*

The spiracles are used when the louse is in air. Living lice were immersed in water and examined under a stereoscopic microscope. A respiratory plastron was not visible. Occasionally air was trapped temporarily beneath the scales but it was not a regular occurrence, nor was the area of trapped air extensive, nor in direct communication with the tracheal system. The small air bubbles which were occasionally attached to setae were not invariably attached to those around the spiracles.

When lice were immersed in water at 6°C, and all visible air bubbles removed from both the lice and the water, some survived for 14 days. It would appear that oxygen can be obtained from water by diffusion through the cuticle.

(ii) *Survival at Different Temperatures*

Adult lice were removed from seals and 16 were placed in air at *c.* 100% R.H. at 6°C. Another 16 were submerged in water, and all the visible bubbles of air were removed from both the lice and the water. Figure 1 shows that the survival rates were similar, and none survived longer than 14 days. No blood was visible in the stomachs of these lice at the conclusion of the experiments so it would appear that death of the lice in both groups was due to starvation.

Another group of nine female lice was kept in air at *c.* 100% R.H. at 2–5°C. One female, which was the most fully engorged, survived 27 days whereas there was a steady mortality of the others over 18 days. Two groups of four lice were exposed to temperatures ranging from −2 to 0°C; one group was exposed in air and the other was submerged in seawater. In each group they survived only 9–13 days. There was no evidence of the lice entering into a state of complete suspended animation.

Lice exposed to a temperature of −20°C for 36 hr were not harmed and became active at 10°C. *A. ogmorhini* can apparently tolerate supercooling.

(*f*) *Transmission*

A total of 40 identified pups were examined at intervals after birth and the stage of louse present determined. Lice were found first on the predilection sites when their birthcoat was being shed, and most of the pups were infested by 6 weeks of age. The initial populations on pups comprised adults and eggs indicating that only adults transferred from the mother.

Similar findings were obtained at Davis, Antarctica (Lugg, unpublished data).

(*g*) *Influence of Warmer Environment on Louse Populations of the Weddell Seal*

In December 1963 two Weddell seals, a pup and a yearling, were successfully transported by air from McMurdo Sound to the New York Aquarium, Coney Island, where they are being kept in water at *c.* 14°C. The initial louse infestation of the yearling was about 110 lice. Early in 1964 Dr. Carleton Ray reported that the infestations on both seals had become more apparent, and examination (by M.D.M.) in June 1964 revealed that lice had spread over the whole body.

VIII. Discussion

Infestations spread solely from Weddell seal cows to their pups by the transference of adult lice, and most pups were infested by 6 weeks of age. Infestations were heaviest on yearling and immature seals, and few infestations were found on mature seals. Female mature seals were more frequently infested than males, and none of the infestations on mature seals was heavy.

Antarctophthirus ogmorhini was active at 5–10°C. A female was observed to oviposit at 10–12°C. and eggs continued to develop and hatch at 0–4, 5, and 10°C but none hatched at constant temperatures of 16 or 20°C. Exposure to −20°C for 36 hr did not harm the lice but at 25°C there were signs of heat stress. These findings indicate that *A. ogmorhini* has become adapted to survive low temperatures, and to be active and to reproduce at temperatures far lower than those recorded for any other mammalian louse. Even *L. macrorhini* on the elephant seal requires temperatures over 25°C for rapid multiplication (Murray and Nicholls 1965). It would appear that reproduction and rapid multiplication of *A. ogmorhini* proceed from 5 to 15°C. These temperatures only occur for prolonged periods when the Weddell seal has hauled out onto the ice, and not when it is in the sea.

The presence of eggs and lice in greatest densities on the tail, ankle, hip, and hind flippers indicates that these regions favour multiplication. The skin temperature of these regions varies with the thermoregulatory requirements of the Weddell seal, and fluctuates from 0 to 30°C, thus favouring louse reproduction, whereas it is more usual for the skin temperature of the rest of the body to approximate that of the seal's habitat (Ray and Smith, unpublished data). The skin temperature immediately around and just within the penile orifice can also be warmer than that of the surrounding skin (Wigg, unpublished data), and it seems likely that it also is determined largely by the thermoregulatory requirements of the seal. When seals were placed in a habitat where the skin temperature of the body was usually at least 14°C, lice dispersed over the whole body.

The presence of 8–15 maturing ova, 3–4 of which were nearly fully developed, in the abdomens of female lice suggests they may lay 6–10 eggs daily as does *L. macrorhini* (Murray and Nicholls 1965); the life cycle was completed in 3–4 weeks on a pup which had commenced to swim; it would appear, therefore, that *A. ogmorhini* has the reproductive potential to increase its numbers rapidly when given the opportunity. However, the relatively small numbers of lice found on seals, even on those which were most heavily infested, indicates the presence of factors which were constantly limiting their numbers.

The life cycle was completed in 3–4 weeks on a pup which spent most of its time on the ice. The normal behaviour of a Weddell seal during the summer is to spend about 8 hr out of the sea daily when the weather is calm and warm, but considerably less when it is windy and cold. It seems improbable therefore that the life cycle is completed in 3–4 weeks on seals other than pups, and little multiplication can occur on seals which remain in the fast ice regions around Antarctica during the winter and rarely haul out onto the ice.

When the seal is in the sea, the temperature of which is about −2°C in Antarctica, the lice are inactive. There is no evidence that *A. ogmorhini* enters into a state of complete suspended animation at temperatures from −2 to 0°C, or that the inability of lice on a seal at sea to absorb sufficient oxygen may be a significant cause of mortality. The death within 2 weeks of most of the lice which were exposed to low temperatures, both in air and submerged in water, after removal from the seal does show, however, that they must feed regularly to survive. Should the temperature of their predilection site rise to 5–15°C for only 4 min, as it may when the seal dissipates heat or the blood flow to the flippers increases after the seal surfaces following a prolonged dive (Scholander 1940), it seems likely that lice could feed. However, this may not occur frequently on a seal living in water at −2°C, and most lice may feed when the seal is ashore. Long periods of inclement weather, which cause the seals to remain in the sea, may therefore cause a mortality of lice. Another cause of mortality is the moult of the seal, when eggs and some lice are undoubtedly lost. As the moult occurs in December and January the population can be restored before the winter.

It would appear that the numbers of *A. ogmorhini* are determined mainly by the relationship of the proportion of time the Weddell seal spends on the ice to the time it spends in the sea, as a rapid increase in numbers can occur on a seal which spends much time ashore and little at sea, a slow increase could occur on a seal which hauls out of the sea regularly but a decline must occur on a seal which rarely comes out of the sea. The population size of this louse is therefore largely determined by the behaviour of the seal, which varies with its age and the climatic conditions to which it is exposed.

The life history of *A. ogmorhini* on the Weddell seal may be summarized as follows. Pups become infested when in close contact with their mothers. The numbers of lice increase rapidly until the pup has been weaned after which the rate of multiplication declines as the pup spends more time in the sea. Pups, immature seals, and some adults apparently leave the immediate shores of Antarctica during the winter for pack ice regions where the ice may be less solid, and where they probably haul out of the sea onto the ice regularly through the winter. On these seals, louse populations are maintained, and a gradual increase in numbers may occur. As seals reach maturity more remain close to the coast of Antarctica during the winter, in regions of thick and fast ice where breathing holes are maintained by sawing with their teeth, and, as a result of spending less time out of the sea, the numbers of their lice decline. Where there are insufficient survivors after the winter to repopulate the seal the following summer, the population of lice disappears. Larger populations of lice are maintained on Weddell seal cows than bulls because they spend more time out of the sea due to pupping and tending their young.

The distributions of *A. ogmorhini* on the Weddell seal, of *L. macrorhini* on the southern elephant seal (Murray and Nicholls 1965), and of *Antarctophthirus lobodontis* Enderlein on the crabeater seal, *Lobodon carcinophagus* (Hombrom & Jacquinot)*, are similar. All are found in densest numbers on the hind flippers, tail, ankle, and hip, and an explanation for this distribution has been given for two of these species. These regions are involved in thermoregulation of the seal, and the consequent fluctuations in skin temperature afford more opportunities for the lice to multiply rapidly when the seal is ashore and more opportunities to feed to survive when the seal is at sea for prolonged periods. The reasons for the survival of *A. ogmorhini* around the anal and penile orifices are undoubtedly the same. It seems likely, therefore, that the distribution of lice on the bodies of other species of seals may be similar to those described, as the thermoregulatory physiology of all seals, other than fur seals, is probably similar.

* The distribution of *A. lobodontis* on an immature male crabeater seal was determined (by M.S.R.S.). Lice were found on the tail, hip, ankle, hind flipper, and around the penile orifice. Eggs were found on the digits of the hind flipper. The lice appeared to be partially buried in the stratum corneum but were not within a burrow as is *L. macrorhini* of the southern elephant seal.

IX. Acknowledgments

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Explanation of Plates 1 and 2

Plate 1

Fig. 1.—Group of Weddell seal cows with pups. Edge of the Erebus Glacier tongue, McMurdo Sound, Antarctica, where tide cracks in the sea ice commenced to open in the late spring. Females have hauled out onto the ice and have pupped; only pups lying close to their mothers may be seen. The age composition of the seals in this group is typical for the time of the year (18.xi.63).

(N.Z.D.S.I.R. Antarctic Division photograph by G. Mannering.)

Fig. 2.—Group of Weddell seals on sea ice. Iceberg stranded off Marble Point, McMurdo Sound, Antarctica with Ross I. in the background. The sea ice is breaking up, and open water is visible. A pool of water has developed at the base of the iceberg, and Weddell seals have hauled out onto the sea ice through cracks in the deteriorating ice. The group is of average size, and it consists of males, females, immatures, and pups, an age composition typical for the time of year (4.i.64). The scattered distribution of the individual seals on the ice around the pool may be seen.

(N.Z.D.S.I.R. Antarctic Division photograph by G. Mannering.)

Plate 2

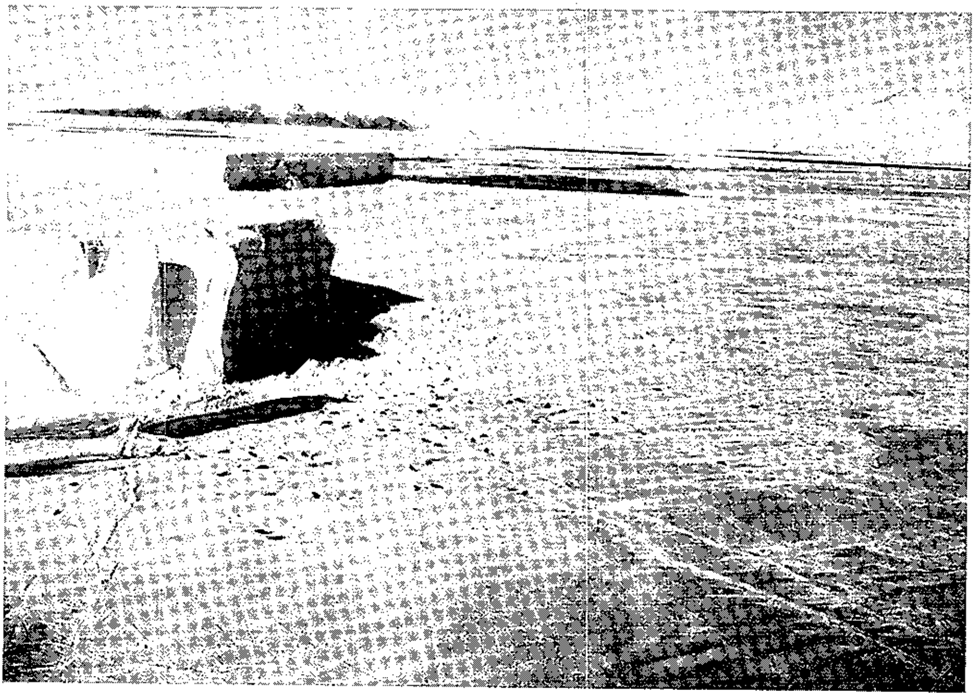
Fig. 1.—Weddell seal cow with pup. The pup, which is 5–6 weeks old, has shed its birth coat. *A. ogmorhini* infestations are found on the tail, ankle, hip, and hind flipper. Occasionally the axilla of the fore flipper and the penile and anal orifices are infested.

(Photograph by M. S. R. Smith.)

Fig. 2.—*A. ogmorhini* on the skin of the Weddell seal. The hair coat of the Weddell seal consists of groups of hairs comprising a guard hair with several undercoat hairs, all of which emerge from a single orifice at the base of a depression in the skin. The lice lie close to the surface of the skin with their heads within the skin depressions. Eggs are attached to the hair groups singly and close to the skin. The hair has been removed from the upper left portion of this preserved specimen to show the uneven surface of the skin, and to reveal the eggs and lice. The four largest lice are females, the other two are males.

(Photograph by I. Roper.)

ECTOPARASITES OF SEALS AND PENGUINS. II



ECTOPARASITES OF SEALS AND PENGUINS. II