Parasites and Parasitic Diseases of Domestic Animals in the Hawaiian Islands[1]

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PARASITES OF ANIMALS have gained entrance to the Hawaiian Islands for a century or more largely with the importation of infected animals from various parts of the world. Because of the mild climatic environment and other favorable factors, these parasites have become established and now constitute an agricultural problem of considerable economic importance. To what extent the people of these islands will be successful in keeping other animal parasites and vectors from entering, especially with the expansion of air and sea transportation, remains to be determined. Much is being done, however, through quarantine, inspection, and other Territorial and Federal regulatory measures to prevent the introduction of additional disease-producing organisms and vectors of disease.

The parasites now present in domestic animals in the Hawaiian Islands are to a large extent the same as are found in continental United States. This is true because most of the animals found in the Islands have come from that area. There are a few parasitic forms, however, which have undoubtedly been introduced from the Orient. These include, at least, *Fasciola gigantica* Cobbold, the common liver fluke of cattle, and *Hymenolepis exigua* Yoshida, a tapeworm frequently found in chickens. In spite of the many parasitic diseases which have been introduced from continental United States, some of the important ones affecting the blood, such as anaplasmosis and piroplasmosis of cattle and dourine of horses, either have not been introduced or have failed to become established.

The present paper represents a résumé of internal and external parasites, and of their intermediate hosts, if any, which have been reported up to the present time from domestic animals in the Hawaiian Islands. Special reference is given to certain species which are of economic importance. Whereas considerable data are available on parasites of chickens, cattle, horses, and swine, information on those of other animals is up to the present time inadequate or entirely lacking. The chief sources of information on the external parasites reported in this paper have been the scattered reports published by various entomologists in the Islands. Data dealing with internal parasites (protozoa, roundworms, tapeworms, and flukes) and any of their intermediate hosts have been secured largely, except as indicated, from the various reports and observations made by the writer during the past several years.

PARASITES OF POULTRY

PROTOZOA

Coccidial organisms, *Eimeria tenella* Railliet and Lucet, are the most important protozoa affecting chickens. Infection with these parasites is as troublesome in Hawaii as it is anywhere else.

Pigeons in Hawaii are commonly infected

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with the malarial organism *Haemoproteus columbae* Celli and Sanfelice (Alicata, 1939*c*). This protozoan lives in the red blood cells and may be responsible for the production of anemia and low vitality. It is spread among pigeons through the bite of the pigeon fly, *Pseudolynchia canariensis* (Macquart), which is generally distributed (Bryan, 1934). *Histomonas meleagridis* (Smith), the causative organism of "blackhead" in turkeys, is responsible for sporadic outbreaks of this disease in various parts of the Islands.

ROUNDWORMS

Up to a few years ago gizzard-worms, *Cheilospirura hamulosa* (Diesing), were widespread among chickens and turkeys in the Territory and were responsible for anemia, emaciation, and deaths, especially among chickens. The infection was checked after the discovery and control of the following arthropods, which were found serving as intermediate hosts (Alicata, 1936; 1938*b*; 1939*c*): (COLEOPTERA) *Carpophilus dimidiatus* Fabricius, *Dactylosternum abdominale* (Fabricius), *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, *Euxestus* sp., *Gonocephalus seriatum* (Boisd.), *Litargus balteatus* Lec., *Oxydema fusiforme* Woll., *Palorus ratzeburgi* (Wissm.), *Sitophilus oryzae* (Linn.), *Tenebroides nana* Melsh., *Tribolium castaneum* (Herbst), and *Typhaea stercorea* Linn.; (ORTHOPTERA) *Atractomorpha ambigua* Bolivar, *Conocephalus saltator* (Sauss.), and *Oxya chinensis* (Thun.); (AMPHIPODA) *Orchestia platensis* Kröyer.

The eyeworm, *Oxyspirura mansoni* (Cobbold), which utilizes the burrowing roach, *Pycnoscelus surinamensis* (Linn.), is common in chickens in the Islands (Alicata, 1936). This eyeworm has also been found in the English sparrow (*Passer domesticus* [Linn.]) (Illingworth, 1931), the mynah bird (*Acridotheris tristis* [Linn.]), and the Chinese dove (*Streptopelia chinensis* [Scopoli]). On this account, these wild birds are believed to assist in spreading the infection in nature. The parasites are located in the inner corner of the eyeball and in the nictating membrane. In heavy infestations there is a puffiness around the eye, and inflammation frequently results in blindness. Infested birds often wink their eyes continually, and the irritation causes the bird to scratch the eye with the claws for relief. The process of scratching frequently causes mechanical injury to the eyeball and development of secondary bacterial infection. Eyeworm infection is most prevalent in dry areas with loose sandy soil in which roaches thrive. As a means of controlling this disease, the writer has advocated the maintenance of giant toads, *Bufo marinus* (Linn.), in poultry yards. These toads are insectivorous and devour roaches readily.

The poultry ascarid, *Ascaridia galli* (Schrank), and two species of cecal worms, *Heterakis gallinae* (Gmelin) and *Subulura brumpti* (Lopez Neyra), are common among chickens. *S. brumpti* is the most prevalent, and unlike *H. gallinae* requires an intermediate host, which may be any one of the following (Alicata, 1939*a*; Cuckler and Alicata, 1944): (COLEOPTERA) *Alphitobius diaperinus* (Panz.), *Ammophorus insularis* Boh., *Dermestes vulpinus* Fabricius, *Gonocephalus seriatum* (Boisd.), and *Tribolium castaneum* (Herbst); (ORTHOPTERA) *Conocephalus saltator* (Sauss.), *Oxya chinensis* (Thun.); (DERMAPTERA) *Euborellia annulipes* (Lucas). The intestinal roundworm, *Ornithostrongylus quadriradiatus* (Stevenson), has been found common in pigeons in the Islands and is believed responsible for unthriftiness and losses among pigeons (Alicata, 1939*c*).

Other roundworms of chickens which require an intermediate host include the crop worm, *Gongylonema ingluvicula* Ransom, and the proventricular worms, *Tetrameres americana* Cram and *Dispharynx spiralis* (Molin). In continental United States *G. ingluvicula* has been found to utilize the beetle

Copris minutus Drury as an intermediate host. In Hawaii, the related beetle *C. incertus* (Say) may be found to serve as a suitable host. *T. americana* is known to utilize any of the following as intermediate hosts in the Islands (Alicata, 1938*c*): (COLEOPTERA) *Dendrophilus* sp. (probably *D. punctatus* Herbst), *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, and *Gonocephalus seriatum* (Boisd.); (ORTHOPTERA) *Blattella germanica* (Linn.); and *Conocephalus saltator* (Sauss.); (DERMAPTERA) *Euborellia annulipes* (Lucas); (AMPHIPODA) *Orchestia platensis* Kröyer. The sow bug, (ISOPODA) *Porcellio laevis* Latr., serves as intermediate hosts for *D. spiralis* (Alicata, 1938*c*), which often produces deep ulcerations of the proventricular wall.

FLUKES

The cecal fluke, *Postharmostomum gallinum* (Witenberg), commonly infects adult chickens raised on the ground. Extensive cecal hemorrhages have been found associated with infection by this parasite. Recent studies have shown that two common land snails, *Eulota similaris* (Fer.) and *Subulina octona* (Brug.), serve as intermediate hosts (Alicata, 1940).

TAPEWORMS

Tapeworms are of common occurrence in chickens. Those known in Hawaii include the following: *Choanotaenia infundibulum* (Bloch), *Hymenolepis carioca* (Magalhaes), *Hymenolepis exigua* Yoshida, *Raillietina cesticillus* (Molin), and *R. tetragona* (Molin) (Alicata, 1938*c*).

Various arthropods in Hawaii are known to serve as intermediate hosts for the above-mentioned tapeworms, as follows (Alicata, 1938*c*; Hall, 1929): *C. infundibulum:* (COLEOPTERA) *Dermestes vulpinus* Fabricius, *Epitragus diremptus* Karsch, *Gonocephalus seriatum* (Boisd.), and (DIPTERA) *Musca domestica* Linn.; *H. exigua:* (AMPHIPODA) *Orchestia platensis* Kröyer; *R. cesticillus:* (COLEOPTERA) *Dermestes vulpinus* and *Gonocephalus seriatum; R. tetragona:* probably various species of ants, especially those of the genera *Pheidole* and *Tetramorium*. Members of this group of ants (*P. vinelandica* and *T. caespitum*) are known intermediate hosts of *R. tetragona* in continental United States (Jones and Horsefall, 1935).

ARTHROPODS

Various species of lice are known to infest poultry in the Islands. These include the following (Illingworth, 1928*a*): chicken body louse, *Eomenacanthus stramineus* (Nitzsch); chicken head louse, *Lipeurus heterographus* Nitzsch; common hen louse, *Menopon gallinae* (Linn.), also found on turkeys and guinea hens; fluff louse of chickens and turkeys, *Goniocotes hologaster* Nitzsch; large chicken louse, *Goniocotes gigas* Taschenberg; large turkey louse, *Goniodes stylifer* Nitzsch; peafowl and guinea hen louse, *Menopon phaeostomum* (Nitzsch); turkey louse, *Lipeurus gallipavonis* Geoffroy; and the chicken wing louse, *Lipeurus caponis* (Linn.).

Mites found on chickens include the red mite, *Dermanyssus gallinae* (De Geer); the wing mite, *Pterolichus obtusus* Robin; and the body mite, *Megninia cubitalis* (Megnis) (Alicata *et al.*, 1946). Included likewise is the tropical fowl mite, *Lyponyssus bursa* (Berlese); this mite has also been reported common in nests of English sparrows and mynah birds. It is known to invade houses, where it bites human beings and causes skin irritation (Zimmerman, 1944).

Other arthropods of poultry include the sticktight flea, *Echidnophaga gallinacea* (Westwood) (Illingworth, 1916); the pigeon fly, *Pseudolynchia canariensis* (Macquart) (= *Lynchia maura* Bigot), generally widespread among pigeons (Bryan, 1934); and the biting louse of pigeons, *Columbicola columbae* (Linn.) (Zimmerman, 1944).

Parasites of Cattle

PROTOZOA

Four species of coccidia, *Eimeria cylindrica* Wilson, *E. bovis* Zublin, *E. zurnii* Rivolta, and *E. bukidnonensis* Tubangui, have been recovered from the feces of young calves (Cuckler and Alicata, 1943). Although no severe cases of bovine coccidiosis have been recorded in the Islands, reports elsewhere indicate that infection may produce bloody diarrhea and emaciation.

ROUNDWORMS

In a recent survey involving the examination of about 375 cattle raised on various islands and slaughtered in Honolulu, the following percentages of roundworm infections were found (Cuckler and Alicata, 1943): gullet worms, *Gongylonema pulchrum* Molin, 54.3 per cent; stomach worms, *Haemonchus contortus* (Rudolphi), 0.9 per cent; intestinal roundworms, *Bunostomum phlebotomum* (Railliet), 6.7 per cent; *Cooperia punctata* (v. Linstow), 4.0 per cent; *C. pectinata* Ransom, 0.3 per cent; and the skin filarid, *Stephanofilaria stilesi* Chitwood, 89.8 per cent. Eggs of *Trichuris ovis* (Abildgaard) and *Strongyloides* sp. (probably *S. papillosus*) have at times been found in the feces of cattle in Hawaii.

The intestinal roundworm, *Oesophagostomum radiatum* (Rudolphi), and the lungworm, *Dictyocaulus viviparus* (Bloch), have also been noted by the writer. Lungworm infection is believed to be of considerable importance, especially among calves, in some sections of the Islands, and deaths resulting from this parasite have been recorded (Willers, 1945).

Of the above roundworms, *Stephanofilaria stilesi* and *Gongylonema pulchrum* require an intermediate host in their development. The intermediate host for *S. stilesi* is unknown. *G. pulchrum* is known to utilize one of various coprophagous beetles and roaches as intermediate host in continental United States (Alicata, 1935). Of insects reported as hosts, *Aphodius lividus* (Oliv.), *Dermestes vulpinus* Fabricius, and *Blattella germanica* (Linn.) occur in Hawaii.

FLUKES

Two species of flukes have been recorded from cattle in the Islands. One species consists of an unidentified rumen fluke reported by Hall (1936), and the other species is the liver fluke, *Fasciola gigantica* Cobbold.

Liver-fluke infection is the most important parasitic disease of beef and dairy cattle. Infection with this parasite was first reported by Dr. A. Lutz (1892) as being common on four of the larger islands. Although at that time the parasites were reported as *Fasciola hepatica* Linn., more recent study has shown them to be *F. gigantica* (Alicata and Swanson, 1937). The importation of this fluke into Hawaii is not clearly understood, but it is believed to have come from the Orient with the introduction of water buffaloes. It is of interest to note that the limnaeid snail, *Fossaria ollula* (Gould), which serves as the intermediate host, has Japan and China as its geographic range (Alicata, 1938*a*). This snail is widely distributed in Hawaii and is common in streams and swampy lowlands.

The maintenance of fluke infection in Hawaii, as elsewhere, is dependent on various factors of which topography, climatic conditions, and agricultural practices are very important. The Hawaiian Islands represent the summits of a 2,000-mile range of volcanic mountains which vary from coastal to centric or eccentric in position. The mountains descend to the ocean abruptly, in steep walls or by gradual transition over relatively flat land with very little drainage. These poorly drained lowlands and valleys, especially on the windward side, often present rather extensive swamps. Rainfall is most prevalent in winter months, but showers during other seasons of the year are sufficient to maintain swampy conditions. These wet areas and the mild Hawaiian climate encourage snail prop-

agation the year round as well as the development and hatching of fluke and other parasite eggs. Moreover, agricultural practices in the Islands have encouraged rather than hindered the maintenance of fluke infection. With ample supplies of vegetation, cattle have been allowed to graze continuously. Many dairymen have long been in the habit of feeding cut forage from wet or swampy areas to cattle. These practices have been largely responsible for the widespread fluke infection. This disease is gradually being brought under control largely through (1) use of copper sulfate for the control of the snail vector in swamps or streams, (2) use of forage grass cut from dry areas, and (3) treatment of infected animals with hexachloroethane. This synthetic compound, although first used in fluke control in Europe in 1926 (Thienel, 1926), was first utilized on a large scale in the United States by the University of Hawaii Agricultural Experiment Station (Alicata, 1941*a*).

TAPEWORMS

The infective larval stage "bladderworm" of *Taenia saginata* Goeze has occasionally been found present in the musculature of cattle in the Islands, according to a personal communication received from Dr. A. H. Julien, Federal meat inspector. The larvae reach maturity in the intestine of man, following ingestion of improperly cooked beef. Cattle acquire the infection as a result of eating vegetation contaminated with human feces containing eggs of this parasite. It is generally believed that most cases of human infection occur among immigrants from the Orient, especially the Philippines.

ARTHROPODS

Several dipterous larvae are known to be parasitic on cattle. In a recent examination of 303 animals (Cuckler and Alicata, 1943), 26.1 per cent showed evidence of the cattle grub, *Hypoderma lineata* (De Villers), a fly first reported in the Islands in 1906 (Bryan, 1934). This parasite is recognized as very injurious to cattle, causing loss of flesh and decreasing the value of the skin for leather. Some years ago, Mr. O. A. Pickerill of the Hawaii Meat Company in a personal communication reported that during the year 1934, of 15,099 hides examined, 4,252, or 28.16 per cent, were grubby.

In recent years a report was made of attacks or "fly strike" of blowflies on young calves on the island of Kauai (Holdaway, 1943; 1945). Observations indicated that three species of flies were involved, *Chrysomia megacephala* (Fabricius), *C. rufifacies* (Macquart), and *Lucilia sericata* (Meigen).[3] These flies ordinarily breed in carcasses and other animal matter. However, they may deposit eggs in a number of different places on recently born calves. The eggs hatch and the larvae or maggots feed on the surface layer and cause an inflamed, malodorous wound. Infested calves become spiritless and, unless suitably treated, die in a few days.

Auricular myiasis of cattle caused by the larvae of *C. megacephala, C. rufifacies,* and *Fannia* sp. have been reported by Zimmerman (1944). Species of adult flies which are pestiferous on cattle in the Islands include the horn fly, *Siphona irritans* (Linn.) (= *Lyperosia irritans* [Linn.]), and the stable fly, *Stomoxys calcitrans* (Linn.) (Bryan, 1934).

Lice, *Haematopinus eurysternus* (Nitzsch) (Cuckler and Alicata, 1943) and *Bovicola bovis* (Linn.) (Zimmerman, 1944), have occasionally been found on cattle. General emaciation or unthriftiness is usually associated with infestation.

The spinose ear tick, *Otobius megnini* (Dugès), which was first noted in recent years (Alicata, 1941*b;* Cuckler and Alicata, 1943; Zimmerman, 1944), is widespread on beef cattle. Of 357 cattle examined from

[3] According to a personal communication from F. G. Holdaway, the identification of *Lucilia* is tentative.

Hawaii, Oahu, and Maui, 160, or 44.8 per cent, showed infestation (Cuckler and Alicata, 1943). In several instances the ticks were found in large numbers filling the entire ear canal. These ectoparasites are known to puncture the tender skin of the ear and suck blood. The wounds thus caused often ulcerate and a condition known as ear canker results.

Parasites of Swine

PROTOZOA

There are two types of protozoa infecting swine in the Islands. They are frequently the cause of dysentery, especially among young animals. Included are the coccidia, *Eimeria debliecki* Douwes, *E. scabra* Henry, and *E. spinosa* Henry, and the ciliate, *Balantidium coli* (Malmsten). Various forms of unidentified amoebae and flagellates of unknown pathogenicity are also frequently noted in the feces of swine.

ROUNDWORMS

In 1938 an examination of the feces of 103 grown pigs from the islands of Oahu and Kauai (Alicata, 1939*b*) revealed the following incidence of parasite eggs: *Ascaris suum* Goeze, 21 per cent; *Oesophagostomum dentatum* (Rudolphi), 32 per cent; *Strongyloides* sp., 43 per cent; *Trichuris suum* (Schrank), 7 per cent.

Adult roundworms which have been recovered at necropsy from swine include the following (Alicata, 1938*d*): stomach worms, *Ascarops strongylina* (Rudolphi) and *Hyostrongylus rubidus* (Hassall and Stiles); kidney worms, *Stephanurus dentatus* Diesing; lungworms, *Choerostrongylus pudendotectus* Vostokov and *Metastrongylus elongatus* (Dujardin). Larvae of *Trichinella spiralis* (Owen) have also been found encysted in the musculature of a domestic pig.

Kidney worms and lungworms are most frequently found among hogs raised in open hog lots. According to a personal communication received from Dr. R. N. Beddow, Veterinarian, Territorial Board of Health, of 25,234 hogs slaughtered in Honolulu during 1945 and 1946, 2.8 per cent showed adult kidney worms in the kidney fat. This undoubtedly represents a partial incidence of infection in swine, since no observation was apparently made on the presence of young migrating worms, which are frequently found in the liver and other parts of the body.

Of the above roundworms, lungworms are known to require earthworms as an intermediate host. At least two species of unidentified earthworms recovered from hog lots around Honolulu have been found by the writer to harbor infective lungworm larvae. It is reported that in Hawaii there are about a dozen species of earthworms of the genus *Pheretima* (Williams, 1931). The stomach worm, *A. strongylina,* utilizes one of various coprophagous beetles as intermediate host in continental United States (Alicata, 1935); in Hawaii, beetles of the genus *Aphodius* possibly serve in this capacity.

Because of the occurrence of the first laboratory-proved case of human trichinosis in Hawaii in 1936 (Alicata, 1938*e*), the writer, under the auspices of the Territorial Board of Health, conducted a survey to determine the source and prevalence of trichina infection in nature. This survey revealed the following information: of 61 domestic and 41 wild hogs examined from the island of Hawaii, 1 and 6, respectively, were found infected; of 2,130 rats and 70 mongooses examined, 57 and 17, respectively, showed infection. No trichinae were found in 92, 130, and 30 domestic hogs examined from the islands of Maui, Oahu, and Kauai, respectively. Of 1,904 rats and 22 mongooses examined on Maui, 1 and 2, respectively, were found infected. Of 352 and 601 rats examined from Oahu and Kauai, respectively, none showed infection.

It is of interest to point out that from

1936 to 1945, 58 cases of human trichinosis have been reported in the Islands by the Territorial Board of Health. Most of the infected persons had eaten, or were suspected of having eaten, improperly cooked wild pork or products made from wild pork (Alicata, 1938*e*). According to records of the Territorial Board of Agriculture and Forestry, during the 8-year period from 1933 through 1940 inclusive (Tinker, 1941), 32,724 wild hogs, or an average of 4,090 a year, were killed on five of the larger islands. Because of the moderately high incidence of trichinosis in wild hogs, meat from these animals is believed to constitute a health menace unless proper precautions in cooking, preserving, and refrigerating are taken. Mention may also be made that of 133 human diaphragms examined at random at autopsy in Honolulu, 7.4 per cent harbored trichinae larvae (Alicata, 1942).

FLUKES

No flukes are known to be present in domestic hogs in Hawaii. However, the liver fluke of cattle, presumably *Fasciola gigantica,* has been reported from wild pigs (Shipley, 1913). Wild hogs are descended from domestic forms which have escaped and now roam wild in the mountains, swamps, and waste lands of the Islands.

TAPEWORMS

No adult tapeworms are found in swine, but the infective larval stage "bladder worm" of *Taenia hydatigena* Pallas has been found attached to the liver and omentum of swine (Alicata, 1938*d*). These larvae are known to reach maturity in the intestinal tract of dogs.

ARTHROPODS

The hog mange mite, *Sarcoptes scabiei suis* Linn., is prevalent on swine in the Islands. The louse, *Haematopinus adventicius* (Neum.) (= *H. suis* [Linn.]), is also present (Illingworth, 1928*b*). Infestation with these ectoparasites is very often associated with malnutrition and unhygienic surroundings.

PARASITES OF HORSES

PROTOZOA

No reports are available on protozoan parasites of horses in the Islands.

ROUNDWORMS

According to a recent survey (Foster and Alicata, 1939), horses in Hawaii harbor at least 25 species of roundworms, as follows: *Strongylus equinus* Mueller, *S. edentatus* (Looss), *S. vulgaris* (Looss), *Triodontophorus serratus* (Looss), *T. brevicauda* (Boulenger), *Gyalocephalus capitatus* Looss, *Poteriostomum imparidentatum* Quiel, *Cyathostomum coronatum* (Looss), *Cylicocercus catinatus* (Looss), *C. goldi* (Boulenger), *C. pateratus* (Yorke and Macfie), *Cylicostephanus calicatus* (Looss), *C. longibursatus* (Yorke and Macfie), *C. minutus* (Yorke and Macfie), *C. asymetricus* (G. Theiler), *Cylicocyclus nassatus* (Looss), *C. leptostomus* (Kotlan), *Cylicodontophorus bicoronatus* (Looss), *C. euproctus* (Boulenger), *Trichostrongylus axei* (Cobbold), *Parascaris equorum* (Goeze), *Oxyuris equi* (Schrank), *Probstmayria vivipara* (Probstmayr), *Habronema muscae* (Carter), and *H. microstoma* (Schneider). Of the above parasites, *S. vulgaris* has been found to be somewhat common, a fact suggesting that verminous arthritis and aneurism, caused by the larval stage of this roundworm, are not infrequent among horses in the Islands.

The roundworms of the genus *Habronema* listed above are known to utilize elsewhere various species of flies as intermediate hosts (Hall, 1929). In Hawaii, the house fly, *Musca domestica* Linn., may transmit *H. muscae* and *H. microstoma,* and the stable fly, *Stomoxys calcitrans* Geoffroy, may transmit *H. microstoma.*

FLUKES

According to a report by Hall (1936), liver flukes collected in 1894 from a horse in Honolulu were sent to the U. S. Bureau of Animal Industry. These flukes were originally diagnosed as *Fasciola hepatica* Linn., but a recent re-examination by Mr. A. McIntosh of that Bureau revealed that they are *F. gigantica* (Cobbold). Moreover, veterinarians on the island of Kauai have verbally reported to the writer the finding of fasciolid flukes in livers of horses. Thus far the writer has not confirmed these observations. In recent years the examination of the livers of five horses pastured in known fluke-infested areas failed to reveal liver fluke infection. In addition, a horse and a mule fed experimentally 650 and 2,300 infective liver fluke cysts, respectively, failed to show evidence of flukes or fluke lesions when autopsied a few months later (Alicata and Swanson, 1938). It appears that equines only rarely become infected with liver flukes.

TAPEWORMS

Two species of tapeworms, *Anoplocephala perfoliata* (Goeze) (Foster and Alicata, 1939) and *A. magna* (Abildgaard) (Swanson, 1939), have been reported from horses in the Islands. The intermediate host for each of these parasites is unknown.

ARTHROPODS

The larvae of the "bot flies," *Gastrophilus intestinalis* (De Geer) and *G. nasalis* (Linn.) (Foster and Alicata, 1939), are commonly found attached to the stomach wall of horses in the Islands. Adult flies, *Stomoxys calcitrans* (Linn.), are also pestiferous on horses.

Parasites of Sheep and Goats

PROTOZOA

No reports are available on the protozoa of sheep and goats in the Islands.

ROUNDWORMS

A recent examination (Cuckler, 1943) of a group of sheep from the island of Kahoolawe revealed the following incidence of roundworms: stomach worms, *Haemonchus contortus* (Rudolphi), in 6 of 15 examined, and *Trichostrongylus instabilis* Railliet in 3 of 10 examined; intestinal worms, *Cooperia punctata* (V. Linstow), in 3 of 10 examined, and *Nematodirus spathiger* (Railliet) in 1 of 10 examined.

FLUKES

Specimens of liver flukes collected from sheep in Honolulu were submitted to the U. S. Bureau of Animal Industry in 1892 (Hall, 1936). These specimens, which were originally identified as *Fasciola hepatica* Linn., are doubtlessly *F. gigantica,* since the former is not known to have occurred in the Islands.

TAPEWORMS

Unidentified larval tapeworms or "bladder worms," probably those of *Taenia hydatigena* Pallas, attached to the liver and peritoneum of sheep have been noted by Dr. A. H. Julien, Federal meat inspector (personal communication). The larvae of *T. hydatigena* are known to reach maturity in the intestinal tract of dogs.

ARTHROPODS

In the examination of 60 sheep from the island of Kahoolawe (Cuckler, 1943), 43 harbored the spinose eartick, *Otobius megnini* (Dugès). Reports also indicate the occurrence on sheep of the "sheep tick," *Melophagus ovinus* (Linn.) (Bryan, 1933; Muir, 1928); the "head maggot," *Oestrus ovis* Linn. (Bryan, 1933); and the "Oriental blowfly," *Chrysomyia megacephala* (Fabricius) (Bryan, 1934). The sucking louse, *Linognathus africanus* Kellog and Paine, and the biting louse, *Bovicola caprae* (Gurlt),

have been reported from goats (Zimmerman, 1944).

PARASITES OF DOGS

PROTOZOA

Canine coccidiosis (species unknown) is known to be present in dogs in Hawaii.

ROUNDWORMS

The roundworms known from dogs in Hawaii include the following: intestinal roundworms, *Toxocara canis* (Werner), *Toxascaris leonina* (V. Linstow), *Ancylostoma caninum* Ercolani, *Trichuris vulpis* (Frohlich), and the heartworm, *Dirofilaria immitis* (Leidy). Heartworms are believed to be common in the Islands. Of the three species of mosquitoes in Hawaii, *Culex quinquefasciatus* Say, *Aedes aegypti* (Linn.), and *A. albopictus* (Skuse), the first two have already been incriminated as intermediate hosts for heartworms (Hall, 1929). In a check list of parasites of dogs and cats, Dikmans (1945) lists the lungworm *Filariodes osleri* (Cobbold) from Hawaii. The life cycle of this parasite is unknown.

TAPEWORMS

Dipylidium caninum (Linn.) is the only tapeworm noted in dogs in Hawaii. This tapeworm is known to utilize fleas and lice as intermediate hosts (Hall, 1929). *Ctenocephalides felis* (Bouché) (Pemberton, 1926) and *Trichodectes latus* Nitzsch (Swezey, 1931), which could serve as hosts, are found on dogs in Hawaii. Infective larvae "bladder worms" of *Taenia hydatigena* Pallas have been found attached to the liver and omentum of swine (and sheep ?) in the Islands; from this finding it may be inferred that the adult stage of this parasite is found in dogs.

ARTHROPODS

Arthropods present on dogs in Hawaii include the following: fleas, *Ctenocephalides felis* (Bouché) (Pemberton, 1926) and *Echidnophaga gallinacea* (Westwood); lice, *Trichodectes latus* Nitzsch (Swezey, 1931); a species of kangaroo lice, *Heterodoxus longitarsus* Piaget, collected from a dog in Honolulu (Pemberton, 1934); ticks, *Rhipicephalus sanguineus* (Latreille) (Van Zwaluwenburg, 1934); and undetermined species of mange mites.

PARASITES OF CATS

PROTOZOA

No reports are available on the protozoan parasites of cats in the Islands.

ROUNDWORMS AND TAPEWORMS

Little information is available on roundworms and tapeworms of cats in the Islands. The following were collected by the writer from a stray cat in Honolulu: (ROUNDWORMS) stomach worms, *Physaloptera praeputialis* Von Linstow; hookworms, *Ancylostoma caninum* Ercolani; lungworms, *Aelurostrongylus abstrusus* (Railliet); (TAPEWORMS) *Taenia taeniaeformis* (Batsch) and *Dipylidium caninum* (Linn.). Immature acanthocephalids, determined by Dr. H. J. Van Cleave as *Arhythmorhynchus* sp., have been collected by the writer from the small intestine of a cat. Dr. Van Cleave believes that the cat is not the natural host. Acanthocephalids of this genus are predominantly parasites of water birds.

Among the above parasites, the life cycle of the stomach worm is unknown. The lungworms are known to require snails or slugs as intermediate hosts (Hobmaier and Hobmaier, 1935). The land snail *Subulina octona* (Brug.) was reported by Van Volkenberg (1937) as serving as intermediate host in Puerto Rico; in Hawaii the writer has found that the land snails *S. octona* and *Eulota similaris* (Fer.) may serve for that purpose. Cats may also acquire lungworms from eating infected mice, the latter acquir-

ing the parasite as a result of eating infected snails. In mice, the larvae of lungworms migrate to the musculature, where they become encysted (Van Volkenberg, 1937). The tapeworm, *T. taeniaeformis,* is known to utilize rats or mice as intermediate hosts; the infective larval forms, "bladder worms," are commonly found in the liver of these rodents in Hawaii. The tapeworm, *D. caninum,* utilizes fleas or lice as an intermediate host (see parasites of dogs).

ARTHROPODS

The cat flea, *Ctenocephalides felis* (Bouché), and the sticktight flea, *Echidnophaga gallinacea* (Westwood), are common on cats in Hawaii; the former is also commonly found under houses frequented by cats. The biting louse, *Felicola subrostrata* (Nitzsch), has been collected from cats (Zimmerman, 1944).

PARASITES OF RABBITS

Very little is known about parasites of rabbits in the Islands. Liver coccidia, *Eimeria stiedae* Lindemann, have been noted by the writer on several occasions. The scab mite, *Psoroptes communis* Fürstenberg (Pemberton, 1946), which is commonly found in the ears, has been reported from rabbits.

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SUMMARY OF HOST LIST OF PARASITES AND INTERMEDIATE HOSTS RECORDED IN HAWAII

NAME OF PARASITE	LOCATION IN HOST	INTERMEDIATE HOST*
	CAT *(Felis domestica)*	
Roundworms:		
Aelurostrongylus abstrusus	Lungs	Gastropoda: *Subulina octona,*[2] *Eulota similaris*[2] Rodentia: *Mus musculus*[3]
Ancylostoma caninum	Small intestine	
Physaloptera praeputialis	Stomach	(Unknown)
Arhythmorhynchus sp.	Small intestine	(Unknown)
Tapeworms:		
Dipylidium caninum	Small intestine	Siphonaptera and Anoplura (see parasites of dog)
Taenia taeniaeformis	Small intestine	Rodentia: *Mus musculus,*[1] *Rattus rattus alexandrinus,*[1] *Rattus rattus norvegicus,*[1] *Rattus rattus rattus*[1]
Arthropods:		
Ctenocephalides felis	External	
Echidnophaga gallinacea	Attached to skin	
Felicola substrata	External	
	CATTLE *(Bos taurus)*	
Protozoa:		
Eimeria bovis	Small intestine	
Eimeria bukidnonensis	Small intestine	

* Legend: (1) = infection found in nature; (2) = determined experimentally; (3) = reported elsewhere for animals similar to those occurring in Hawaii.

Eimeria cylindrica	Small intestine	
Eimeria zurnii	Small intestine	
Roundworms:		
Bunostomum phlebotomum	Small intestine	
Cooperia pectinata	Small intestine	
Cooperia punctata	Small intestine	
Dictyocaulus viviparus	Lungs	
Gongylonema pulchrum	Esophagus	Coleoptera: *Aphodius lividus*,[3] *Dermestes vulpinus*[3] Orthoptera: *Blattella germanica*[3]
Haemonchus contortus	Fourth stomach or abomasum	
Oesophagostomum radiatum	Cecum and colon	
Stephanofilaria stilesi	Skin	(Unknown)
Strongyloides sp. (*papillosus*?)	Small intestine	
Trichuris ovis	Cecum	
Flukes:		
Fasciola gigantica	Liver	Gastropoda: *Fossaria ollula*[1]
(Rumen fluke)	Rumen	(Unknown)
Tapeworms:		
Taenia saginata (cysticercus)	Muscles	Artiodactyla: *Bos taurus*[1] (cattle are intermediate hosts; man is the final host)
Arthropods:		
Bovicola bovis	External	
Chrysomyia megacephala (larva)	In wounds and external	
Chrysomyia rufifacies (larva)	In wounds and external	
Fannia sp. (larva)	External	
Haematopinus eurysternus	External	
Hypoderma lineatum	Under skin	
Lucilia sericata? (see text) (larvae)	External	
Otobius megnini	Inside ears	

CHICKEN *(Gallus gallus)*

Protozoa:		
Eimeria tenella	Ceca	
Roundworms:		
Ascaridia galli	Small intestine	
Cheilospirura hamulosa	Gizzard	Coleoptera: *Carpophilus dimidiatus*,[2] *Dactylosternum abdominale*,[2] *Dermestes vulpinus*,[2] *Epitragus diremptus*,[1] *Euxestus* sp.,[2] *Gonocephalus seriatum*,[2] *Litargus balteatus*,[2] *Oxydema fusiforme*,[2] *Palorus ratzeburgi*,[2] *Sitophilus oryzae*,[2] *Tenebroides nana*,[1] *Tribolium castaneum*,[2] *Typhaea stercorea*[2] Orthoptera: *Atractomorpha ambigua*,[2] *Conocephalus saltator*,[2] *Oxya chinensis*[2] Amphipoda: *Orchestia platensis*[1]
Dispharynx spiralis	Proventriculus	Isopoda: *Porcellio laevis*[1]
Gongylonema ingluvicula	Crop	(Unknown; probably coprophagous beetles)
Heterakis gallinae	Ceca	
Oxyspirura mansoni	Conjunctival sac	Orthoptera: *Pycnoscelus surinamensis*[1]
Subulura brumpti	Ceca	Coleoptera: *Alphitobius diaperinus*,[1] *Ammophirus insularis*,[1] *Dermestes vulpinus*,[1]

* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

		Gonocephalus seriatum,[1] *Tribolium castaneum*[2]
		Orthoptera: *Conocephalus saltator*,[2] *Oxya chinensis*[2]
		Dermaptera: *Euborellia annulipes*[1]
Tetrameres americana	Proventriculus	Coleoptera: *Dendrophilus* sp.,[1] *Dermestes vulpinus*,[1] *Epitragus diremptus*,[1] *Gonocephalus seriatum*[1]
		Orthoptera: *Blattella germanica*,[1] *Conocephalus saltator*[2]
		Dermaptera: *Euborellia annulipes*[1]
		Amphipoda: *Orchestia platensis*[1]
Flukes:		
Postharmostomum gallinum	Ceca	Gastropoda: *Eulota similaris*,[1] *Subulina octona*[1]
Tapeworms:		
Choanotaenia infundibulum	Small intestine	Coleoptera: *Dermestes vulpinus*,[1] *Epitragus diremptus*,[1] *Gonocephalus seriatum*[1]
		Diptera: *Musca domestica*[3]
Hymenolepis exigua	Small intestine	Amphipoda: *Orchestia platensis*[1]
Raillietina cesticillus	Small intestine	Coleoptera: *Dermestes vulpinus*,[1] *Gonocephalus seriatum*[1]
Raillietina tetragona	Small intestine	(Probably ants of the genera *Pheidole* and *Tetramorium*)[3]
Arthropods:		
Dermanyssus gallinae	External	
Echidnophaga gallinacea	External	
Eomenacanthus stramineus	External	
Goniocotes gigas	External	
Goniocotes hologaster	External	
Goniodes stylifer	External	
Lipeurus caponis	External	
Lipeurus heterographus	External	
Lyponyssus bursa	External	
Megninia cubitalis	External	
Menopon gallinae	External	
Pterolichus obtusus	External	

DOG (*Canis familiaris*)

Protozoa:		
(Coccidia of undetermined species)	Intestine	
Roundworms:		
Ancylostoma caninum	Small intestine	
Dirofilaria immitis	Heart and pulmonary artery	Diptera: *Aedes aegypti*,[3] *Culex quinquefasciatus*[3]
Filariodes osleri (see text)	Lungs	(Unknown)
Toxascaris leonina	Small intestine	
Toxocara canis	Small intestine	
Trichuris vulpis	Cecum	
Tapeworms:		
Dipylidium caninum	Small intestine	Siphonaptera: *Ctenocephalides felis*,[3] *Pulex irritans*[3]
		Anoplura: *Trichodectes latus*[3]
Taenia hydatigena?	Small intestine	Artiodactyla (see parasites of swine)
Arthropods:		
Ctenocephalides felis	External	

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Echidnophaga gallinacea	External	
Heterodoxus longitarsus	External	
Rhipicephalus sanguineus	External	
Trichodectes latus	External	
(Mites of undetermined species)	External	

GOAT *(Capra hircus)*

Arthropods:		
Bovicola caprae	External	
Linognathus africanus	External	

GUINEA FOWL *(Numida meleagris)*

Arthropods:		
Menopon gallinae	External	
Menopon phaeostomum	External	

HORSE *(Equus caballus)*

Roundworms:		
Cyathostomum coronatum	Large intestine	
Cylicocercus catinatus	Large intestine	
Cylicocercus goldi	Large intestine	
Cylicocercus pateratus	Large intestine	
Cylicocyclus leptostomus	Large intestine	
Cylicocyclus nassatus	Large intestine	
Cylicodontophorus bicoronatus	Large intestine	
Cylicodontophorus euproctus	Large intestine	
Cylicostephanus calicatus	Large intestine	
Cylicostephanus longibursatus	Large intestine	
Cylicostephanus minutus	Large intestine	
Cylicosternus asymetricus	Large intestine	
Gyalocephalus capitatus	Large intestine	
Habronema microstoma	Stomach	Diptera: *Musca domestica*,[3] *Stomoxys calcitrans*[3]
Habronema muscae	Stomach	Diptera: *Musca domestica*[3]
Oxyuris equi	Colon	
Parascaris equorum	Small intestine	
Poteriostomum imparidentatum	Large intestine	
Probstmayria vivipara	Colon	
Strongylus edentatus	Large intestine	
Strongylus equinus	Large intestine	
Strongylus vulgaris	Large intestine	
Trichostrongylus axei	Stomach	
Triodontophorus brevicauda	Large intestine	
Triodontophorus serratus	Large intestine	
Flukes:		
Fasciola gigantica	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Anoplocephala magna	Small intestine	(Unknown)
Anoplocephala perfoliata	Cecum	(Unknown)
Arthropods:		
Gastrophilus intestinalis (larvae)	Stomach	
Gastrophilus nasalis (larvae)	Stomach	

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PEAFOWL *(Pavo cristatus)*

Arthropods:		
Menopon phaeostomum	External	

PIGEON *(Columba livia domestica)*

Protozoa:		
Haemoproteus columbae	Blood	Diptera: *Pseudolynchia canariensis*[1]
Roundworms:		
Ornithostrongylus quadriradiatus	Small intestine	
Arthropods:		
Columbicola columbae	External	
Pseudolynchia canariensis	External	

RABBIT *(Oryctolagus cuniculari s)*

Protozoa:		
Eimeria stiedae	Liver	
Arthropods:		
Psoroptes communis	External	

SHEEP *(Ovis aries)*

Roundworms:		
Cooperia punctata	Small intestine	
Haemonchus contortus	Fourth stomach	
Nematodirus spathiger	Small intestine	
Flukes:		
Fasciola sp. (*gigantica* ?)	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Taenia hydatigena ? (cysticercus)	Attached to liver, mesentery, and omentum	Artiodactyla (see parasites of swine)
Arthropods:		
Chrysomyia megacephala (larvae)	In wounds and external	
Melophagus ovinus	External	
Oestrus ovis (larvae)	Nasal cavities and sinuses of head	
Otobius megnini	Inside ears	

SWINE *(Sus scrofa domestica)*

Protozoa:		
Balantidium coli	Large intestine	
Eimeria debliecki	Large intestine	
Eimeria scabra	Large intestine	
Eimeria spinosa	Large intestine	
Roundworms:		
Ascaris suum	Small intestine	

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* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

Ascarops strongylina	Stomach	(Unknown; probably coprophagous beetles of genus *Aphodius*)
Choerostrongylus pudendotectus	Lungs	Macrodrili (earthworms, probably of the genus *Pheretima*)
Hyostrongylus rubidus	Stomach	
Metastrongylus elongatus	Lungs	Macrodrili (earthworms, probably of the genus *Pheretima*)
Stephanurus dentatus	Adults in kidneys and kidney fat; immature forms in liver and other internal organs	
Strongyloides sp.		
Trichinella spiralis	Adults in small intestine, larvae in muscles	
Trichuris suum	Cecum	
Flukes:		
Fasciola sp. (*gigantica* ?)	Liver	Gastropoda: *Fossaria ollula*[1]
Tapeworms:		
Taenia hydatigena (cysticercus)	Attached to liver, mesentary, and omentum	Artiodactyla: *Sus scrofa domestica*,[1] *Ovis aries*,[1] *Canis familiaris*[3] is the final host
Arthropods:		
Haematopinus adventicius	External	
Sarcoptes scabiei suis	External	

TURKEY (*Meleagris gallopavo*)

Protozoa:		
Histomonas meleagridis	Intestine, liver	
Roundworms:		
Cheilospirura hamulosa	Gizzard	(See parasites of the chicken)
Arthropods:		
Goniocotes hologaster	External	
Goniodes stylifer	External	
Lipeurus gallipavonis	External	
Menopon gallinae	External	

* Legend: ([1]) = infection found in nature; ([2]) = determined experimentally; ([3]) = reported elsewhere for animals similar to those occurring in Hawaii.

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