A SUMMARY OF KNOWN PARASITES AND DISEASES RECORDED FROM THE AVIFAUNA OF THE HAWAIIAN ISLANDS

Sandra G. van Riper and Charles van Riper III

ABSTRACT

Introduced parasites and diseases are among the many threats which confront the continued existence of native Hawaiian landbirds. These birds are infected with a variety of endemic parasites, and many new parasites have arrived in Hawai'i via introduced birds. There is evidence today which suggests that disease is playing a role in limiting the numbers and distributions of native birds. To better understand the interactions of parasites with their hosts, a myriad of native and introduced disease-causing organisms must be identified.

This paper presents a summary of the recorded parasites and diseases in Hawaiian birds. Each disease-causing organism is discussed in terms of its characteristics of infection and pathogenicity, life cycle and intermediate hosts, and avian hosts in Hawai'i. The disease records and references are categorized taxonomically and by avian host. Most diseases appear to be of little concern to biologists worried about the preservation of Hawaiian birdlife. However, at least 2 have been important in the past (avian pox and malaria), and others could be equally important in the future. It is, therefore, imperative that the impact of the disease threat be recognized, and that steps be taken to properly deal with this situation in the Islands. Recommendations are given for future directions that disease research might pursue, and for possible monitoring and control methods for extant and potential newly arriving diseases.

INTRODUCTION

More than 20 million years ago, molten lava rose from the ocean depths to form the first Hawaiian island. Volcanic activity constantly added new material to replace eroded land, leaving today an island

chain extending more than 5,000 kilometers across the Pacific and rising in places to heights greater than 9,000 m from the ocean floor. Sporadic biological colonization relying principally on the trade winds and ocean currents led to the evolution of many endemic land and fresh-water bird species, including 3 unique subspecies of sea birds. Colonizing birds brought compliments of parasites to these remote islands. Today the biological complexity is enhanced as new infectious organisms continue to arrive and interact with native and introduced bird species.

The first avian parasites to reach the Hawaiian Islands undoubtedly arrived with early migrant birds. In recent times there has been a tremendous influx of new arrivals, and consequently the number of parasites and diseases has also increased. Most diseases hold little threat to well established populations, and indeed may support the ecological balance and stability of the host population. However, when confronted with newly encountered diseases, the native birds often become more severely infected than their introduced counterparts.

The situation of differential species susceptibility has been documented in North American birds, where introduced avian species succumb more readily to the native eastern equine encephalitis virus than do native birds (Karstad 1971). A similar case may be made for avian malaria in Hawai'i (van Riper et al., in press; Warner 1968), where native birds are more susceptible to this introduced parasite. Of special note is the fact that many extant populations of Hawaiian birds are small, and when population numbers are not sufficient to sustain fluctuations caused by disease outbreaks, the threat of extinction is enhanced.

In order to preserve and properly protect the Hawaiian avifauna, it is imperative that the impact of disease be recognized, and that proper steps be taken to adequately deal with it. The procurement of baseline data showing which avian diseases are currently present in Hawai'i is especially important. The purpose of this paper is to catalog the known information on parasites and disease factors recorded in wild Hawaiian birds. Captive and domesticated birds are considered only where transmission to wild populations is possible (e.g., domestic chickens, turkeys, some zoo birds, and pigeons). Scientific names of birds not given in the text are given in the Appendix. Each disease is discussed in terms of its individual characteristics of infection and pathogenicity, life cycle, and avian hosts in Hawai'i; and records of parasites and diseases are summarized in the Appendix. Confusing

reports have been omitted, as have many cases of parasites not identified to genus or species.

CLASSIFICATION OF PARASITES REPORTED FROM HAWAIIAN BIRDS

The taxonomic classification given below is based on information from the following sources: Baker and Wharton 1952; Bequaert 1941; Goff 1980; Goff and van Riper 1980; Keymer 1982b; Krantz 1978; Kudo 1966; Levine 1980, 1982a, 1982b; Levine, van Riper, and van Riper 1980; Lewin and Holmes 1971; McDonald 1981; Rothschild and Clay 1957; Turner 1971; Wardle, McLeod, and Radinovsky 1974. Synonyms used in reference to Hawaiian birds are given in parentheses.

Phylum: Protozoa
- Order: Rhizomastigida
  - Family: Mastigamoebidae
    - *Histomonas meleagridis*
- Order: Trichomonadida
  - Family: Trichomonadidae
    - *Trichomonas gallinae* (= *T. columbae*)
- Order: Coccidida
  - Family: Eimeriidae
    - *Eimeria tenella*
    - *Isospora ivensae*
    - *Isospora brayi*
    - *Isospora phaeornis*
    - *Isospora loxopis*
    - *Isospora vanriperorum*
  - Family: Atoxoplasmatidae
    - *Atoxoplasma* sp.
- Order: Haemosporida
  - Family: Plasmodiidae
    - *Plasmodium relictum*
  - Family: Haemoproteidae
    - *Haemoproteus columbae*

Phylum: Nematoda
- Order: Strongylorida
  - Family: Syngamidae
    - *Syngamus trachea*
  - Family: Trichostrongylidae
    - *Amidostomum* sp. (= *Amidospomen*)
    - *Ornithostrongylus quadriradiatus*
- Order: Ascaridorida
  - Family: Heterakidae
    - *Ascaridia galli*
    - *Ascaridia perspicillum*
    - *Ascaridia* sp.
    - *Aulonocephalus pennula*
    - *Heterakis gallinarum* (= *H. papillosa* = *H. gallinae*)
    - *Heterakis* sp.

Family: Ascarididae
Porrocaecum semiteres
Porrocaecum ensicaudatum
Family: Subuluridae
Subulura brumpti
(= Allodapa brumpti)
Subulura skrjabinensis
Subulura sp.
Order: Spirurorida
Family: Spiruridae
Cyrnea graphophasiani
Microtetrameres sp.
Procyrnea longialatus
Tetrameres americana
(= Tropisurus americanus)
Tetrameres sp.
Family: Acuariidae
Cheilospirura hamulosa
(= Acuaria hamulosa)
Cheilospirura sp.
Dispharynx nasuta (= D. spiralis)
Dispharynx sp.
Synhimantus
(= Dispharynx zosteropsi)
Viguiera hawaiiensis
Family: Thelaziidae
Gongylonema ingluvicola
Oxyspirura mansoni
Oxyspirura sp.
Order: Dorylaimorida
Family: Trichuridae
Capillaria sp.

Phylum: Acanthocephala
Order: Echinorhynchidea
Family: Plagiorhynchidae
Plagiorhynchus charadrii
Order: Gigantorhynchidea
Family: Gigantorhynchiidae
Mediorhynchus orientalis

Phylum: Cestoda
Order: Davaineidea
Family: Davaineidae
Fuhrmannetta crassula
(= Raillietina crassula)
Raillietina cesticillus
(= Davainea cesticillus)
Raillietina tetragona
(= Davainea tetragona)
Raillietina sp.
Order: Hymenolepididea
Family: Hymenolepididae
Hymenolepis carioca

(= Echinolepis carioca;

= Davainea carioca)
Hymenolepis megalops
(= Cloacotaenia megalops)
Orientolepis exigua
(= Hymenolepis exigua;
= Hymenosphenacanthus exiguus)
Order: Dilepididea
Family: Paruterinidae
Anonchotaenia brasilense
Family: Dipylidiidae
Choanotaenia infundibulum
(= C. infundibuliformis)
Family: Dilepididae
Metroliasthes lucida

Phylum: Trematoda
Order: Strigeatoidea
Family: Schistosomatidae
Austrobilharzia variglandis
Family: Brachylaemidae
Postharmostomum gallinum
Urotocus rossittensis
Order: Echinostomida
Family: Philophthalmidae
Philophthalmus gralli
Order: Opisthorchiida
Family: Heterophyidae
Centrocestus formosanus
Haplorchis taichui
Haplorchis yokogawai

Phylum: Arthropoda
Class: Arachnida
Subclass: Acari
Order: Parasitiformes
Suborder: Ixodida
Family: Argasidae
Ornithodoros capensis
Ornithodoros denmarki
Family: Ixodidae
Haemaphysalis wellingtoni
Ixodes laysanensis
Suborder: Gamesida
Family: Rhinonyssidae
Mesonyssus geopeliae
Neonyssus sp.
Paraneonyssus sp.
Ptilonyssus hirsti
(= Haemolaelaps casalis)
Ptilonyssus sp.
Rhinonyssus coniventris
Rhinonyssus sp.
Sternostoma tracheacolum

Family: Dermanyssidae
Dermanyssus gallinae
Family: Macronyssidae
Ornithonyssus bursa
(= Liponyssus bursa)
Ornithonyssus sylviarum
(= Liponyssus sylivaun)
Ornithonyssus sp.
Family: Laelapidae
Androlaelaps sp.
Haemolaelaps fenilis
(= H. megaventralis;
= Atricholaelaps megaventralis;
= H. casalis)
Suborder: Actinedida
Family: Cheyletidae
Bakericheyla chanayi
Cheyletus malaccensis
Cheyletus eruditus
Cheyletus sp.
Family: Cheylettiellidae
Neocheyletiella media
(= Ornithochyla sp.)
Ornithocheyletia leiothrix
Family: Ereynetidae
Boydaia agelaii
Boydaia nigra
Opthalmognathus tenoricae
Family: Harpyrhynchidae
Harpyrhynchus pilirostris
Harpyrhynchus sp.
Family: Trombiculidae
Eutrombicula conantae
Guntherana domrowi
Leptotrombidium intermedium
Neoschoengastia gallinarum
Neoschoengastia ewingi
Neoschoengastia gettmanni
Neotrombicula tamiayi
Schoengastia pobsa
Toritrombicula nihoaensis
Toritrombicula oahuensis
Suborder: Acaridida
Family: Pyroglyphidae
Dermatophagoides evansi
Family: Analgidae
Analges sp.
Anhemialges sp.
Megninia columbae
Megninia cubitalis
Megninia ginglymura
Megninia sp.
Mesalgoides sp.
Onychalges sp.

Ornithocheyla sp.
Strelkovarius sp.
Family: Dermoglyphidae
Dermoglyphus elongatus
Falculifer rostratus
Gabucinia delibatus
Gabucinia sp.
Pterolichus obtusus
Pterolichus sp.
Pteronyssus sp.
Xoloptes sp.
Family: Proctophyllodidae
Montesauria sp.
Proctophyllodes longiphyllus
Proctophyllodes vegetans
Proctophyllodes pinnatus
Proctophyllodes truncatus
Proctophyllodes sp.
Pterodectes sp.
Pteroherpus oxyplax
Family: Sarcoptidae
Knemidokoptes mutans
Mesoknemidocoptes laevis
(= Knemidokoptes laevis)
Family: Cytoditidae
Cytodites nudus
Family: Pteronyssidae
Mouchetia sp.
n. gen., n. sp.
Family: Trouessartiidae
Calcealges sp.
Calcealges yunkeri
Trouessartia sp.
Family: Xolalgidae
Ingrassiella sp.
n. gen., n. sp.
Family: Hypoderidae
Neottialges fregatae
Neottialges hawaiiensis
Class: Insecta
Order: Mallophaga
Family: Menoponidae
Actornithophilus epiphanes
Actornithophilus kilauensis
Actornithophilus milleri
Amyrsidea monostoecha
Austromenopon infrequens
Austromenopon sternophilum
Colpocephalum brachysomum
Colpocephalum discrepans
Colpocephalum hilensis
Colpocephalum turbinatum
Longimenopon puffinus
Machaerilaemus hawaiiensis

Menopon sp.
Menopon gallinae
Menopon fulvomaculatum
Menopon phaeostomum
Menacanthus spinosus
Menacanthus stramineus
Myrsidea sp.
Myrsidea cyrtostigma
Myrsidea incerta
Myrsidea invadens
Trinotin querquedulae
Uchida sp.

Family: Philopteridae

Anaticola crassicorne
Bruelia stenzona
Bruelia vulgata
Columbicola columbae
Columbicola sp.
Chelopistes meleagridis
Cuclotogaster heterographa
Docophoroides sp.
Goniocotes asterocephalus
Goniocotes bidentatus
Goniocotes chinensis
Goniocotes gallinae
Goniocotes hologaster
Goniodes sp.
Goniodes colchici
Goniodes dissimilis
Goniodes gigas
Goniodes lativentris
Goniodes mammillatus
(= G. mammilatus)
Halipeurus mirabilis
Harrisoniella sp.
Lagopoecus colchicus
Lagopoecus docophoroides
Lipeurus caponis
Lipeurus maculosus
Lunaceps sp.
Oxyliperus polytrapezius
Philopterus macgregori
Philopterus subflavescens
Quadraceps birostris
Quadraceps connexa
Quadraceps oraria
Quadraceps separata
Rallicola advena
Saemundssonia conicus
Saemundssonia snyderi
Trabeculus (= Giebelia) mirabilis

Order: Siphonaptera

Family: Pulicidae

Echidnophaga gallinacea

Order: Diptera

Family: Hippoboscidae
- Icosta (= Lynchia) nigra
- Olfersia aenescens
- Olfersia spinifera
- Ornithoctona hulahula
- Ornithoica vicina (= O. pusilla)
- Pseudolynchia canariensis

Family: Culicidae
- Aedes aegypti
- Aedes albopictus
- Aedes vexans
- Culex quinquefasciatus

ENDOPARASITES

Protozoa

Histomonas

Infection Characteristics: Histomonas meleagridis is a well-known and economically important parasite of gallinaceous birds, characterized by necrosis of the liver and ulceration of the caecum. It causes the disease "blackhead," which is typically less pathogenic in chickens than in turkeys (Kemp and Springer 1978).

Life Cycle: In captive turkeys and chickens, blackhead is usually passed from bird to bird within the ova of the nematode Heterakis gallinarum (Ruff 1978). Mechanical transmission may also be accomplished via earthworms, flies, grasshoppers, sowbugs, and crickets (Kemp and Springer 1978).

Hawaiian Hosts: Histomonas meleagridis has been reported in Hawai'i only from domestic chickens and turkeys (Alicata 1964). While transmission to wild gallinaceous birds is possible, it does not seem to be prevalent in Hawai'i.

Trichomonas

Infection Characteristics: Trichomonas gallinae is the only trichomonad known to cause mortality in wild birds. It infects primarily the mouth, throat, and crop, and secondarily the liver, lungs, heart, and other internal organs (Kocan and Herman 1971). Death may result from destruction of host tissue, or by mechanical blockage of the throat which ultimately results in starvation. The lesions in the mouth may superficially resemble aspergillosis, candidiasis, or avian pox, so any diagnosis must differentiate among these 4 maladies. This is not a common parasite of wild birds. However, it has been known to cause severe epidemics in wild populations of mourning doves (Zenaidura macroura) in Alabama (Haugen 1952), and should an

epizootic of trichomoniasis occur in Hawai'i, it could have catastrophic results (Kocan and Banko 1974).

Life Cycle: Transmission of Trichomonas is direct, with parasites transferred during the feeding of young or during courtship feeding, particularly when regurgitation is involved. Eating of contaminated food is also a means of transmission (Kocan and Herman 1971). Some species of native Hawaiian birds feed their young by regurgitation (van Riper 1978, 1980), so there is the potential for transmission.

Hawaiian Hosts: Trichomonas gallinae was first reported in Hawai'i from 2 individuals in a flock of Signal Corps pigeons (Yeager and Gleiser 1946). Since that time there have been very few instances of this disease noted in the Islands. Smith and Guest (1974) captured one nutmeg mannikin at Diamond Head, O'ahu, that later died of Trichomonas after a period of time in an aviary. The only wild birds to be discovered with trichomoniasis in Hawai'i have been 2 zebra doves captured by Kocan and Banko (1974) and one 'apapane that we captured by mist net on the island of Hawai'i (unpubl. data).

Coccidia (Eimeria and Isospora)

Infection Characteristics: Most of the information known about coccidiosis comes from studies of poultry, but at least 5 genera of intestinal coccidia infect wild birds: Eimeria, Isospora, Dorisiella, Wenyonella, and Tyzzeria (Todd and Hammond 1971). Coccidia are very host specific. Generally the degree of pathogenicity varies in individuals, causing inflammation and destruction of intestinal tissue, diarrhea, and often dehydration. Young animals are the most severely affected, and coccidia have been implicated in the mortality of young quail and grouse (Bennett, Greiner, and Threlfall 1976; Herman, Jankiewicz, and Saarni 1942). Immunity increases with exposure and older individuals often serve as reservoirs (Todd and Hammond 1971).

Life Cycle: Coccidia are intestinal protozoans with a direct life cycle. The protozoans are shed with fecal material and survive best in warm, humid conditions (Reid 1978b). In captivity, transmission is accomplished via contaminated food or water (Todd and Hammond 1971). Little is known about transmission in the wild.

Hawaiian Hosts: Unfortunately, the genera of coccidia have seldom been differentiated in Hawaiian parasite surveys, and such reports of wild birds include the Japanese white-eye (Guest 1973), zebra dove, northern mockingbird (Mimus polyglottos), red-crested

cardinal, house sparrow, blue-capped cordonbleu, red-cheeked cordonbleu (Uraeginthus bengalus), lavender waxbill, and orange-cheeked waxbill (Smith and Guest 1974). Captive birds with coccidiosis from the Honolulu Zoo, University of Hawai'i, Paradise Park, and other areas include the 'anianiau, common 'amakihi, northern cardinal, and Hawaiian goose or nene (A. Miyahara, pers. comm.; Honolulu Zoo 1964-1967 necropsy records). Eimeria tenella is a common parasite in fowl and has been identified from chickens (Alicata 1964). Five new species of Isospora were recently described from birds on the island of Hawai'i (Levine, van Riper, and van Riper 1980). Seventeen of 59 Japanese white-eyes were positive for Isospora bravi, 3 of 15 nutmeg mannikins carried Isospora ivensae, one of 11 Hawaiian thrushes had Isospora phaeornis, 3 of 24 common 'amakihi had Isospora loxopis, and one northern cardinal examined had Isospora vanriperorum (Levine 1982a). In addition, we found 2 'apapane and one 'elepaio infected with Isospora sp. from the island of Hawai'i (unpubl. data).

Atoxoplasma

Infection Characteristics: Atoxoplasma is a protozoan parasite that infects the white blood cells of passerine birds. This disease is relatively non-pathogenic and some avian populations have chronic infection rates of 100% with few adverse signs (Lainson 1959).

Life Cycle: Atoxoplasma has been incorrectly referred to in the past as avian toxoplasmosis, and a controversy exists concerning the life cycle and taxonomy of this parasite. It is felt by some (Lainson 1959, 1960) that mites, in particular Dermanyssus gallinae, are responsible for transmission, and that the genus should be Lankesterella. However, Box (1970, 1971, 1977) provided evidence that Atoxoplasma may be a stage of the intestinal coccidian Isospora. More complete reviews may be found in Baker et al. (1972) and Levine (1982b).

Hawaiian Hosts: Atoxoplasma was unknown in Hawai'i until 1978, when it was discovered in a house sparrow (van Riper et al., in press). Of 70 house sparrows examined on the island of Hawai'i, 9% were infected, as were 17.4% of 121 nutmeg mannikins. In addition, several house finches that we held in captivity were positive for Atoxoplasma (unpubl. data).

Plasmodium

Infection Characteristics: Avian malaria in Hawai'i is caused by the protozoan parasite Plasmodium relictum. This parasite infects peripheral red blood cells and internal tissue such as liver, spleen, bone

marrow, and even brain cells (Garnham 1966). Infections can cause anemia, hemorrhages, and lesions (Keymer 1982b). There is evidence that this disease is limiting numbers and distributions of some native Hawaiian birds (van Riper et al., in press; Warner 1968).

Life Cycle: All species of malaria are transmitted by mosquitoes. The principal vector for avian malaria in Hawai'i is the night-biting mosquito Culex quinquefasciatus (van Riper et al., in press). The parasite enters the insect tissue with ingested host blood. The Plasmodium sexual cycle occurs in the mosquito, while sexual and asexual stages are found in the bird.

Hawaiian Hosts: Six species of malaria have been reported from the Hawaiian Islands: P. cathemerium (Navvab Gojrati 1970), P. vaughani (Fisher and Baldwin 1947), P. circumflexum (Navvab Gojrati 1970), P. elongatum (Warner 1968), P. gallinaceaum (Navvab Gojrati 1970), and P. relictum (Navvab Gojrati 1970; van Riper et al., in press). However, Laird and van Riper (1981) have reviewed these records and concluded that only one species of malaria is present in Hawai'i, Plasmodium relictum capistranoae. Because this malarial parasite exhibits many unusual morphological forms in the naive native Hawaiian birds, it can be easily mistaken for other Plasmodium species. See Laird and van Riper (1981) for a more complete discussion.

The avian host list of wild-caught birds infected with Plasmodium in Hawai'i includes: red-billed leiothrix (Baldwin 1941; Fisher and Baldwin 1947; van Riper et al., in press), Japanese white-eye (Baldwin 1941; Navvab Gojrati 1970; van Riper et al., in press; Warner 1968), common 'amakihi (van Riper 1975; van Riper et al., in press), house finch (van Riper et al., in press; Warner 1968), nutmeg mannikin, northern cardinal, house sparrow, Hawaiian thrush, 'elepaio, 'i'iwi (van Riper et al., in press), 'apapane (Navvab Gojrati 1970; van Riper et al., in press), Hawaiian crow (Jenkins and van Riper, in prep.), and rock dove (unpubl. data). Warner (1968) reported the dark-rumped petrel (Pterodroma phaeopygia) as having malaria, but it was later found that this bird was a Townsend's shearwater (Banko 1980; Simons 1983). Van Riper and Barbee (1978) and Simons (1983) failed to find malaria in the dark-rumped petrels that they examined. Plasmodium relictum was also identified from rockhopper penguins (Eudyptes crestatus) at the Honolulu Zoo (Laird and van Riper 1981).

Haemoproteus

Infection Characteristics: Haemoproteus columbae is a common parasite of rock doves throughout the world and is often referred to as "pigeon malaria." The sexual stages of this parasite infect the red blood cells, while all stages develop in endothelian cells of blood vessels in the lungs, liver, spleen, and other internal organs (Cook 1971a). Most Haemoproteus infections have not been reported as being severely pathogenic to their hosts, and some rock dove populations have infection rates up to 100%, with few adverse overt signs being exhibited by the birds (Levine and Kantor 1959).

Life Cycle: Haemoproteus is transmitted by members of the Hippoboscidae (louse flies) and/or Culicoides (biting midges) (Cook 1971a). The common pigeon hippoboscid, Pseudolynchia canariensis, is the vector of H. columbae. The sexual stages of the protozoan take place within the insect, and infection is accomplished when the fly bites another bird.

Hawaiian Hosts: Haemoproteus columbae is present in Hawai'i in both wild and captive rock doves (Alicata 1964; Kartman 1949; Navvab Gojrati 1970; Yeager and Gleiser 1946). In a 1978 survey we conducted of 230 pigeons from the Honolulu Zoo, over 98% were infected with Haemoproteus (unpubl. data). Warner (1968) reported a possible infection of house finches and an 'apapane with Haemoproteus, but the parasite was probably misidentified (Laird and van Riper 1981).

Leucocytozoon

Infection Characteristics: Leucocytozoon occurs only in birds, and it has a worldwide distribution. After an acute stage following initial infection, most cases become chronic with occasional relapses when the avian host is under stress (Cook 1971b).

Life Cycle: These blood parasites primarily develop within leukocytes and occasionally in erythrocytes. They multiply in epithelian and other cells. The intermediate hosts are blackflies of the family Simuliidae (Cook 1971b).

Hawaiian Hosts: Leucocytozoon has been reported only once in Hawai'i (Navvab Gojrati 1970), and this was probably an error (Laird and van Riper 1981). The vectors of this parasite are absent from the Islands (Crosskey, in press); therefore, this parasite does not at present constitute a serious threat to the Hawaiian birds.

Nematoda

Syngamus

Infection Characteristics: Syngamus trachea, or the gapeworm, is usually encountered in the trachea, although the bronchi may also be infected (Wehr 1971). The worms feed on blood, causing mechanical damage and production of mucus where they attach to the tissue. Young birds seem most seriously affected, with clinical signs being gaping, coughing, and pneumonia-like symptoms (Levine 1980). The lumen of the trachea may become obstructed, and the bird suffocates (Wehr 1971).

Life Cycle: The life cycle of Syngamus trachea may be direct or include an earthworm or other invertebrate which the parasite utilizes as a transport host. This parasite has been found in earthworms as long as 3.5 years after ingestion (Levine 1980).

Hawaiian Hosts: Syngamus trachea has been reported in wild birds only on O'ahu: one red-crested cardinal (Smith 1973b) and one house finch (Smith and Guest 1974).

Ornithostrongylus

Infection Characteristics: Ornithostrongylus quadriradiatus is found in rock doves worldwide (Wehr 1971). This parasite infects the small intestine, feeding on blood (Ruff 1978). In some instances it may appear in a very acute form and produce many fatalities (Wehr 1971).

Life Cycle: Eggs are shed in the feces and transmission is accomplished via fecal contamination (Ruff 1978).

Hawaiian Hosts: Ornithostrongylus quadriradiatus has been reported only from rock doves in Hawai'i. Alicata (1939a, 1964) believed that this parasite was responsible for general unthriftiness and losses among the rock doves in the Islands.

Amidostomum

Infection Characteristics: Members of this genus often infect Anseriformes and are usually found under the horny lining of the gizzard (Levine 1980). The Canada goose gizzard worm Amidostomum anseris causes considerable mortality in young birds, as well as inhibiting growth and development of those that survive. According to Herman and Wehr (1954), A. anseris itself is not a primary source of loss but rather an important contributing factor.

Life Cycle: The life cycle of the Hawaiian parasite is unknown but A. anseris has a direct life

cycle. Eggs are shed in feces and larvae penetrate the skin or are eaten (Levine 1980).

Hawaiian Hosts: Amidostomum sp. was reported from a wild Hawaiian goose (Banko and Manuwal 1982), but unfortunately no specific identification of the worm was made.

Heterakis

Infection Characteristics: Members of the genus Heterakis are common parasites of Galliformes and occasionally of captive geese and ducks (Wehr 1971). These parasites are usually found in the caecum, although the small intestine may also be infected. They live on intestinal contents and do not migrate during their development, so damage to the host is minimal (Levine 1980). Heterakis gallinarum is the vector of the protozoan Histomonas meleagridis, which causes blackhead in chickens and turkeys (Ruff 1978).

Life Cycle: Eggs are shed in feces and infect a bird when they are ingested. Sowbugs and earthworms may also ingest ova and carry them for long periods of time, facilitating transmission to birds (Levine 1980).

Hawaiian Hosts: In Hawai'i, H. gallinarum has been reported in domestic chickens and other wild game birds (Alicata 1964; Guberlet 1926; Lewin and Holmes 1971; Schwartz and Schwartz 1949, 1951; Swanson 1939). Banko and Manuwal (1982) reported a species of Heterakis from wild Hawaiian geese. Avery (1966) reported H. dispar in captive Hawaiian geese at Slimbridge, England. Possibly this is the parasite observed by Banko and Manuwal.

Aulonocephalus

Infection Characteristics: The ascarid Aulonocephalus pennula is a common parasite of quail from the southwestern United States, and it is not very pathogenic to its host. It is usually found in the caecum and occasionally in the small intestine (Lewin and Holmes 1971).

Life Cycle: The life cycle is unknown (Lewin and Holmes 1971).

Hawaiian Hosts: Aulonocephalus pennula has been reported from the California quail in Hawai'i (Lewin and Holmes 1971). This constituted a new host record and is the only report of this parasite in the Islands.

Ascaridia

Infection Characteristics: Ascaridia worms are common and are often a serious problem in poultry, causing retardation of growth, constipation or

diarrhea, and loss of condition. These large roundworms are found in the intestine, which may be blocked by heavy infections. Ascarids have also been found to augment the effects of other diseases such as coccidiosis, Heterakis, and infectious bronchitis (Levine 1980; Ruff 1978), probably by lowering the host's general resistance.

Life Cycle: The life cycle of this helminth does not require an intermediate host (Wehr 1971), although eggs may be ingested by grasshoppers or earthworms and in turn infect an avian host when the invertebrate is eaten. The eggs hatch in the host's proventriculus or upper intestine and the larvae cause destruction and hemorrhaging of the intestinal mucosa during migration (Ruff 1978).

Hawaiian Hosts: Ascaridia galli and A. perspicillum have been reported from domestic chickens (Alicata 1964; Guberlet 1926; Swanson 1939) and Ascaridia sp. from ring-necked pheasants and spotted doves (Schwartz and Schwartz 1949, 1951). Alicata (1964) thought that the pheasant ascarid infection reported by Schwartz and Schwartz (1949) was probably A. galli.

Porrocaecum

Infection Characteristics: Adult Porrocaecum worms reside in the intestine, where they feed on large quantities of blood. These parasites cause subnormal weight, vomiting, and severe anemia (Wehr 1971).

Life Cycle: All members of this genus require intermediate hosts such as earthworms (Wehr 1971). In one study from North America, 60% of the earthworms in soil covered with bird droppings contained infective P. ensicaudatum larvae (Levine 1980).

Hawiian Hosts: Two members of this genus have been reported from Hawai'i: Porrocaecum semiteres and P. ensicaudatum, both from the lesser golden plover (Okimoto 1975).

Subulura

Infection Characteristics: Members of the genus Subulura infect a variety of birds, usually Galliformes, but occasionally Anseriformes, Columbiformes or other wild birds (Levine 1980). Adult worms reside in the caecum or small intestine, where little damage to the host occurs (Wehr 1971).

Life Cycle: Little is known about the life cycle of species of Subulura in the wild (Wehr 1971), but Subulura brumpti, a common parasite of poultry, requires an intermediate host (Alicata 1939b). In Hawai'i these include any of the following: the

beetles Alphitobius diaperinus, Ammophorus insularis, Dermestes vulpinus, Gonocephalum seriatum, and Tribolium castaneum; the grasshoppers Conocephalus saltator and Oxya chinensis; and the dermapter Euborellia annulipes (Cuckler and Alicata 1944).

Hawaiian Hosts: Subulura brumpti has been recorded in Hawai'i from the gray francolin, Barbary partridge, Japanese quail, ring-necked pheasant, California quail, domestic chicken, wild turkey, and spotted dove (Alicata 1939b; Lewin and Holmes 1971; Schwartz and Schwartz 1951). Subulura skrjabinensis has been recorded from the Pacific golden plover (Okimoto 1975), and Subulura sp. (possibly S. brumpti) in chickens, ring-necked pheasants, and Japanese quail (Schwartz and Schwartz 1949; Swanson 1939).

Cyrnea and Procyrnea

Infection Characteristics: These helminth groups infect the proventriculus but apparently do not cause serious damage to their hosts (Levine 1980).

Life Cycle: All of the Cyrnea and Procyrnea species require intermediate hosts. The host of C. graphophasiani is unknown, but other species of Cyrnea (e.g. C. colina) can utilize the German cockroach (Blatella germanica) (Levine 1980; Cram 1931), which is present in Hawai'i.

Hawaiian Hosts: Cyrnea graphophasiani was reported from ring-necked pheasants (Schwartz and Schwartz 1951). This is the only member of this genus reported from the Islands and constituted a new host record for the parasite. It has not subsequently been recorded in the Islands. Procyrnea longialatus, a new species, was collected from the proventriculus of Japanese white-eyes and 'apapane from the island of Hawai'i (Cid del Prado Vera, Maggenti, and van Riper, in press).

Tetrameres and Microtetrameres

Infection Characteristics: Both Tetrameres and Microtetrameres are found primarily in the proventriculus (Wehr 1971) and are known as globular stomach worms. Some species produce severe pathology because they require extensive blood to produce eggs (Wehr 1971). T. americana, the species which infects chickens, is well studied and very important in the poultry industry (Alicata 1964).

Life Cycle: Throughout the world, various species of Tetrameres utilize amphipods, grasshoppers, cockroaches, and earthworms as intermediate hosts. In Hawai'i Tetrameres americana utilizes grasshoppers (Conocephalus saltator and Oxya chinensis), and the

German cockroach as intermediate hosts (Cram 1931; Kartman 1951). The intermediate hosts of Microtetrameres in Hawai'i are unknown.

Hawaiian Hosts: Mitrotetrameres sp. has been reported in Hawai'i from the Japanese white-eye (Smith and Guest 1974) and Tetrameres sp. from the rock dove, red-crested cardinal, house sparrow, lavender waxbill, and common 'amakihi (Alicata 1964; Kartman 1951; Smith and Guest 1974; van Riper 1975). But without knowing what species are present in Hawai'i, it is difficult to predict the effect of infections on host populations. Tetrameres americana infects domestic poultry in the Islands (Alicata 1964).

Cheilospirura

Infection Characteristics: Cheilospirurads are generally found in gallinaceous birds. The worms live beneath the gizzard lining, causing severe deterioration of this organ (Wehr 1971).

Life Cycle: The beetles Tenebroides nana and Epitragus diremptus, and the sandhopper Orchestia platensis all serve as naturally infected intermediate hosts in Hawai'i (Alicata 1938b). Experimental intermediate hosts include the beetles Carpophilus dimidiatus, Dactylosternum abdominale, Dermestes vulpinus, Epitragus diremptus, Euxestus sp., Gonocephalum seriatum, Litargus balteatus, Oxydema fusiforme, Palorus ratzeburgi, Sitophilus oryzae, Tenebroides nana, Tribolium castaneum, and Typhaea stercorea; the grasshoppers Atractomorpha ambigua, Conocephalus saltator, and Oxya chinensis; and the amphipod Orchestia platensis (Alicata 1947, 1964).

Hawaiian Hosts: The first report in Hawai'i of Cheilospirura hamulosa was by Swanson (1939) in domestic chickens. Schwartz and Schwartz (1949) reported Cheilospirura sp. in the ring-necked pheasant, and in 1951 they identified C. hamulosa from the same host. Domestic turkeys also harbor C. hamulosa (Alicata 1964).

Dispharynx and Synhimantus

Infection Characteristics: Dispharynx nasuta has a worldwide distribution and has been reported from a variety of columbiform, galliform, and passeriform birds (Wehr 1971). It is a common parasite of the proventriculus, esophagus, and rarely, the intestine (Levine 1980). D. nasuta causes deep ulcerations and becomes almost buried under proliferating tissue (Levine 1980). Considerable losses have been recorded in ruffed grouse (Bonasa umbellus) from the United States, with young birds being most severely affected (Wehr 1971). In a survey of birds in New York City, the

parasite was found to be pathogenic mainly in gallinaceous birds, with catbirds (Dumetella carolinensis) being the only passerine species obviously affected (Goble and Kutz 1945). However, some pigeon populations also experience heavy losses from this parasite (Hwang et al. 1961).

Life Cycle: All members of Dispharynx and Synhimantus require an intermediate host. The intemediate host of D. nasuta in Hawai'i is the sowbug Porcellio laevis (Alicata 1964). Eggs hatch inside the sowbug and become infective after 26 days. The life cycle of S. zosteropsi is unknown.

Hawaiian Hosts: In Hawai'i Dispharynx nasuta has been reported from California quail, Barbary partridge, domestic chickens, turkeys, and pigeons (Alicata 1964; Lewin and Holmes 1971). Dispharynx sp. has also been reported in the common myna, red-crested cardinal, and northern cardinal (Smith and Guest 1974). We found a species of Dispharynx in zebra doves from the Honolulu Zoo. All could well have been D. nasuta. The closely related species Synhimantus zosteropsi is being described from the gizzard of Japanese white-eyes on the island of Hawai'i (Cid del Prado Vera, Maggenti, and van Riper, in press).

Viguiera

Infection Characteristics: Members of the genus Viguiera infect the proventriculus and gizzard, and in heavy infections the erosion of the tissue may be severe. These worms are worldwide in distribution (Cram 1927).

Life Cycle: All members of Viguiera require an intermediate host. Many spiruroirids utilize arthropods (Levine 1980), but the hosts for Viguiera in Hawai'i are unknown.

Hawaiian Hosts: Viguiera hawaiiensis, a new species, was collected from between the gizzard tunic layers of the 'apapane, common 'amakihi, and 'i'iwi on the island of Hawai'i (Cid del Prado Vera, Maggenti, and van Riper, in press).

Oxyspirura

Infection Characteristics: The distribution of Oxyspirura mansoni, the common eyeworm, includes a wide variety of hosts worldwide. This worm infects primarily Galliformes, Columbiformes, and Passeriformes (Ruff 1978). Adult worms are found beneath the nictitating membrane of the eye, causing lesions which vary from mild conjunctivitis to severe ophthalmia (Levine 1980).

Life Cycle: The intermediate host of Oxyspirura mansoni in Hawai'i, and worldwide, is the burrowing

cockroach Pycnoscelus surinamensis (Schwabe 1951). The propensity of birds to eat cockroaches and cockroach availability are probably the limiting factors in this parasite's distribution. The maintenance of giant toads (Bufo marinus) has been advocated as a means of cockroach control (Alicata 1947).

Hawaiian Hosts: Oxyspirura mansoni is the most commonly reported parasitic nematode in Hawai'i, and it has been found in the following introduced avian species: Barbary partridge, gray francolin, bare-throated francolin, Japanese quail, Kalij pheasant, domestic chicken, ring-necked pheasant, wild turkey, California quail, spotted dove, zebra dove, common myna, red-crested cardinal, and house sparrow (Alicata 1936, 1964; Eddinger 1967; Illingsworth 1931; Lewin and Holmes 1971; Schwartz and Schwartz 1949, 1951; Smith and Guest 1974; Swanson 1939). We found rock doves at the Honolulu Zoo to be occasionally infected (unpubl. data). In addition, a second, unidentified species of Oxyspirura was found in California quail and bare-throated francolin (Lewin and Holmes 1971).

Gongylonema

Infection Characteristics: Gongylonema ingluvicola is known as the common poultry cropworm. It produces only local lesions without serious pathological effects to the crop (Ruff 1978).

Life Cycle: The beetle Copris minutis serves as an intermediate host in the continental United States and in Hawai'i; the beetle Copris incertus is also a suitable host (Alicata 1964).

Hawaiian Hosts: In Hawai'i Gongylonema ingluvicola has been reported from ring-necked pheasants (Swanson 1939) and domestic chickens (Alicata 1939a).

Capillaria

Infection Characteristics: Capillarid worms usually cause extensive damage to their hosts because adults feed directly on blood and tissue. The intestinal lining may be destroyed and absorption capabilities greatly decreased (Wehr 1971).

Life Cycle: Some Capillaria species have direct life cycles, while others require intermediate hosts, such as earthworms (Levine 1980; Wehr 1971). The capillarids in Hawai'i have not been determined to species, and their life cycles are unknown.

Hawaiian Hosts: Capillaria sp. has been reported in the northern cardinal, blue-capped cordonbleu, orange-cheeked waxbill (Smith and Guest 1974), and common 'amakihi (van Riper 1975). We have found a species

of Capillaria in 'apapane and 'i'iwi from the island of Hawai'i (unpubl. data). Cid del Prado Vera, Maggenti, and van Riper (in press) reported a species of Capillaria from the 'apapane. Captive common 'amakihi from Paradise Park also harbor a capillarid (A. Miyahara, pers. comm.).

Acanthocephala

Infection Characteristics: Acanthocephalans, or thorny-headed worms, are found in the intestines of many vertebrates, especially fish, where they cause inflammation at the site of attachment. Anemia and/or enteritis is common, and in some cases the gut lining may be completely perforated (Schmidt 1969).

Life Cycle: The life cycles of acanthocephalans in Hawai'i are undetermined, but all require one or more intermediate hosts. These hosts may include various arthropods, vertebrates (lizards or amphibians), or annelids (Ruff 1978).

Hawaiian Hosts: Smith and Guest (1974) found Plagiorhynchus charadrii and Mediorhynchus sp. in lesser golden plovers, and the latter in a common myna, red-crested cardinal, and northern cardinal. Okimoto (1975) reported Plagiorhynchus charadrii and Mediorhynchus orientalis from golden plovers, and Schmidt and Kuntz (1977) collected M. orientalis larvae from a golden plover. Although only reported in Hawai'i from plovers, M. orientalis seems to prefer passerine species as hosts (Schmidt and Kuntz 1977). The only acanthocephalan reported from a native passerine was identified as Apororhynchus hemignathi in the 'akialoa by Perkins (1903).

Cestoda

Tapeworms are common parasites of birds. Unfortunately, many reports from Hawai'i merely record "tapeworms" without specific identification. While this information is of note, it is of little value in determining the overall picture of parasite distributions in the Islands. These records include: rock dove (Schwartz and Schwartz 1949; Yeager and Gleiser 1946); spotted dove (Smith and Guest 1974); common myna (Guberlet 1926--2 species; Smith and Guest 1974); red-crested cardinal (Smith and Guest 1974); red-cheeked cordonbleu (Smith and Guest 1974); lavender waxbill (Smith and Guest 1974); 'akepa (Perkins 1903); and house sparrow (Smith and Guest 1974); common 'amakihi, 'apapane, and 'i'iwi (Baldwin 1948).

Raillietina

Infection Characteristics: Two members of Raillietina have been reported in Hawai'i, R. cesticillus and R. tetragona. There have been reports of R.

cesticillus causing pathology and reduced growth in poultry, but controlled experiments have failed to substantiate this. Reid (1978a) stated that perhaps modern optimal nutritional formulas may account for this disparity. On the other hand, R. tetragona has been shown to cause weight loss and a decrease in egg production which is more apparent in some breeds of chickens than others. R. cesticillus embeds in the duodenum and jejunum, while R. tetragona usually inhabits the posterior half of the intestine (Reid 1978a).

Life Cycle: Intermediate hosts in Hawai'i as listed by Alicata (1964) are: R. cesticillus--the beetles Dermestes vulpinus and Gonocephalum seriatum; R. tetragona--probably various species of ants, especially Pheidole sp. and Tetramorium sp.

Hawaiian Hosts: In Hawai'i, Raillietina cesticillus and R. tetragona are common in chickens (Alicata 1964), and an unidentified species of Raillietina has been recovered from pigeons (Yeager and Gleiser 1946).

Fuhrmannetta

Infection Characteristics: Fuhrmannetta tapeworms are characteristic of Columbiformes and occasionally Galliformes (Lewin and Holmes 1971). Their pathogenicity is unknown.

Life Cycle: The life history is unknown.

Hawaiian Hosts: Fuhrmannetta crassula was reported from California quail by Lewin and Holmes (1971), a first record for this species. They also speculated that the cestode in the spotted dove reported by Schwartz and Schwartz (1949) was Fuhrmannetta crassula.

Hymenolepis

Infection Characteristics: Hymenolepis carioca and H. megalops are well-known parasites of poultry and waterfowl (Reid 1978a). H. carioca is reportedly one of the least pathogenic tapeworms. The pathogenicity of H. megalops is largely unknown, although in England there are cases of severe mortality in ducks when this species is present in combination with H. coronula and H. furcigera (Reid 1978). Neither of these 2 species has been observed in Hawai'i. Interestingly, H. megalops is one of the few tapeworms that attach to the cloaca or bursa Fabricius instead of to the intestinal wall proper.

Life Cycle: Alicata (1964) listed the intermediate hosts for Hymenolepis carioca as the beetle Aphodius granarius and the fly Stomoxys calcitrans in Hawai'i. However, Reid (1978a) doubted that flies

carry this parasite and stated that hosts throughout the world include many beetles and a termite. The life history of H. megalops is unknown.

Hawaiian Hosts: Hymenolepis carioca was reported from chickens by Guberlet (1926), and later from the same host by Alicata (1964). Hymenolepis megalops was found in Hawaiian ducks (Alicata 1964).

Orientolepis

Infection Characteristics: Members of this genus are closely related to Hymenolepis. One species has been reported from Hawai'i, Orientolepis exigua. Its pathogenicity is unknown.

Life Cycle: The amphipod Orchestia platensis serves as the intermediate host of this tapeworm in Hawai'i (Alicata and Chang 1939).

Hawaiian Hosts: Orientolepis exigua is common in chickens in Hawai'i (Alicata 1964) and has been recovered once from wild turkeys (Lewin and Holmes 1971).

Anonchotaenia

Infection Characteristics: Members of the bird family Fringillidae in North and South America and the Hawaiian Drepanidinae are the most common hosts of this genus of tapeworms (Vogue and Davis 1953). The pathogenicity is unknown.

Life Cycle: The life cycle of Anonchotaenia is unknown.

Hawaiian Hosts: Anonchotaenia brasilense was first recovered from the common 'amakihi, 'i'iwi, and 'apapane by P. Baldwin in 1948 and was later identified by Vogue and Davis (1953). We have recovered this tapeworm from the same species (unpubl. data). Perkins (1903) reported Drepanidotaenia hemignathi from an 'akialoa, and this may have been A. brazilense.

Choanotaenia

Infection Characteristics: Choanotaenia infundibulum is a common parasite of chickens throughout the world. It is a large, robust species which attaches to the upper half of the intestine. There have been no controlled experiments to determine its pathogenicity (Reid 1978a).

Life Cycle: The intermediate hosts of C. infundibulum in Hawai'i include the beetles Dermestes vulpinus, Epitragus diremptus, and Gonocephalum seriatum, and the house fly Musca domestica (Alicata 1964). Throughout the world a wide variety of insects

(beetles, grasshoppers, termites) have been shown to be experimental hosts (Reid 1978a).

Hawaiian Hosts: Choanotaenia infundibulum was first identified in Hawai'i from chickens by Guberlet (1926), and this was later confirmed by Alicata (1938a). Lewin and Holmes (1971) also reported this parasite from Barbary partridge, Japanese quail, and California quail.

Metroliasthes

Infection Characteristics: Metroliasthes lucida is a long tapeworm often found in turkeys, guinea fowl, and sometimes chickens. The pathogenicity of this species is unknown (Reid 1978a).

Life Cycle: Throughout the world, grasshoppers serve as the intermediate host for M. lucida (Ruff 1978).

Hawaiian Hosts: Metroliasthes lucida was found in wild Hawaiian turkeys (Lewin and Holmes 1971). This is the only report of this tapeworm in Hawai'i.

Trematoda

Austrobilharzia

Infection Characteristics: Austrobilharzia variglandis is a blood fluke found in mesenteric veins of avian hosts, although larval dermatitis in humans has been reported (Chu and Cutress 1954).

Life Cycle: This fluke utilizes the littorine snail Littorina pintado as an intermediate host in Hawai'i (Alicata 1964). Eggs hatch in water into miracidia which penetrate the snail host. After maturation, cercariae are released and penetrate the skin of the final host (Noble and Noble 1971).

Hawaiian Hosts: Chu and Cutress (1954) reported the schistosome fluke, Austrobilharzia variglandis, from a ruddy turnstone.

Postharmostomum

Infection Characteristics: Postharmostomum gallinum is a cecal fluke of galliform and columbiform birds worldwide. It causes inflammation and hemorrhage in the caecum, and it is a common parasite of chickens raised on the ground (Alicata 1964).

Life Cycle: The land snail Bradybaena similaris is the first and second intermediate host; the land snail Subulina octona may also serve as a second intermediate host in Hawai'i (Alicata 1940). Birds become infected by eating snails containing metacercariae.

Hawaiian Hosts: Alicata (1940) reported this cecal fluke in chickens from Hawai'i.

Urotocus

Infection Characteristics: Urotocus rossittensis is a cosmopolitan species, found in a variety of passerine hosts worldwide (Williams 1960). The flukes are almost always located in the bursa Fabricius. The organ becomes distended when infected.

Life Cycle: The life cycle is unknown, but in one drepanid that we found with a fluke infection, the land snail Tornatellaria was recovered from the crop contents. This snail may serve as an intermediate host to the fluke, but more study is needed.

Hawaiian Hosts: One 'amakihi and 2 'apapane from a sample of 60 birds on Hawai'i were infected with Urotocus rossittensis (unpubl. data). Van Riper (1975) reported a "fluke" in common 'amakihi, which was probably this species.

Philophthalmus

Infection Characteristics: Philophthalmus gralli is a small trematode which occurs in the eyes of game birds throughout the world. The infection results in congestion and erosion of the conjunctiva (Kingston 1978).

Life Cycle: The melanid snails Thiara granifera and Stenomelania newcombi serve as intermediate hosts for eye flukes in Hawai'i. The cercariae encyst on any solid object including snail shells or crayfish exoskeletons. When the snail or crayfish is eaten, the metacercariae migrate to the eye of the final host (Alicata 1962, 1969; Alicata and Ching 1960; Ching 1961).

Hawaiian Hosts: The eye fluke has been observed in Hawaiian coots and cattle egrets (Alicata 1969).

Centrocestus and Haplorchis

Infection Characteristics: Flukes in the family Heterophyidae normally live in the small intestine and cause little harm. Some pain or diarrhea may result from the infections, and occasionally the eggs may find their way into the blood and cause mild to serious trouble in the organs into which they infiltrate (Noble and Noble 1971).

Life Cycle: Heterophyid flukes utilize melanid snails and fish as first and second intermediate hosts, respectively. Martin (1958) determined that the fresh water snail Stenomelania newcombi serves as the first intermediate host for Centrocestus formosanus and

Haplorchis yokogawai. The snail Tarebia granifera is the first intermediate host of Haplochis taichui. In Hawai'i, the fish Mugil cephalus, Gambusia affinis, or Xiphophorus helleri serve as a second host for Centrocestus formosanus and Haplochis taichui. H. taichui also utilizes the fish Mollienesia formosus. Haplochis yokogawai was not recovered from any free-living intermediate hosts, but Martin speculated that hosts are probably the mullet (Mugil cephalus) and the Chinese catfish (Clarias fuscus).

Hawaiian Hosts: Martin (1958) reported three heterophyid flukes (Centrocestus formosanus, Haplorchis taichui, and H. yokogawai) from the black-crowned night heron in Hawai'i. Besides this bird, cats and rats will serve as final hosts, and all 3 fluke species will infect man if infected raw fish is eaten. Okimoto (1975) reported a heterophyid fluke in a lesser golden plover but gave no further description of the parasite.

ECTOPARASITES

Ectoparasites are found on the body or feathers of their avian host, for part or all of the parasite's life cycle. We have included among the ectoparasites the respiratory mites, although many species are actually found internally in the lungs, air sacs, or even embedded within the internal organs. Because of the numbers of ectoparasites and paucity of information on the infection characteristics of some species, we have discussed these parasites by order, suborder, and family in most cases rather than by genus as in the endoparasites. Moreover, the subsections of "Infection Characteristics" and "Life Cycle" have been condensed into one.

Acari

Ixodida Ticks

Infection Characteristics and Life Cycle: Ticks are the largest of the parasitic Acarina. They typically frequent nests, intermittently feeding on their hosts during all of the parasite's life stages. Heavy infestation can lead to severe host anemia, nest desertion, and even death (Baker and Wharton 1952). In addition, a number of arboviruses have been isolated from ticks (Brennan 1965). Tick eggs are laid in the nest or near the ground. The larvae feed on the host, molting into nymphs which in turn feed on the host before assuming adult form. Some ticks require several hosts at various stages to complete their life cycles (Baker and Wharton 1952).

Hawaiian Hosts: Only 3 species of ticks have been reported from wild birds in the Hawaiian Islands: Ornithodoros capensis, O. denmarki (soft ticks), and

Ixodes laysanensis (hard ticks). Ticks have been reported from the black-footed and Laysan albatrosses, wedge-tailed and Townsend's shearwaters, brown noddy, ruddy turnstone, and Laysan duck (Butler 1961; Butler and Usinger 1963; Wilson 1964a; Kohls, Sonenshine, and Clifford 1965). Ornithodoros capensis is generally abundant on Laysan, Kure, Pearl and Hermes Reef, Lisianski, Gardner, Necker, Nihoa, and French Frigate Shoals (Garrett and Haramoto 1967). However, the parasite has, in many cases, been in the nest rather than directly on the host when collected. Haemaphysalis wellingtoni was recovered from a pheasant from Thailand at the Honolulu Quarantine Station, but there is no evidence of this parasite being established in Hawai'i (Garrett and Haramoto 1967).

Gamasida Mites

Infection Characteristics and Life Cycle: The Gamasida mites are a heterogeneous taxonomic group and include some of the most notorious pathogenic mites, including the Rhinonyssidae, Dermanyssidae, and Macronyssidae. The Rhinonyssidae, or bird nasal mites, are found internally within the air sacs and respiratory system, and even embedded in the internal organs and peritoneum of their hosts. These mites can cause severe respiratory distress (Arnall and Keymer 1975). Little is known about respiratory mites, but they probably spend entire life cycles on or in their host (Keymer 1982b). Dermanyssus gallinae, the red mite, is one of the best known of the Dermanyssidae. It feeds at night, hiding near roosts during the day. It is common among poultry and a variety of wild and cage birds. D. gallinae can cause weight loss, anemia, and even death (Keymer 1982b) and has been implicated in the transmission of Atoxoplasma (Lainson 1960), eastern equine encephalomyelitis (Howitt et al. 1948), and trypanosomes (Macfie and Thompson 1929; Manwell and Johnson 1931). Another mite that sucks blood and can cause similar serious problems is Ornithonyssus sylviarum (Macronyssidae). While this species appears uncommonly on wild birds, this may not be an accurate reflection of the true distribution because it visits the host only for feeding, and therefore might be missed during surveys (Goff 1980). The Laelapidae are usually parasitic (Baker and Wharton 1952) and have also been implicated in disease transmission (Krantz 1978).

Hawaiian Hosts: Gamasida mites have been reported from individuals or the nests of the following avian species in Hawai'i: Hawaiian crow, zebra dove, house sparrow, 'amakihi, nutmeg mannikin, golden plover, lavender waxbill, blue-headed cordonbleu, orange-cheeked waxbill, red-eared waxbill, domestic chicken, common myna, house finch, and 'apapane (see the Appendix for a complete mite species list with references).

Actinedida Mites

Infection Characteristics and Life Cycle: Actinedida mites are a very diverse group, cosmopolitan in distribution, and found in all habitat types (Krantz 1978). Cheyletidae mites are usually free-living predators, although they are found on the bodies of birds and sometimes appear to injure the host (Baker and Wharton 1952). The Harpyrhynchidae are generally parasitic. They are found in or under the cuticles of birds, and most of the specimens that have been recovered in Hawai'i were found in body washes of birds (Goff 1980). Trombiculidae (chiggers) cause irritation to their hosts, and some release toxins that may result in allergic reactions (Arnall and Keymer 1975). Chiggers feed on their hosts only as larvae and are free-living predators as nymphs and adults, feeding on small arthropods in the soil (Baker and Wharton 1952).

Hawaiian Hosts: Mites of the suborder Actinedida have been identified from the following Hawaiian birds or their nests: Japanese white-eye, red-billed leiothrix, house sparrow, common 'amakihi, 'apapane, 'i'iwi, Laysan finch, ruddy turnstone, brown noddy, black-crowned night heron, black-footed and Laysan albatross, and golden plover (see Appendix for references). In addition, mites identified only to the family Syringophilidae were reported from the quills of common 'amakihi, palila, 'elepaio, and Japanese white-eye (Berger 1981).

Acaridida Mites

Infection Characteristics and Life Cycle: This group includes various species of feather mites from the Analgidae, Dermoglyphidae, Trouessartiidae, Proctophyllodidae, Pyroglyphidae, Sarcoptidae, Pteronyssidae, Cytoditidae, and Xolalgidae. The feather mites, as a rule, are not harmful to their hosts. They are scavengers, feeding on feather debris and dead skin (Evans, Sheals, and MacFarlane 1961; Krantz 1978). However, in some cases heavy infestation may lead to feather picking. We have found several 'apapane with abnormally high infestations of feather mites and deformed beaks, suggesting the importance of preening in the control of these parasites. Each group of feather mites has a distinct local preference upon the surface or within the quills (Krantz 1978), and remains with the host for the entire parasite life cycle. An Acaridida nest mite that causes little effect on the host is Dermatophagoides, which feeds mainly on detritus in the nest and is only occasionally found on birds (Krantz 1978). The specimens collected in Hawai'i were considered nonparasitic (Goff 1980). Sarcoptid mites of the genera Mesoknemidocoptes and Knemidokoptes are many times a problem in caged birds. These ectoparasites cause severe irritation to individuals, referred to as scaly

leg and scaly face (Keymer 1982b). Sarcoptid mites have not yet been recovered from wild Hawaiian birds. Cytodites nudus is a common air sac and respiratory mite of chickens, with pathogenesis varying from mild to severe (Loomis 1978). Little is known about the incidence, life cycle, or effects of Cytodites in wild birds (Keymer 1982b).

Hawaiian Hosts: Feather mites have been reported from the ring-necked pheasant, rock dove, spotted dove, domestic chicken, 'anianiau, Japanese white-eye, common myna, nutmeg mannikin, Hawaiian crow, Hawaiian thrush, 'apapane, 'i'iwi, common 'amakihi, millerbird, California quail, Japanese quail, northern cardinal, and house finch (see Appendix for a complete list of references). Other Acaridida in Hawai'i include Dermatophagoides (Pyroglyphidae) from the house sparrow (Goff 1980); Knemidokoptes and Mesoknemidocoptes (Sarcoptidae) from the chicken (Bice 1932); a new species of Mouchetia (Pteronyssidae) described from the Japanese white-eye and 'apapane, and one species yet to be determined from the red-billed leiothrix (Goff 1980); 2 members of the Xolalgidae (Ingrassiella) from common 'amakihi and 'i'iwi; a new as yet unnamed species from the short-eared owl (Goff 1980); Cytodites nudus (Cytoditidae) from the chicken (Bice 1932); and Cytodites sp. from a red-billed leiothrix (Goff 1980).

Insecta

Mallophaga

Infection Characteristics: Mallophaga, or feather lice, feed primarily on feathers or scavenged debris from feather surfaces; they may also take blood, serum, and skin tissues. Some species effectively puncture young feathers and feed on the central pulp and blood, while other species penetrate the shafts of mature feathers and feed on the dried feather core (Rothschild and Clay 1957). Generally, harm to the host is minimal except in very heavy infections (Ash 1960), especially when blood-sucking species are involved. Bathing, preening, and other grooming behaviors help to eliminate lice. Mallophaga are not important carriers of disease although at least one louse in swifts serves as an intermediate host to a filarian (Noble and Noble 1971), and eastern equine encephalomyelitis has been isolated from another species (Howitt et al. 1948); however, neither has been reported from Hawai'i. Birds generally have several species of lice, and young birds tend to have heavier loads than do adults (Rothschild and Clay 1957).

Life Cycle: The entire life cycle of Mallophaga is spent on the host (Keymer 1982b). Eggs are attached directly to feathers, and several nymphal stages develop prior to emergence of the adult form. Lice

cannot live for more than a few days away from the host.

Hawaiian Hosts: Mallophaga have been reported from a variety of species of birds of Hawai'i (see Appendix for host list and references). Indeed, probably all avian species are infected with at least one type of louse (Rothschild and Clay 1957).

Siphonaptera

Infection Characteristics: Echidnophaga gallinacea has a wide range of hosts in tropical and subtropical areas (Rothschild and Clay 1957). It is commonly known as the stick-tight flea, and unlike most fleas, remains embedded in the skin of the host, usually about the head. Adults feed on blood and can cause irritation, anemia, and even death in heavy infections (Turner 1971). Fleas have not been implicated in the transmission of other avian diseases (Loomis 1978).

Life Cycle: The eggs are forcibly ejected and reach the litter where the larvae hatch and feed on organic material (Loomis 1978). After a pupal stage, the adult form is assumed.

Hawaiian Hosts: Only one species of flea, Echidnophaga gallinacea, has been reported from Hawai'i. It was found on the domestic chicken (Illingsworth 1916) and the California quail (Schwartz and Schwartz 1949, 1951).

Hippoboscidae

Infection Characteristics: Hippoboscid flies are capable of flight but usually cling to the bird's feathers, moving rapidly over the body and feeding periodically on blood. Hippoboscids cause anemia, especially in heavy infections on very small birds (Keymer 1982b). They can also act as an intermediate host for other parasites. Pseudolynchia canariensis, the common pigeonfly, carries Haemoproteus, a blood protozoan. Ornithoica vicina is a very common hippoboscid fly on birds from North America, particularly passerines, and is common throughout the Pacific islands (Bequaert 1941). Olfersia are common flies of seabirds and are widespread throughout the Pacific and Atlantic. Icosta nigra is usually found on birds of prey in North America.

Life Cycle: Eggs are laid in the nest, but the adults remain near or on their host for most of the life cycle (Keymer 1982b).

Hawaiian Hosts: There have been several species of Hippoboscidae reported from birds in Hawai'i;

white-eye, northern cardinal, and 'elepaio (W. Hansen, pers. comm.). Therefore, the many reports of "lesions" may indeed be a true reflection of the picture of avian pox in the Islands, but more substantiation is needed.

Newcastle disease

Infection Characteristics: Domestic poultry that are infected with Newcastle disease exhibit coughing, lowered productivity, leg and wing paralysis or other nervous symptoms, diarrhea, hemorrhage, and death (Hanson 1978). Very little is known about the pathogenesis in wild birds (Palmer and Trainer 1971).

Transmission: This disease is extremely contagious, being transmitted via contact with sick birds or their droppings (Hanson 1978). It has been reported to be carried by the mite Dermanyssus gallinae (Palmer and Trainer 1971) and other invertebrates such as earthworms (Boyd and Hanson 1958).

Hawaiian Hosts: Newcastle disease was introduced accidentally to Hawai'i from California in July 1977 by an infected parrot. In 1979 a ban on importation of all live birds from California to Hawai'i was imposed on the State (Berger 1981). The disease has never been reported from wild Hawaiian birds, and a survey of 17 wild birds and 599 captive birds for Newcastle disease in 1980 was negative (U.S. Department of Agriculture and Southeastern Cooperative Wildlife Disease Study 1980), although the disease was later reported from Hilo in 1981.

Arboviruses or togaviruses

Infection Characteristics: There are several arboviruses that constitute a threat to a wide variety of domestic and wild birds (Buescher 1956; Coleman 1978; Hammon, Sather, and McClure 1958; Karstad 1971). Many infected individuals remain asymptomatic carriers (Kissling et al. 1954), although the disease is often fatal, with neurological signs predominating, including muscular tremors and degrees of paralysis (Cavill 1982).

Transmission: Arboviruses are transmitted chiefly by mosquitoes, and secondarily by other arthropods such as mites, lice, ticks, and directly from bird to bird (Brennan 1965; Cavill 1982; Howitt et al. 1948; Sulkin and Izumi 1947).

Hawaiian Hosts: Both the American (eastern equine encephalitis, western equine encephalitis, St. Louis encephalitis) and the Asian types (Japanese B encephalitis virus) could reach Hawai'i. Several surveys of birds in Hawai'i have indicated that these arboviruses are not yet present in the Islands

(Quisenberry and Wallace 1959; Wallace et al. 1964), but several potential vectors (Aedes spp., Culex quinquefasciatus, and various mites) are.

Bacterial Diseases

Infection Characteristics: Bacterial diseases are common and often a high percent are fatal. In many cases, disease is caused by a bacterium that is usually commensal. Stress of other disease factors can easily upset the physiological balance and lead to bacterial infections. In birds, enteritis is commonly associated with Escherichia coli, Staphylococcus, Salmonella, Pseudomonas aeruginosa, Pasteurella, or Yersinia; septicemic diseases are related to Salmonella, E. coli, Pseudomonas, Streptococcus, Staphylococcus, or Pasteurella; and respiratory diseases such as pneumonia are often associated with E. coli, Salmonella, Klebsiella, Corynebacterium, Pseudomonas, and Staphylococcus (T-W-Fiennes 1982). Botulism, a paralytic disease, is caused by eating food contaminated by the toxin produced by the bacterium Clostridium botulinum. Death is due to paralysis of the respiratory and/or cardiac muscles. Many deaths from this disease occur in waterfowl, shorebirds, or game birds if conditions are conducive (Rosen 1971).

Transmission: Transmission of bacterial diseases varies but generally occurs via contact with sick or carrier individuals, or through contaminated material. Botulism is found naturally in the soil, but when water levels drop and temperatures are high, the organism multiplies in dead organic material and releases a toxin. The organic material may be decaying vegetation, various invertebrates (e.g. maggots), or vertebrates (e.g. fish). The toxin is nearly always fatal when ingested by birds.

Hawaiian Hosts: Most of the information on bacterial infections in Hawaiian birds is fragmentary. While many of the bacteria reported are not normally recognized as pathogenic, several of the types that have been identified are potentially serious pathogens. Staphylococcus was diagnosed as the cause of death of several Laysan finches in an outbreak at the Honolulu Zoo (Throp 1970). It began as a swelling on the tarsus of one bird and rapidly spread throughout the colony, causing many deaths. The birds showed little resistance to the bacterium, although Staphylococcus is ubiquitous and normally found on the skin. It is not unreasonable to assume that other native birds might also be susceptible to this bacterium. We also found Staphylococcus to be a problem in captive Laysan finches, and at least 2 individuals had Staphylococcus infections when they died in our aviary.

Escherichia coli and Salmonella have also been implicated in disease in wild birds. We discovered an 'apapane on the island of Hawai'i that had been killed by a cat; it had liver lesions typical of E. coli, and the gall bladder was distended and swollen. E. coli was isolated from both the liver and gall bladder. Salmonella was isolated from a wild palila from Mauna Kea that died after one night in an aviary. The bird had an enlarged heart and inflamed pericardium. In addition, we have been able to determine the presence of several other bacteria in the birds on the island of Hawai'i. Most of the following examples were probably not pathogenic (T.R. Sawa, pers. comm.). From Laysan finches, alpha and beta Streptococcus, Pseudomonas aeruginosa, Klebsiella pneumoniae, Serratia marcescens, Staphylococcus epidermis, and Citrobacter diversus were isolated. One house finch had Escherichia coli, and pancreatic lesions were evident in the bird. All of these birds were captive individuals. From the following wild birds we isolated the following bacteria: palila - Salmonella; 'i'iwi - Staphylococcus epidermis and Citrobacter fruendii; 'elepaio - alpha Streptococcus; 'apapane - Klebsiella pneumoniae, Escherichia coli, Pseudomonas pseudoalcaligens, and Enterobacter cloacae.

There has been only one recorded outbreak of botulism in Hawai'i, at Ka'elepulu Pond (Enchanted Lakes), O'ahu, in 1953 (Brock and Breese 1953). The infected species were primarily northern pintail and northern shoveler ducks. Other species included the American wigeon, American coot, black-necked stilt, greater scaup, black-crowned night heron, green-winged teal, and bufflehead.

Fungal Diseases

Aspergillus

Infection Characteristics: Avian aspergillosis is caused by the fungus Aspergillus fumigatus (Raper, Fennell, and Austwick 1973). It can assume either a chronic or acute form and usually infects the upper respiratory tract or abdominal organs (Keymer 1982a). The pathogenesis in wild birds is almost unknown, but in captive individuals where it is a common problem, the disease is often fatal and almost always incurable (O'meara and Witter 1971a).

Transmission: The spores of this fungus are very common and are present in most areas of the world. Most birds have been exposed and are resistant. In fact, the fungus can often be isolated from healthy tissue. It is contracted by inhalation of the spores or hyphae, and infection tends to be related to the age and physiological state of the bird (very young

birds seem to be more susceptible) and number of spores inhaled (Keymer 1982a; O'meara and Witter 1971a).

Hawaiian Hosts: Aspergillus has been reported from several captive species in Hawai'i but has been infrequently found in wild birds. We found it in a wild Hawaiian thrush and common 'amakihi (unpubl. data). The thrush died less than 24 hours after capture, but in the common 'amakihi there were no apparent lesions or disease symptoms. Infected captive birds include the nene (Honolulu Zoo necropsy records, 1964), Hawaiian owl (Honolulu Zoo necropsy records, 1967), and common 'amakihi (Honolulu Zoo necropsy records, 1966). Probably all species of Hawaiian birds are susceptible if the conditions are conducive for infection.

Candida

Infection Characteristics: Candida albicans infects the digestive tract or respiratory system, causing lesions and inflammation. It is very rare in wild birds (O'meara and Witter 1971b).

Transmission: Transmission is accomplished via contaminated food or water, or by inhalation of the spores. The fungus is very widespread, so there appears to be more than ample opportunity for contact by wild birds (O'meara and Witter 1971b).

Hawaiian Hosts: Candidiasis has been reported only from captive birds in Hawai'i. 'Apapane harbor Candida albicans (A. Miyahara 1969 necropsy records), and we discovered one Laysan finch that was infected with this fungus (unpubl. data).

DISCUSSION

The isolation of the Hawaiian Islands has led to disharmonic patterning of biological species, and avian parasites and disease-causing organisms are no exception. Major taxonomic groups (protozoans, various helminths, ectoparasites, viruses, bacteria, fungi) are represented. However, within broad categories, many diseases are absent. This is especially true for bacteria and viruses. Prehistoric colonizing birds undoubtedly brought a spectrum of parasites with them, and these have coevolved with their hosts. Other parasites arrived concomitantly with the importation of alien birds, and this process is ongoing. Today biologists are faced with an array of parasites interacting with a unique assemblage of birds. Besides the simple cataloguing of what is present in Hawai'i, research is needed to determine the impact of each disease and the means of controlling or eradicating it if necessary. This discussion will deal with 3 points:

1. The difference between the threats posed by host-specific versus generalized diseases;
2. Examples of 2 non-specific diseases that have negatively influenced native birds; and,
3. Suggestions for directions of future research on avian diseases in Hawai'i.

The majority of parasites infecting Hawaiian birds fall into the host-specific category, infecting primarily one preferred host or related species. These usually cause mild, self-limiting infections, because parasites are most successful when causing the least trauma. A dramatic example of this is Haemoproteus in rock doves: incidence of infection includes nearly all of the population, and individual birds, which have very high parasitisms, show few adverse signs. Another example is coccidia in the native drepanids. Several endemic species have been described, but rarely are infections seen in the wild that cause overt symptoms. Host-specific parasites seldom significantly interrupt the life cycle of the host upon which they depend to complete their life cycle, although parasite trauma may be increased when multiple infections occur. For example, the presence of Ascaridia in birds augments the pathology of concurrent infections of coccidia, Heterakis, and infectious bronchitis (Levine 1980; Ruff 1978). Occasionally, epidemics flare when a balance is upset, but in stable host populations, even occasional epidemics are not extremely serious.

Generally, host-specific parasites retain a great deal of specificity when transplanted to the Islands and therefore pose little threat to potential new hosts. Even though their introduction to Hawai'i results in a superficial "exposure" to new avian groups, most parasite distributions are inhibited by less obvious factors, including the lack of potential vectors and intermediate hosts, eating habits of potential hosts, and humidity and soil conditions that affect survival of ova. If these factors are overcome, when confronted with the physiology of a new host, the final destination of the parasite within the host tissue may be abberrant, or as is the case of the acanthocephalan Mediorhynchus orientalis, larvae may fail to reach sexual maturity.

Those parasites that readily cross species boundaries, infecting a diverse spectrum of hosts, cause diseases with which managers and biologists in Hawai'i need to be most concerned, because it is these that have the greatest ability to impact native birds. However, not all cause severe diseases. The most widespread parasite reported in the widest variety of Hawaiian species is the eyeworm, Oxyspirura mansoni, which typically causes little harm to its host

populations. Its distribution is probably limited only by the intermediate host. If a means of transmission is available when a non-specific disease arrives (e.g., proper vector), native and introduced birds become immediate new targets. Unfortunately, because the native birds are often "naive" in the evolutionary sense, they tend to be more susceptible than are introduced species--as in the well-studied case of avian malaria.

Avian malaria is a parasitic infection of the blood, caused in Hawai'i by the protozoan Plasmodium relictum. It infects a wide range of avian species, has probably contributed to the extinction of some native bird species, and certainly contributes to limited distributions of others. Malaria was reported as early as 1947 by Fisher and Baldwin, but the case against Plasmodium crystallized with Warner (1968), although he failed to find any native birds infected in the wild. He did, however, show a high degree of susceptibility to the malarial parasite by native birds when exposed experimentally. He proposed that malaria had greatly influenced bird distribution and was a major factor in their demise.

Of all the diseases and parasites recorded from the native Hawaiian avifauna, malaria has been the best studied ecologically and appears to be presently having the greatest influence on these birds. During the course of an extensive field and laboratory study, van Riper et al. (in press) found that on Hawai'i Island native birds had a high incidence of infection in their populations, and more severe infections, than did the introduced species. Elevation and climate relating to the vector's distribution seemed to be related to infection levels and were strongly reflective of species distribution. Van Riper et al. (in press) suggested that malaria is one of the major bird population-regulating mechanisms operative on Hawai'i Island today, and appears to be restricting the native Hawaiian land birds to the higher and drier forest areas.

Another widespread disease capable of readily infecting a variety of bird species is avian pox. Lesions typical of avian pox have been mentioned for many years since Perkins (1893, 1903), who first described open sores on several native species. Since avian pox has probably been in the Islands for almost 100 years, surviving bird species appear to have adapted a degree of resistance. Field workers continue to observe a high incidence of lesions and evidence of past lesions (e.g., missing toes), and a thorough study of birds that have a history of lesions would perhaps be enlightening. Avian pox probably led to the deaths of countless Hawaiian birds, and even entire species,

early in the century, but there are few data to support this. Of first priority in the study of Hawaiian bird diseases should be a complete study of avian pox, examining geographic distribution, host infection rates, and susceptibility of various avian species. The investigation should contain laboratory work complimented by field surveys. Avian pox has long been enigmatic in Hawaiian disease studies and probably is more important than has been believed.

Other non-host specific diseases may be shown to be important to Hawaiian birds, and more study is needed in this area. A paucity of data exists in Hawai'i concerning bacterial and viral diseases in general. Moreover, all diseases and parasites should be examined in terms of ecosystem and island type. Areas of disease concentration should be mapped throughout the Islands; possibly the absence of birds in particular ecosystems might be thus explained. With more information, controlling diseases might become more feasible.

At present it is important that no new diseases be introduced to the Islands. The obvious solution is a more careful control in the importation of avian species, including the monitoring and clearing of all parasites in imported birds. The Hawaiian goose and other captive-bred species should be carefully examined for disease before being introduced into wild populations. For example, Avery (1966) reported a gapeworm (Cyathosthoma sp.), mycrobacteriosis, and 2 species of tapeworms (Menatoparataiena southwelli and Fimbiaria fasiolaris) from captive Hawaiian geese at Slimbridge, England. It is not known if any of these are yet in Hawai'i, but great care should be taken to prevent their introduction. There is evidence that arboviruses, Newcastle disease, and avian influenza similarly are absent (Quisenberry and Wallace 1959; Wallace et al. 1964; U.S. Department of Agriculture and Southeastern Cooperative Wildlife Disease Study 1980; Okimoto 1975), and they should be carefully guarded against.

In summary, we understand some of the impacts that diseases have had on Hawaiian birds. However, more information is needed for long-term predictions regarding the well-being of this unique compliment of avian species. And, while parasites and diseases are only a few of the many threats that confront the continued existence of Hawai'i's birds, they need to be fully considered in any program of management and preservation.

ACKNOWLEDGEMENTS

This paper is dedicated to the late R.E. Warner, who pioneered disease work on the native Hawaiian birds. We would like to express our gratitude to T.R. Sawa of the Hawaii State Department of Agriculture for identification of the many bacteria samples that we collected from native birds. For help in the identification of the trematode Urotocus rossittensis and the avian pox virus, we thank A.O. Bush and W. Hansen, respectively. C.J. Ralph provided assistance in locating references, M.L. Goff and A. Miyahara provided information from their personal experience, and M. Murphy typed the draft ms. For their critical and helpful comments on the manuscript, we are appreciative to J.E. Alicata, M.L. Goff, R.M. Nakamura, D.M. Berger, and C.W. Smith. This work was supported by the Cooperative National Park Resources Studies Unit at the University of Hawai'i through funding provided by the U.S. Department of the Interior, National Park Service, Western Region.

APPENDIX

Parasite and Disease Records of Hawaiian Birds[1]

Procellariiformes

Black-footed albatross — *Diomedea nigripes*
- Acari
  - *Leptotrombidium intermedium* (nest) - Goff 1971
  - *Neoschoengastia gallinarum* (nest) - Goff 1971
  - *Neotrombicula tamiayi* (nest) - Goff 1971
  - *Ornithodoros capensis* (nest) - Wilson 1964a
- Mallophaga
  - *Harrisoniella* sp. - Thompson 1948
- Hippoboscidae
  - *Olfersia aenescens* - Maa 1968

Laysan albatross — *Diomedea immutabilis*
- Acari
  - *Ixodes laysanensis* - Wilson 1964a
  - *Neoschoengastia gettmanni* (nest) - Goff 1984
  - *Ornithodoros capensis* (nest) - Kohls, Sonenshine, and Clifford 1965; Wilson 1964a
- Mallophaga
  - *Docophoroides* sp. - Thompson 1948
  - *Harrisoniella* sp. - Thompson 1948
- Hippoboscidae
  - *Olfersia aenescens* - Maa 1968

Wedge-tailed shearwater — *Puffinus pacificus*
- Acari
  - *Ixodes laysanensis* - Wilson 1964a
  - *Ornithodoros capensis* - Takahashi et al. 1982
- Mallophaga
  - *Halipeurus mirabilis* - Thompson 1948
  - *Longimenopon puffinus* - Thompson 1948
  - *Trabeculus mirabilis* - Thompson 1948
- Hippoboscidae
  - *Olfersia aenescens* - Bequaert 1941

Christmas shearwater — *Puffinus nativitatus*
- Mallophaga
  - *Longimenopon puffinus* - Thompson 1948

Townsend's (Newell's) shearwater — *Puffinus auricularis*
- Protozoa
  - *Plasmodium* sp. - Warner 1968 in dark-rumped petrel; corrected by Banko 1980
- Acari
  - *Ornithodoros capensis* (nest) - Wilson 1964a

Red-footed booby — *Sula sula*
- Hippoboscidae
  - *Olfersia aenescens* - Maa 1968

Pelecaniformes

Red-tailed tropicbird — Phaethon rubricauda
- Viruses
  - Avian pox - Locke, Wirtz, and Brown 1965

Great frigatebird — Fregata minor
- Acari
  - Neottialges fregatae - Fain and Amerson 1968
  - Neottialges hawaiiensis - Fain and Amerson 1968
- Hippoboscidae
  - Olfersia spinifera - Bequaert 1941; Maa 1968

Ciconiiformes

Cattle egret — Bulbulcus ibis
- Trematoda
  - Philophthalmus gralli - Alicata 1969

Black-crowned night heron Nycticorax nycticorax
- Acari
  - Opthalmognathus tenorioae - Fain and Goff 1980
- Trematoda
  - Centrocestus formosanus - Martin 1958
  - Haplorchis taichui - Martin 1958
  - Haplorchis yokogawai - Martin 1958
- Bacteria
  - Botulism - Brock and Breese 1953

Anseriformes

Hawaiian goose (nene) — Nesochen sandvicensis
- Nematoda
  - Amidostomum sp. - Banko and Manuwal 1982
  - Heterakis sp. - Banko and Manuwal 1982

Green-winged teal — Anas crecca
- Bacteria
  - Botulism - Brock and Breese 1953

Hawaiian duck — Anas wyvilliana
- Cestoda
  - Hymenolepis megalops - Alicata 1964
- Mallophaga
  - Anaticola crassicorne - Schwartz and Schwartz 1953
  - Trinotin querquedulae - Schwartz and Schwarts 1953

Laysan duck (teal) Anas laysanensis
Acari
Ixodes laysanensis (in ear) - Butler 1961; Butler and Usinger 1963

Northern pintail Anas acuta
Bacteria
Botulism - Brock and Breese 1953

Northern shoveler Anas clypeata
Bacteria
Botulism - Brock and Breese 1953

American wigeon Anas americana
Bacteria
Botulism - Brock and Breese 1953

Greater scaup Aythya marila
Bacteria
Botulism - Brock and Breese 1953

Bufflehead Bucephala albeola
Bacteria
Botulism - Brock and Breese 1953

Galliformes

Gray francolin Francolinus pondicerianus
Nematoda
Heterakis gallinarum - Lewin and Holmes 1971
Oxyspirura mansoni - Lewin and Holmes 1971
Subulura brumpti - Lewin and Holmes 1971

Bare-throated francolin Pternistes leucoscepus
Nematoda
Oxyspirura sp. - Lewin and Holmes 1971
Oxyspirura mansoni - Lewin and Holmes 1971

Barbary partridge Alectoris barbara
Nematoda
Dispharynx nasuta - Lewin and Holmes 1971
Oxyspirura mansoni - Lewin and Holmes 1971
Cestoda
Choanotaenia infundibulum - Lewin and Holmes 1971

Japanese quail Coturnix japonica
Nematoda
Oxyspirura mansoni - Schwartz and Schwartz 1949, 1951
Subulura sp. - Schwartz and Schwartz 1949
Subulura brumpti - Lewin and Holmes 1971; Schwartz and Schwartz 1951

Cestoda
Choanotaenia infundibulum - Lewin and Holmes 1971
Acari
Xoloptes sp. - Schwartz and Schwartz 1949
Mallophaga
Goniocotes asterocephalus - Schwartz and Schwartz 1949
Hippoboscidae
Ornithoica vicina - Schwartz and Schwartz 1949, 1951

Kalij pheasant — Lophura leucomelana
Nematoda
Oxyspirura mansoni - Lewin and Mahrt 1983
Mallophaga
Amyrsidea monostoecha - Lewin and Mahrt 1983
Lagopoecus colchicus - Lewin and Mahrt 1983

Red junglefowl — Gallus gallus
Mallophaga
Goniodes sp. (larvae) - Schwartz and Schwartz 1949
Goniodes dissimilis - Schwartz and Schwartz 1949
Lipeurus caponis - Schwartz and Schwartz 1949, 1951
Menopon gallinae - Schwartz and Schwartz 1949
Hippoboscidae
Ornithoica vicina - Schwartz and Schwartz 1949, 1951

Domestic chicken — Gallus gallus
Protozoa
Eimeria tenella - Alicata 1947, 1964
Histomonas meleagridis - Alicata 1964
Nematoda
Ascaridia galli - Alicata 1964; Swanson 1939
Ascaridia perspicillum - Guberlet 1926
Cheilospirura hamulosa - Alicata 1938b; Swanson 1939
Dispharynx nasuta - Alicata 1964; (= D. spiralis) Swanson 1939
Gongylonemum ingluvicola - Alicata 1964
Heterakis sp. - Swanson 1939
Heterakis gallinarum - Alicata 1964; Guberlet 1926
Oxyspirura mansoni - Alicata 1936; Schwabe 1950, 1951; Swanson 1939
Subulura sp. - Swanson 1939
Subulura brumpti - Alicata 1939b
Tetrameres americana - Alicata 1964; Swanson 1939

Cestoda
- Choanotaenia infundibulum - Alicata 1938a; Guberlet 1926
- Hymenolepis carioca - Alicata 1938a; Guberlet 1926
- Orientolepis exigua - Alicata 1938a
- Raillietina cesticillus - Alicata 1938a; Guberlet 1926
- Raillietina tetragona - Alicata 1938a; Guberlet 1926

Trematoda
- Philophthalmus gralli (experimental infection) - Alicata 1962; Alicata and Noda 1960; Ching 1961
- Postharmostomum gallinum - Alicata 1940

Acari
- Cytodites nudus (air passage, liver, lungs) - Bice 1932
- Dermanyssus gallinae - Alicata et al. 1946; Pemberton 1943
- Knemidokoptes mutans (leg) - Bice 1932
- Megninia cubitalis - Alicata et al. 1946
- Mesoknemidocoptes laevis (leg) - Bice 1932
- Ornithonyssus bursa - Zimmerman 1944
- Ornithonyssus sylviarum (feather) - Garrett and Haramoto 1967
- Pterolichus obtusus - Alicata et al. 1946

Mallophaga
- Chelopistes meleagridis - Illingsworth 1928
- Cuclotogaster heterographa - Illingsworth 1928
- Goniocotes gallinae - Illingsworth 1928
- Goniodes dissimilis - Zimmerman 1948
- Goniodes gigas - Illingsworth 1928
- Lipeurus caponis - Illingsworth 1928
- Menacanthus stramineus - Illingsworth 1928
- Menopon gallinae - Illingsworth 1928

Siphonaptera
- Echidnophaga gallinacea - Illingsworth 1916; Pemberton 1943

Ring-necked pheasant — Phasianus colchichus

Nematoda
- Ascaridia sp. - (probably A. galli) Schwartz and Schwartz 1949, 1951
- Cheilospirura sp. - Schwartz and Schwartz 1949
- Cheilospirura hamulosa - Schwartz and Schwartz 1951
- Cyrnea graphophasiani - Schwartz and Schwartz 1951
- Gongylonemum ingluvicola - Swanson 1939
- Heterakis sp. - Schwartz and Schwartz 1949
- Heterakis gallinarum - Lewin and Holmes 1971; Schwartz and Schwartz 1951

Oxyspirura mansoni - Alicata 1936; Lewin and Holmes 1971; Schwartz and Schwartz 1949, 1951; Schwabe 1950, 1951; Swanson 1939
Subulura sp. - Schwartz and Schwartz 1949
Subulura brumpti - Lewin and Holmes 1971; Schwartz and Schwartz 1951

Trematoda
Philophthalmus gralli - Lewin and Holmes 1971

Acari
Megninia columbae - Schwartz and Schwartz 1949, 1951
Megninia ginglymura - Schwartz and Schwartz 1949, 1951

Mallophaga
Goniocotes hologaster - Zimmerman 1948
Goniodes sp. (larvae) - Schwartz and Schwartz 1949, 1951
Goniodes colchici - Schwartz and Schwartz 1949, 1951
Goniodes mammillatus (= G. mammilatus) - Schwartz and Schwartz 1949, 1951
Lipeurus caponis - Schwartz and Schwartz 1949, 1951; Zimmerman 1948
Lipeurus maculosus - Schwartz and Schwartz 1949, 1951
Menopon fulvomaculatum - Schwartz and Schwartz 1949, 1951
Uchida sp. - Schwartz and Schwartz 1949, 1951

Hippoboscidae
Ornithoica vicina - Bequaert 1941; Maa 1966; Schwartz and Schwartz 1949, 1951

Common peafowl — Pavo cristatus

Mallophaga
Menopon phaeostomum - Illingsworth 1928

Wild turkey — Meleagris gallopavo

Nematoda
Oxyspirura mansoni - Lewin and Holmes 1971
Subulura brumpti - Lewin and Holmes 1971

Cestoda
Metroliasthes lucida - Lewin and Holmes 1971
Orientolepis exigua - Lewin and Holmes 1971

Domestic turkey — Meleagris gallopavo

Protozoa
Histomonas meleagridis - Alicata 1947, 1964

Nematoda
Cheilospirura hamulosa - Alicata 1964
Dispharynx nasuta - Alicata 1964
Heterakis gallinarum - Alicata 1964

Mallophaga
Chelopistes meleagridis - Illingsworth 1928
Goniocotes gallinae - Illingsworth 1928

Menopon gallinae - Illingsworth 1928
Oxylipeurus polytrapezius - Illingsworth 1928

California quail — Callipepla californica
Nematoda
Aulonocephalus pennula - Lewin and Holmes 1971
Dispharynx nasuta - Lewin and Holmes 1971
Oxyspirura sp. - Lewin and Holmes 1971
Oxyspirura mansoni - Lewin and Holmes 1971
Subulura brumpti - Lewin and Holmes 1971
Cestoda
Fuhrmannetta crassula - Lewin and Holmes 1971
Choanotaenia infundibulum - Lewin and Holmes 1971
Acari
Xoloptes sp. - Schwartz and Schwartz 1949
Mallophaga
Goniodes sp. (larvae) - Schwartz and Schwartz 1949
Goniodes mammillatus - Schwartz and Schwartz 1949; Zimmerman 1948
Lagopoecus docophoroides - Schwartz and Schwartz 1949
Menopon sp. - Schwartz and Schwartz 1949
Menopon fulvomaculatum - Schwartz and Schwartz 1949
Siphonaptera
Echidnophaga gallinacea - Schwartz and Schwartz 1949, 1951

Helmeted guineafowl — Numida meleagris
Mallophaga
Goniodes gigas - Zimmerman 1948
Menopon gallinae - Illingsworth 1928
Menopon phaeostomum - Illingsworth 1928

Gruiformes

American coot — Fulica americana
Trematoda
Philophthalmus gralli - Alicata 1969
Mallophaga
Quadraceps oraria - Zimmerman 1948
Rallicola advena - Zimmerman 1948
Bacteria
Botulism - Brock and Breese 1953

Charadriiformes

Lesser golden plover — Pluvialis dominica
Nematoda
Porrocaecum ensicaudatum - Okimoto 1975
Porrocaecum semiteres - Okimoto 1975

Subulura skrjabinensis - Okimoto 1975
Acanthocephala
Mediorhynchus sp. (probably M. orientalis) - Smith and Guest 1974
Mediorhynchus orientalis - Okimoto 1975; Schmidt and Kuntz 1977
Plagiorhynchus charadrii - Okimoto 1975; Smith and Guest 1974
Acari
Neoschoengastia gallinarum (nest) - Goff 1971
Rhinonyssus coniventris - Wilson 1964b
Toritrombicula oahuensis - Goff 1977
Mallophaga
Colpocephalum brachysomum - Zimmerman 1948
Quadraceps birostris - Zimmerman 1948
Saemundssonia conicus - Zimmerman 1948

Black-necked stilt — Himantopus mexicanus
Bacteria
Botulism - Brock and Breese 1953

Wandering tattler — Heteroscelus incanus
Mallophaga
Actornithophilus kilauensis - Zimmerman 1948

Saemundssonia conicus - Zimmerman 1948

Bristle-thighed curlew — Numenius tahitiensis
Mallophaga
Lunaceps sp. - Thompson 1948

Red-necked phalarope — Phalaropus lobatus
Mallophaga
Quadraceps connexa - Thompson 1948

Ruddy Turnstone — Arenaria interpres
Trematoda
Austrobilharzia variglandis - Chu and Cutress 1954
Acari
Guntherana domrowi - Brennan 1965; Goff 1984
Ixodes laysanensis - Wilson 1964a

Glaucous gull — Larus hyperboreus
Mallophaga
Austromenoppon infrequens - Thompson 1948

Gray-backed tern — Sterna lunata
Mallophaga
Quadraceps birostris - Zimmerman 1948
Saemundssonia snyderi - Thompson 1948; Zimmerman 1948

Sooty tern — Sterna fuscata
- Acari
  - Ornithodoros capensis - Amerson 1966
- Mallophaga
  - Saemundssonia snyderi - Thompson 1948
- Hippoboscidae
  - Olfersia aenescens - Maa 1968

Brown noddy — Anous stolidus
- Acari
  - Guntherana domrowi - Brennan 1965; Goff 1984
  - Ornithodoros capensis - Kohls, Sonenshine, and Clifford 1965
  - Ornithodoros denmarki - Kohls, Sonenshine, and Clifford 1965
- Mallophaga
  - Actornithophilus epiphanes - Zimmerman 1948
  - Actornithophilus milleri - Thompson 1948
  - Austromenopon sternophilum - Thompson 1948
  - Colpocephalum discrepans - Zimmerman 1948
  - Quadraceps separata - Thompson 1948; Zimmerman 1948

Columbiformes

Rock dove (pigeon) — Columba livia
- Protozoa
  - Haemoproteus columbae - Alicata 1947, 1964; Kartman 1949; Navvab Gojrati 1970; Yeager and Gleiser 1946; van Riper[2]
  - Plasmodium sp. (probably P. relictum) - Navvab Gojrati 1970
  - Plasmodium relictum - van Riper[2]
  - Trichomonas gallinae - Yeager and Gleiser 1946
- Nematoda
  - Ascaridia sp. - Schwartz and Schwartz 1949
  - Dispharnyx nasuta - Alicata 1964
  - Ornithostrongylus quadriradiatus - Alicata 1939a
  - Tetrameres sp. - van Riper[2]
  - Oxyspirura mansoni - van Riper[2]
- Cestoda
  - Raillietina sp. - Yeager and Gleiser 1946
- Acari
  - Falculifer rostratus - Yeager and Gleiser 1946
  - Gabucinia sp. - Garrett and Haramoto 1967
  - Megninia columbae - Schwartz and Schwartz 1949
- Mallophaga
  - Columbicola columbae - Schwartz and Schwartz 1949; Yeager and Gleiser 1946; Zimmerman 1944, 1948
  - Colpocephalum turbinatum - Zimmerman 1948
  - Goniocotes bidentatus - Schwartz and Schwartz 1949
  - Menopon gallinae - Illingsworth 1928

Hippoboscidae
Ornithoica vicina - Maa 1966
Pseudolynchia canariensis - Bequaert 1941; Bryan 1934; Schwartz and Schwartz 1949, 1959; Yeager and Gleiser 1946

Spotted dove (Chinese, Lace-necked dove) Streptopelia chinensis
Nematoda
Ascaridia sp. - Schwartz and Schwartz 1949
Oxyspirura mansoni - Alicata 1947; Schwartz and Schwartz 1949, 1951; Smith and Guest 1974
Subulura brumpti - Schwartz and Schwartz 1951
Acari
Pterolichus sp. - Alicata, Kartman, and Fisher 1948
Mallophaga
Columbicola sp. - Schwartz and Schwartz 1949
Columbicola columbae - Zimmerman 1948
Goniocotes chinensis - Schwartz and Schwartz 1949; Zimmerman 1948
Goniodes sp. (larvae) - Schwartz and Schwartz 1949
Goniodes lativentris - Zimmerman 1948 ("Dove" = probably this bird)
Myrsidea invadens - Zimmerman 1948 ("Dove" = probably this bird)

Zebra dove (Barred dove) Geopelia striata
Protozoa
Trichomonas gallinae - Kocan and Banko 1974
Nematoda
Dispharnyx sp. - van Riper[2]
Oxyspirura mansoni - Smith and Guest 1974
Acari
Mesonyssus geopeliae - Wilson 1966
Ornithonyssus bursa - Alicata, Kartman, and Fisher 1948
Mallophaga
Columbicola sp. - Schwartz and Schwartz 1949
Columbicola columbae - Alicata, Kartman, and Fisher 1948; Zimmerman 1948
Goniodes sp. - Alicata, Kartman, and Fisher 1948
Goniocotes asterocephalus - Schwartz and Schwartz 1949
Goniocotes chinensis - Schwartz and Schwartz 1949; Zimmerman 1948
Menopon sp. (larvae) - Schwartz and Schwartz 1949

Strigiformes

Common barn owl — *Tyto alba*
- Hippoboscidae
  - *Ornithoica vicina* - Maa 1969a

Short-eared owl (Pueo, Hawaiian owl) — *Asio flammeus*
- Acari
  - Xolalgidae n.gen., n.sp. (body wash) - Goff 1980
- Mallophaga
  - *Colpocephalum brachysomum* - Zimmerman 1948
- Hippoboscidae
  - *Icosta nigra* - Bequaert 1941
  - *Ornithoica vicina* - Bequaert 1941; Maa 1966
- Fungi
  - *Aspergillus fumigatus* (captive) - Honolulu Zoo Necropsy Reports 1967

Passeriformes

Hawaiian crow ('Alala) — *Corvus hawaiiensis*
- Protozoa
  - *Plasmodium relictum* - Jenkins and van Riper, in prep.
- Acari
  - *Analges* sp. - M.L. Goff, pers. comm.
  - *Gabucinia delibatus* - M.L. Goff, pers. comm.
  - *Mesalgoides* sp. - M.L. Goff, pers. comm.
  - *Ornithonyssus bursa* (nest) - Garrett and Haramoto 1967; Tomich 1967
  - *Ornithonyssus sylviarum* - Banko 1974

Millerbird — *Acrocephalus familiaris*
- Acari
  - *Pterodectes* sp. - M.L. Goff, pers. comm.
  - *Pteroherpus oxyplax* - M.L. Goff, pers. comm.
  - *Trouessartia trouessarti* - M.L. Goff, pers. comm.
  - Xolalgidae n.gen., n.sp. - M.L. Goff, pers. comm.

'Elepaio — *Chasiempsis sandwichensis*
- Protozoa
  - *Isopora* sp. - van Riper[2]
  - *Plasmodium relictum* - van Riper et al., in press
- Acari
  - *Ornithonyssus sylviarum* (nest) - Goff 1980
- Viruses
  - Avian pox - van Riper[2]
- Bacteria
  - *Streptococcus* - van Riper[2]

White-rumped shama — Copsychus malabaricus

Acari

Bakercheyla chanayi - Radovsky 1971

Hawaiian thrush — Phaeornis obscurus

Protozoa

Isospora phaeornis - Levine, van Riper, and van Riper 1980

Plasmodium relictum - van Riper et al., in press

Acari

Analges sp. (body wash) - Goff 1980

Proctophyllodes sp. (body wash) - Goff 1980

Pterodectes sp. (body wash) - Goff 1980

Ptilonyssus sp. (body wash) - Goff 1980

Trouessartia sp. (body wash) - Goff 1980

Viruses

Avian pox - van Riper[2]

Fungi

Aspergillus fumigatus - van Riper[2]

Red-billed leiothrix — Leiothrix lutea

Protozoa

Plasmodium sp. (probably P. relictum) - Baldwin 1941

Plasmodium relictum - van Riper et al., in press

Plasmodium vaughani (probably P. relictum) - Fisher and Baldwin 1947

Acari

Cytodites nudas (body wash) - Goff 1980; M.L. Goff, pers. comm.

Neocheyletiella media (body wash) - Goff 1980

Ornithocheyletia leiothrix (body wash) - Goff 1980; M.L. Goff, pers. comm.

Pteronyssidae n.gen., n.sp. (body wash) - Goff 1980

Common myna — Acrodotheres tristis

Protozoa

Plasmodium relictum - van Riper[2]

Nematoda

Dispharnyx sp. - Smith and Guest 1974

Microtetrameres sp. - Alicata, Kartman, and Fisher 1948; Smith and Guest 1974

Oxyspirura mansoni - Alicata 1947, 1964; Eddinger 1967; Swanson 1939

Acanthocephala

Mediorhynchus sp. (Probably M. orientalis) - Smith and Guest 1974

Acari

Montesauria sp. - Alicata, Kartman, and Fisher 1948

Ornithonyssus bursa - Berger 1981; Zimmerman 1944

Pteronyssus sp. - Alicata, Kartman, and Fisher 1948
Trouessartia sp. - Alicata, Kartman, and Fisher 1948

Mallophaga
Menacanthus spinosus - Alicata, Kartman, and Fisher 1948
Myrsidea invadens - Alicata, Kartman, and Fisher 1948

Japanese white-eye — Zosterops japonicus

Protozoa
Isospora brayi - Levine, van Riper, and van Riper 1980
Plasmodium sp. (probably P. relictum) - Baldwin 1941
Plasmodium relictum - van Riper et al., in press

Nematoda
Microtetrameres sp. - Smith and Guest 1974
Procyrnea longialatus - Cid del Prado Vera, Maggenti, and van Riper, in press
Synhimantus zosteropsi - Cid del Prado Vera, Maggenti, and van Riper, in press

Acari
Anhemialges sp. (body wash) - Goff 1980
Calcealges yunkeri (body wash) - Goff 1980
Dermoglyphus elongatus - Alicata, Kartman, and Fisher 1948
Megninia sp. - Alicata, Kartman, and Fisher 1948
Mouchetia sp. (body wash) - Goff 1980
Pteronyssus sp. - Alicata, Kartman, and Fisher 1948
Ptilonyssus sp. (nasal cavity) - Smith and Guest 1974
Ornithocheyla sp. (body wash) - Goff 1980
Ornithonyssus sylviarum (nest) - Goff 1980
Strelkovarius sp. (body wash) - Goff 1980
Trouessartia sp. - Alicata, Kartman, and Fisher 1948; Goff 1980

Hippoboscidae
Ornithoica vicina - Hardy 1952

Viruses
Avian pox - van Riper[2]

Red-crested cardinal — Paroaria coronata

Nematoda
Dispharnyx sp. - Smith and Guest 1974
Oxyspirura mansoni - Berger 1981; Smith and Guest 1974
Syngamus trachea - Smith 1973b
Tetrameres sp. - Smith and Guest 1974

Acanthocephala
Mediorhynchus sp. (probably M. orientalis)
- Smith and Guest 1974
Acari
Ptilonyssus sp. (nasal cavity)
- Smith and Guest 1974
Mallophaga
Myrsidea incerta - Alicata, Kartman, and Fisher 1948

Northern cardinal — Cardinalis cardinalis
Protozoa
Isospora vanriperorum - Levine, van Riper, and van Riper 1980
Plasmodium relictum - van Riper et al., in press
Nematoda
Capillaria sp. - Smith and Guest 1974
Dispharnyx sp. - Smith and Guest 1974
Acanthocephala
Mediorhynchus sp. (probably M. orientalis)
- Smith and Guest 1974
Acari
Proctophyllodes longiphyllus - Garrett and Haramoto 1967
Viruses
Avian pox - van Riper[2]

House finch — Carpodacus mexicanus
Protozoa
Atoxoplasma sp. - van Riper[2]
Plasmodium relictum - van Riper et al., in press
Plasmodium sp. (probably P. relictum)
- Warner 1968
Nematoda
Syngamus trachea - Smith and Guest 1974
Acari
Ornithonyssus sylviarum (body wash)
- Goff 1980
Proctophyllodes pinnatus (body wash)
- Goff 1980
Proctophyllodes vegetans - Garrett and Haramoto 1967
Mallophaga
Colpocephalum discrepans - Zimmerman 1948
Philopterus subflavescens - Zimmerman 1948
Viruses
Avian pox - van Riper[2]
Bacteria
Escherichia coli (captive) - van Riper[2]

Laysan finch — Telespyza cantans
Acari

Schoengastia pobsa - Brennan and Amerson 1971; Goff 1984

Viruses

Avian pox (captive) - van Riper[2]

Bacteria

Staphylococcus epidermis (captive) - van Riper[2]

Streptococcus (captive) - van Riper[2]

Pseudomonas aeruginosa (captive) - van Riper[2]

Klebsiella pneumoniae (captive) - van Riper[2]

Serratia marcescens (captive) - van Riper[2]

Citrobacter diversus (captive) - van Riper[2]

Fungi

Candida albicans (captive) - van Riper[2]

Nihoa finch — Telespyza ultima

Acari

Analges sp. - M.L. Goff, pers. comm.

Boydaia agelaii - M.L. Goff, pers. comm.

Eutrombicula conantae - Goff 1984

Ingrassiella sp. - M.L. Goff, pers. comm.

Neoschoengastia ewingi - Goff 1984

Proctophyllodes sp. - M.L. Goff, pers. comm.

Toritrombicula nihoaensis - Goff 1984

Palila — Loxioides bailleui

Bacteria

Salmonella - van Riper[2]

Common 'amakihi — Hemignathus virens

Protozoa

Isospora loxopis - Levine, van Riper, and van Riper 1980

Plasmodium relictum - van Riper 1975; van Riper et al., in press

Nematoda

Viguiera hawaiiensis - Cid del Prado Vera, Maggenti, and van Riper, in press

Cestoda

Anonchotaenia brasilense - Vogue and Davis 1953; van Riper[2]

Trematoda

Urotocus rossittensis - van Riper[2]

Acari

Analges sp. - Goff 1980

Cheyletus malaccensis - Goff 1980; M.L. Goff, pers. comm.

Harpyrhynchus sp. - Goff 1980

Ornithonyssus sp. - Berger 1981

Ornithonyssus sylviarum (nest) - Goff 1980

Proctophyllodes sp. - Goff 1980

Pterodectes sp. - Goff 1980

Ptilonyssus sp. (nasal cavity) - Goff 1980

Rhinonyssus sp. (nasal cavity)
- van Riper 1975
Trouessartia sp. - Goff 1980
Mallophaga
Machaerilaemus hawaiiensis - Zimmerman 1948
Philopterus macgregori - Zimmerman 1948
Hippoboscidae
Ornithoica vicina - Bequaert 1941; Maa 1966
Viruses
Avian pox - van Riper[2]
Fungi
Aspergillus fumigatus (captive)
- Honolulu Zoo Necropsy Reports 1966

'Anianiau — Hemignathus parvus
Protozoa
Isopora sp. (captive) - van Riper 1975
Acari
Megnina sp. - Haramoto in Berger 1981

Kaua'i 'akialoa — Hemignathus procerus
Acanthocephala
Apororhynchus hemignathi - Perkins 1903
Cestoda
Drepanidotaenia hemignathi - Perkins 1903

'Akepa — Loxops coccineus
Viruses
Avian pox - Henshaw 1902

'I'iwi — Vestiaria coccinea
Protozoa
Plasmodium relictum - van Riper et al., in press
Nematoda
Viguiera hawaiiensis - Cid del Prado Vera, Maggenti, and van Riper, in press
Cestoda
Anonchotaenia brasilense - Vogue and Davis 1953; van Riper[2]
Acari
Analges sp. - Goff 1980
Cheyletus eruditus - Goff 1980; M.L. Goff, pers. comm.
Cheyletus sp. - Berger 1981
Ingressiella sp. - Goff 1980
Proctophyllodes sp. - Goff 1980
Mallophaga
Colpocephalum hilensis - Zimmerman 1948
Myrsidea cyrtostigma - Alicata 1969; Zimmerman 1948
Hippoboscidae
Ornithoica vicina - Bequaert 1941; Maa 1966
Viruses
Avian pox - van Riper[2]

Bacteria
Staphylococcus epidermis - van Riper[2]
Citrobacter fruendii - van Riper[2]

'Apapane — Himatione sanguinea
Protozoa
Plasmodium relictum - Navvab Gojrati 1970; van Riper et al., in press
Trichomonas gallinae - van Riper[2]
Nematoda
Procyrnea longialatus - Cid del Prado Vera, Maggenti, and van Riper, in press
Viguiera hawaiiensis - Cid del Prado Vera, Maggenti, and van Riper, in press
Cestoda
Anonchotaenia brasilense - Vogue and Davis 1953; van Riper[2]
Trematoda
Urotocus rossittensis - van Riper[2]
Acari
Analges sp. - Goff 1980
Androlaelaps sp. - Goff 1980
Anhemialges sp. - Goff 1980
Calcealges sp. - Goff 1980
Harpyrhynchus sp. - Goff 1980
Mouchetia sp. - Goff 1980
Proctophyllodes sp. - Goff 1980
Pterodectes sp. - Goff 1980
Ptilonyssus sp. (2 new species) (nasal cavity) - Goff 1980
Mallophaga
Myrsidea cyrtostigma - Zimmerman 1948
Viruses
Avian pox - van Riper[2]
Bacteria
Klebsiella pneumoniae - van Riper[2]
Escherichia coli - van Riper[2]
Pseudomonas pseudoalcaligens - van Riper[2]
Enterobacter cloacae - van Riper[2]
Fungi
Candida albicans (captive) - A. Miyahara, pers. comm.

House sparrow — Passer domesticus
Protozoa
Atoxoplasma sp. - van Riper et al., in press
Plasmodium relictum - van Riper et al., in press
Nematoda
Oxyspirura mansoni - Illingsworth 1931
Tetrameres sp. - Kartman 1951
Acari
Boydaia nigra - Fain and Goff 1980
Dermatophagoides evansi (body wash) - Goff 1980; M.L. Goff, pers. comm.

Haemolaelaps fenilis - Alicata, Kartman, and Fisher 1948
Harpyrhynchus pilirostris - Garrett and Haramoto 1967; Goff 1980
Neonyssus sp. - Alicata, Kartman, and Fisher 1948
Ornithonyssus bursa (nest) - Garrett and Haramoto 1967; Zimmerman 1944
Ornithonyssus sylviarum (nest) - Goff 1980
Proctophyllodes truncatus - Alicata, Kartman, and Fisher 1948
Ptilonyssus hirsti - Wilson 1964b; Goff 1980

Mallophaga
Bruelia vulgata - Zimmerman 1948
Myrsidea sp. - Alicata, Kartman, and Fisher 1948

Hippoboscidae
Ornithoica vicina - Alicata, Kartman, and Fisher 1948; Maa 1966

Viruses
Avian pox - van Riper[2]

Blue-capped cordonbleu — Uraeginthus cyanocephala

Nematoda
Capillaria sp. - Smith and Guest 1974

Acari
Sternostoma tracheacolum (respiratory tract) - Smith and Guest 1974; (internal organs) Smith 1973a

Lavender waxbill — Estrilda caerulescens

Nematoda
Tetrameres sp. - Smith and Guest 1974

Acari
Ptilonyssus sp. (nasal cavity) - Smith and Guest 1974

Orange-cheeked waxbill — Estrilda melpoda

Nematoda
Capillaria sp. - Smith and Guest 1974

Acari
Sternostoma tracheacolum (body cavity) - Smith and Guest 1974

Black-rumped waxbill (Red-eared) — Estrilda troglodytes

Acari
Sternostoma tracheacolum (internal organs) - Smith 1973a

Nutmeg mannikin (Ricebird) — Lonchura punctulata

Protozoa
Atoxoplasma sp. - van Riper et al., in press

Isospora ivensae - Levine, van Riper, and van Riper 1980
Plasmodium relictum - van Riper et al., in press
Trichomonas gallinae (captive) - Smith and Guest 1974

Acari
Haemolaeplaps fenilis (nest) - Garrett and Haramoto 1967
Onychalges sp. - Goff 1980
Paraneonyssus sp. (nasal cavity) - Goff 1980
Pterodectes sp. - Goff 1980
Ptilonyssus sp. (nasal cavity) - Goff 1980
Trouessartia sp. - Goff 1980

Mallophaga
Bruelia stenzona - Zimmerman 1948
Philopterus subflavescens - Zimmerman 1948

---

[1] Taxonomy of the avian species follows the A.O.U. Check-list of North American Birds 1983.

[2] Parasites and diseases found by the authors but not previously published.

LITERATURE CITED

Alicata, J.E. 1936. Poultry parasites. Hawaii Agric. Exp. Stn. Rep. 1936, 79-82.

Alicata, J.E. 1938a. Studies on poultry parasites. Hawaii Agric. Exp. Stn. Rep. 1937, 93-96.

Alicata, J.E. 1938b. The life history of the gizzard worm (Cheilospirura hamulosa) and its mode of transmission to chickens, with special reference to Hawaiian conditions. Livro Jubilar Prof. Travassos 3:11-19. Rio de Janeiro, Brazil.

Alicata, J.E. 1939a. Poultry parasites. Hawaii Agric. Exp. Stn. Rep. 1938, 79-82.

Alicata, J.E. 1939b. Preliminary note on the life history of Subulura brumpti, a common cecal nematode of poultry in Hawaii. J. Parasitol. 25: 179-180.

Alicata, J.E. 1940. The life cycle of Postharmostomum gallinum, the cecal fluke of poultry. J. Parasitol. 26:135-143.

Alicata, J.E. 1947. Parasites and parasitic diseases of domestic animals in the Hawaiian Islands. Pac. Sci. 1:69-84.

Alicata, J.E. 1962. Life cycle and developmental stages of Philophthalmus gralli in the intermediate and final hosts. J. Parasitol. 48:47-54.

Alicata, J.E. 1964. Parasitic infections of man and animals in Hawaii. Hawaii Agric. Exp. Stn. Tech. Bull. 61.

Alicata, J.E. 1969. Parasites of man and animals in Hawaii. Basel, Switzerland: S. Karger.

Alicata, J.E., and E. Chang. 1939. The life history of Hymenolepis exigua, a cestode of poultry in Hawaii. J. Parasitol. 25:121-127.

Alicata, J.E., and H.L. Ching. 1960. On the infection of birds and mammals with the cercaria and metacercaria of the eye-fluke, Philophthalmus. J. Parasitol. 46:16.

Alicata, J.E., L. Kartman, and H.I. Fisher. 1948. Wild birds as possible carriers of poultry parasites. Hawaii Agric. Exp. Stn. Rep. 1946-1948, 104-105.

Alicata, J.E., F.G. Holdaway, J.H. Quisenberry, and D.D. Jensen. 1946. Observations on the comparative efficacy of certain old and new insecticides in the control of lice and mites of chickens. Poultry Sci. 15:376-380.

Amadon, D. 1950. The Hawaiian honeycreepers (Aves, Drepaniidae). Am. Mus. Nat. Hist. Bull. 95: 151-262.

American Ornithologists' Union. 1983. Check-list of North American birds. Lawrence, Kansas: Allen Pr., Inc.

Amerson, A.B., Jr. 1966. Ornithodoros capensis (Acarina: Argasidae) infesting sooty tern (Sterna fuscata) nasal cavities. J. Parasitol. 52: 1220-1221.

Arnall, L., and I.F. Keymer. 1975. Bird diseases. Neptune City, New Jersey: T.F.H. Pub., Inc.

Ash, J.S. 1960. A study of the Mallophaga of birds with particular reference to their ecology. Ibis 102:93-110.

Avery, R.A. 1966. Helminth parasites of wildfowl from Slimbridge, Gloucestershire. I. Parasites of captive Anatidae. J. Helminthol. 40:269-280.

Baker, E.W., and G.H. Wharton. 1952. An introduction to acarology. New York: MacMillan Co.

Baker, J.R., G.F. Bennett, G.W. Clark, and M. Laird. 1972. Avian blood coccidians. Adv. Parasitol. 10:1-30.

Baldwin, P.H. 1941. Report to the Superintendent of Hawaii Volcanoes National Park, 2 August. Typescript.

Baldwin, P.H. 1948. Discovery of tapeworm parasites in three genera of Hawaiian honey suckers. Elepaio 9:29.

Banko, P.C. 1974. Report on alala (Corvus tropicus). Natl. Park Serv., Hawaii Volcanoes Natl. Park. Typescript.

Banko, P.C., and D.A. Manuwal. 1982. Life history, ecology, and management of nene (Branta sandvicensis) in Hawaii Volcanoes and Haleakala National Parks. Final Rep., Natl. Park Serv.

Contract CX-8000-8-0005. Seattle: Univ. Wash. Coop. Natl. Park Resour. Stud. Unit.

Banko, W.E. 1980. History of endemic Hawaiian birds. Univ. Hawaii Coop. Natl. Park Resour. Stud. Unit Tech. Rep. 026/10. Honolulu: Univ. Hawaii.

Bennett, G.F., E.C. Greiner, and W. Threlfall. 1976. Protozoans. In Wildlife Diseases, ed. L.A. Page, 25-33. New York: Plenum Pub. Co.

Bequaert, J.C. 1941. The Hippoboscidae of Oceania (Diptera). B.P. Bishop Mus. Occ. Pap. 16:247-292.

Berger, A.J. 1981. Hawaiian birdlife. 2nd ed. Honolulu: Univ. Pr. Hawaii.

Bice, C.M. 1932. Poultry diseases common in Hawaii. Hawaii Agric. Exp. Stn. Circ. 5.

Bohart, R.M., and R.K. Washino. 1978. Mosquitoes of California. Univ. Calif. Agric. Sci. Pub. Berkeley.

Box, E.D. 1970. Atoxoplasma associated with an isosporan oocyst in canaries. J. Protozool. 17: 391-396.

Box, E.D. 1971. Lankesterella (Atoxoplasma). In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 309-312. Ames, Iowa: Iowa State Univ. Pr.

Box, E.D. 1977. Life cycles of two Isospora species in the canary, Serinus canarius Linnaeus. J. Protozool. 24:57-67.

Boyd, R.J., and R.P. Hanson. 1958. Survival of Newcastle disease virus in nature. Avian Dis. 2:82-93.

Brennan, J.M. 1965. A small collection of chiggers (Acarina: Trombiculidae) from the North Central Pacific. J. Parasitol. 51:888-892.

Brennan, J.M., and J. R. Amerson, Jr. 1971. Six new species and additional records of chiggers from the central Pacific (Acarina: Trombiculidae). J. Parasitol. 57:1311-1317.

Brock, V.E., and P.L. Breese. 1953. Duck botulism at Kaelepulu Pond, Kailua, Oahu. Elepaio 13:80-81.

Bryan, E.H., Jr. 1934. A review of the Hawaiian Diptera, with descriptions of new species. Proc. Hawaii. Entomol. Soc. 8:399-468.

Buescher, E.L. 1956. Arthropod-borne encephalitis in Japan and South-east Asia. Am. J. Public Health 46:597-600.

Butler, G.D., Jr. 1961. Insects and other arthropods from Laysan Island. Proc. Hawaii. Entomol. Soc. 17:379-387.

Butler, G.D., Jr., and R.L. Usinger. 1963. Insects and other invertebrates from Laysan Island. Atoll Res. Bull. 98.

Cavill, J.P. 1982. Viral diseases. In Diseases of cage and aviary birds, ed. M.L. Petrak, 515-527. Philadelphia, Penn.: Lea and Febiger.

Ching, H.L. 1961. The development and morphological variation of Philophthalmus gralli Mathis and Leger, 1910, with a comparison of species of Philophthalmus Looss, 1899. Proc. Helminthol. Soc. Wash. 28:130-138.

Chu, G.W.T.C., and C.E. Cutress. 1954. Austrobilharzia variglandis (Miller and Northup, 1926) Penner, 1953, (Trematoda: Schistosomatidae) in Hawaii with notes of its biology. J. Parasitol. 40:515-523.

Cid del Prado Vera, I., A.R. Maggenti, and C. van Riper III. In press. New species of Spiruridae (Nemata: Spirurida) from endemic Hawaiian honeycreepers (Passeriformes: Drepanididae), the Japanese white-eye (Passeriformes: Zoosteropidae [sic]) and a new species of Acuariidae (Nemata: Spirurida) from the Japanaes white-eye collected on the island of Hawaii. Proc. Helminthol. Soc. Wash.

Coleman, P.H. 1978. Arbovirus infections. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 654-659. Ames, Iowa: Iowa State Univ. Pr.

Cook, R.S. 1971a. Haemoproteus Kruse 1890. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 300-308. Ames, Iowa: Iowa State Univ. Pr.

Cook, R.S. 1971b. Leucocytozoon Danilewsky 1980. In Infectious and parasitic diseases of wild birds,

ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 291-299. Ames, Iowa: Iowa State Univ. Pr.

Cram, E.B. 1927. Bird parasites of the nematode suborders Strongylata, Ascaridata, and Spirurata. U.S. Nat. Mus. Bull. 140.

Cram, E.B. 1931. Developmental stages of some nematodes of the Spiruroidea parasitic in poultry and game birds. U.S. Dep. Agric. Tech. Bull. 227.

Crosskey, R.W. In press. Geographical distribution. In Blackflies: the future for biological methods in integrated control, ed. M. Laird. London: Academic Pr.

Cuckler, A.C., and J.E. Alicata. 1944. The life history of Subulura brumpti, a cecal nematode of poultry in Hawaii. Trans. Am. Microscop. Soc. 63: 345-347.

Eddinger, C.R. 1967. A study of the breeding behavior of the mynah (Acridotheres tristis L.). Elepaio 28:1-5, 11-15.

Evans, G.O., J.G. Sheals, and D. MacFarlane. 1961. The terrestrial acari of the British Isles. London: Trustees Brit. Mus.

Fain, A., and A.B. Amerson, Jr. 1968. Two new heteromorphic deutonymphs (Hypopi) (Acarina: Hypoderidae) from the great frigatebird (Fregata minor). J. Med. Entomol. 5:320-324.

Fain, A., and M.L. Goff. 1980. Speleognathine mites (Acari: Ereynetidae) from birds in the Hawaiian Islands, with descriptions of a new species. J. Med. Entomol. 17:506-508.

Fisher, H.I., and P.H. Baldwin. 1947. Notes on the red-billed leiothrix in Hawaii. Pac. Sci. 1: 45-51.

Garnham, P.C.C. 1966. Malaria parasites and other Haemosporidia. Oxford: Blackwell Sci. Pub.

Garrett, L.E., and F.H. Haramoto. 1967. A catalog of Hawaiian Acarina. Proc. Hawaii. Entomol. Soc. 19: 381-414.

Goble, F.C., and H.L. Kutz. 1945. The genus Dispharynx (Nematoda: Acuariidae) in galliform and passeriform birds. J. Parasitol. 31:323-331.

Goff, M.L. 1971. New records of chiggers (Acarina, Trombiculidae) from the Northwestern Hawaiian Islands. J. Med. Entomol. 8:456.

Goff, M.L. 1977. A new species of Toritrombicula (Acarina: Trombiculidae) from the Pacific golden plover in the Hawaiian Islands. J. Med. Entomol. 13:735-737.

Goff, M.L. 1980. Mites (Chelicerata: Acari) parasitic on birds in Hawaii Volcanoes National Park. Univ. Hawaii Coop. Natl. Park Resour. Stud. Unit Tech. Rep. 29. Honolulu: Univ. Hawaii.

Goff, M.L. 1984. Three new species and new records of chiggers (Acari: Trombiculidae) from the Northwestern Hawaiian Islands. J. Med. Entomol. 21: 257-262.

Goff, M.L., and C. van Riper III. 1980. Distribution of mosquitoes (Diptera: Culicidae) on the East Flank of Mauna Loa Volcano, Hawaii. Pac. Insects 22:178-188.

Guberlet, J.E. 1926. Notes on the parasitic fauna of Hawaii. B.P. Bishop Mus. Spec. Pub. 11:29-30.

Guest, S.J. 1973. A reproductive biology and natural history of the Japanese white-eye (Zosterops japonica japonica) in urban Oahu. Univ. Hawaii Island Ecosys. Tech. Rep. 29.

Hammon, W. McD., G.E. Sather, and H.E. McClure. 1958. Serologic survey of Japanese B encephalitis virus infection in birds in Japan. Am. J. Hyg. 67:118-133.

Hanson, R.P. 1978. Newcastle disease. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 513-535. Ames, Iowa: Iowa State Univ. Pr.

Hardy, D.E. 1952. Additions and corrections to Bryan's check list of the Hawaiian Diptera. Proc. Hawaii. Entomol. Soc. 14:443-484.

Haugen, A.D. 1952. Trichomoniasis in Alabama mourning doves. J. Wildl. Manage. 16:149-164.

Henshaw, H.W. 1902. Birds of the Hawaiian Islands, being a complete list of the birds of the Hawaiian possessions, with notes on their habits. In Hawaiian almanac and annual for 1902, 54-106. Honolulu: Thos. G. Thrum.

Herman, C.M., and E.E. Wehr. 1954. The occurrence of gizzard worms in Canada geese. J. Wildl. Manage. 18:509-513.

Herman, C.M., H.A. Jankiewicz, and R.W. Saarni. 1942. Coccidiosis in California quail. Condor 44:168-171.

Hofstad, M.S., B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr. 1978. Diseases of poultry. Ames, Iowa: Iowa State Univ. Pr.

Howitt, B.F., H.R. Dodge, L.K. Bishop, and R.H. Gorrie. 1948. Virus of eastern equine encephalomyelitis isolated from chicken mites (Dermanyssus gallinae) and chicken lice (Eomenacanthus stramineus). Proc. Soc. Exp. Biol. Med. 68:622-625.

Hwang, J.C., N. Tolgay, W.T. Shalkop, and D.S. Jaquette. 1961. Case report--Dispharynx nasuta causing severe proventriculitis in pigeons. Avian Dis. 5:60-65.

Illingsworth, J.F. 1916. Notes on the hen flea ("Echidnophaga gallinacea" Westw.). Proc. Hawaii. Entomol. Soc. 3:252-254.

Illingsworth, J.F. 1928. Lice affecting poultry in Hawaii. Proc. Hawaii. Entomol. Soc. 7:41-42.

Illingsworth, J.F. 1931. Manson's eyeworm distributed by English sparrow. Proc. Hawaii. Entomol. Soc. 7:461.

Karstad, L. 1971. Arboviruses. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 17-21. Ames, Iowa: Iowa State Univ. Pr.

Kartman, L. 1949. Observations on the Haemoproteus of pigeons in Honolulu, Hawaii. Pac. Sci. 3:127-132.

Kartman, L. 1951. Notes on Tetrameres sp. (Nematoda, Spiruroidea) parasitic in the English sparrow in Hawaii. Pac. Sci. 5:252-255.

Kear, J., and A.J. Berger. 1980. The Hawaiian goose: an experiment in conservation. Vermillion, S. Dakota: Buteo Books.

Kemp, R.L., and W.T. Springer. 1978. Histomoniasis. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 832-840. Ames, Iowa: Iowa State Univ. Pr.

Keymer, I.F. 1982a. Mycoses. In Diseases of cage and aviary birds, ed. M.L. Petrak, 599-605. Philadelphia, Penn.: Lea and Febiger.

Keymer, I.F. 1982b. Parasitic diseases. In Diseases of cage and aviary birds, ed. M.L. Petrak, 535-598. Philadelphia, Penn.: Lea and Febiger.

Kingston, N. 1978. Trematodes. In Diseases of poultry, ed. S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 759-782. Ames, Iowa: Iowa State Univ. Pr.

Kissling, R.E., R.W. Chamberlain, R.K. Sikes, and M.E. Eidson. 1954. Studies on the North American arthropod-borne encephalitides. III. Eastern equine encephalitis in wild birds. Am. J. Hyg. 60:251-265.

Kocan, R.M., and W. Banko. 1974. Trichomoniasis in the Hawaiian barred dove. J. Wildl. Dis. 10:359-360.

Kocan, R.M., and C.M. Herman. 1971. Trichomoniasis. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 282-290. Ames, Iowa: Iowa State Univ. Pr.

Kohls, G.M., D.E. Sonenshine, and C.M. Clifford. 1965. The systematics of the subfamily Ornithodorinae (Acarina: Argasidae). II. Identification of the larvae of the Western Hemisphere and descriptions of three new species. Annals Entomol. Soc. Am. 58:331-364.

Krantz, G.W. 1978. A manual of acarology. Corvallis, Ore.: Oregon State Univ. Book Stores, Inc.

Kudo, R.S. 1966. Protozoology. Springfield, Ill.: C.C. Thomas, Pub.

Lainson, R. 1959. Atoxoplasma Garnham, 1950, as a synonym for Lankesterella Labbe, 1899. Its life cycle in the English sparrow (Passer domesticus domesticus, Linn.). J. Protozool. 6:360-371.

Lainson, R. 1960. The transmission of Lankesterella (= Atoxoplasma) in birds by the mite Dermanyssus gallinae. J. Protozool. 7:321-322.

Laird, M., and C. van Riper, III. 1981. Questionable reports of Plasmodium from birds in Hawaii, with the recognition of P. relictum ssp. capistranoae (Russell, 1932) as the avian malaria parasite

there. In Parasitological Topics, ed. E.V. Canning, 159-165. Soc. of Cap. Protozool. Spec. Pub. 1. Lawrence, Kans.: Allen Pr.

Levine, N.D. 1980. Nematode parasites of domestic animals and of man. Minneapolis, Minn.: Burgess Pub. Co.

Levine, N.D. 1982a. Isospora vanriperorum n.nom. for I. cardinalis Levine, Van Riper & Van Riper, 1980, Preoccupied. J. Protozool. 29:653.

Levine, N.D. 1982b. The genus Atoxoplasma (Protozoa, Apicomplexa). J. Parasitol. 68:719-723.

Levine, N.D., and S. Kantor. 1959. Check list of blood parasites of birds of the order Columbiformes. Wildl. Dis. 1:1-38.

Levine, N.D., S. van Riper, and C. van Riper, III. 1980. Five new species of Isospora from Hawaiian birds. J. Protozool. 27:258-259.

Lewin, V., and J.C. Holmes. 1971. Helminths from the exotic game birds of the Puuwaawaa Ranch, Hawaii. Pac. Sci. 25:372-381.

Lewin, V., and J.L. Mahrt. 1983. Parasites of Kalij pheasants (Lophura leucomelana) on the island of Hawaii. Pac. Sci. 37:81-83.

Locke, L.N., W.O. Wirtz, II, and E.E. Brown. 1965. Pox infection and a secondary cutaneous mycosis in a red-tailed tropicbird (Phaethon rubricauda). Wildl. Dis. Assn. Bull. 1:60-61.

Loomis, E.C. 1978. External parasites. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 667-704. Ames, Iowa: Iowa State Univ. Pr.

Maa, T.C. 1966. Studies in Hippoboscidae (Diptera). Part 1. Pac. Insects Monogr. 10:1-148.

Maa, T.C. 1967. Diptera: Hippoboscidae. Insects Micronesia 14:267-271.

Maa, T.C. 1968. Records of Hippoboscidae (Diptera) from the central Pacific. J. Med. Entomol. 5:325-328.

Maa, T.C. 1969a. A revised checklist and concise host index of Hippoboscidae (Diptera). Pac. Insects Monogr. 20:261-299.

Maa, T.C. 1969b. Synopses of the genera Ornithophila and Ornithoctona with remarks on their habitat diversification. Pac. Insects Monogr. 20:1-23.

McDonald, M.E. 1981. Key to trematodes reported in waterfowl. U.S. Fish Wildl. Serv. Resour. Pub. 142.

MacFie, J.W.S., and J.G. Thompson. 1929. A trypanosome of the canary (Serinus canarius Koch). Trans. Royal Soc. Trop. Med. Hyg. 23:5-6, 185-191.

Martin, W.E. 1958. The life histories of some Hawaiian heterophyid trematodes. J. Parasitol. 44:305-323.

Munro, G.C. 1969. Birds of Hawaii. Rutland, Vt.: C.E. Tuttle Co., Inc.

Navvab Gojrati, H.A. 1970. Epizootiological survey of avian malaria in the Hawaiian Islands. Ph.D. Diss. Honolulu: Univ. Hawaii.

Noble, E.R., and G.A. Noble. 1971. Parasitology. Philadelphia, Penn.: Lea and Febiger.

Okamoto [sic = Okimoto], B. 1975. Parasites of the Pacific golden plover and their use as biological markers. Elepaio 36:53-54.

O'meara, D.C., and J.F. Witter. 1971a. Aspergillosis. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 153-162. Ames, Iowa: Iowa State Univ. Pr.

O'meara, D.C., and J.F. Witter. 1971b. Candidiasis. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 163-169. Ames, Iowa: Iowa State Univ. Pr.

Palmer, S.F., and D.O. Trainer. 1971. Newcastle disease. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 3-16. Ames, Iowa: Iowa State Univ. Pr.

Pemberton, C.E. 1943. Insects and other arthropods of medical interest in Hawaii. Hawaii Med. J. 2:191-194.

Perkins, R.C.L. 1893. Notes on collecting in Kona, Hawaii. Ibis 1893:101-114.

Perkins, R.C.L. 1903. Vertebrata. In Fauna Hawaiiensis, ed. D. Sharp, Vol. 1, Part IV, 365-466. Cambridge, England: The Univ. Pr.

Quisenberry, W.B., and G.D. Wallace. 1959. Arthropod-borne virus encephalitis potentials in Hawaii. Hawaii Med. J. 19:29-31.

Radovsky, F.J. 1971. Notes and exhibitions: Bakericheyla chanayi. Proc. Hawaii. Entomol. Soc. 21:10.

Raper, K.B., D.I, Fennell, and P.K.C. Austwick. 1973. The genus Aspergillus. Huntington, New York: R.E. Krieger Pub. Co.

Reid, W.M. 1978a. Cestodes. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 737-758. Ames, Iowa: Iowa State Univ. Pr.

Reid, W.M. 1978b. Coccidiosis. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 784-815. Ames, Iowa: Iowa State Univ. Pr.

Rosen, M.N. 1971. Botulism. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 100-117. Ames, Iowa: Iowa State Univ. Pr.

Rothschild, M., and T. Clay. 1957. Fleas, flukes, and cuckoos. New York: MacMillan and Co.

Ruff, M.D. 1978. Nematodes and acanthocephalans. In Diseases of poultry, ed. M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H.W. Yoder, Jr., 705-736. Ames, Iowa: Iowa State Univ. Pr.

Schmidt, G.D. 1969. Acanthocephala as agents of disease in wild mammals. Wildl. Dis. 53:1-10.

Schmidt, G.D., and R.E. Kuntz. 1977. Revision of Mediorhynchus Van Cleave 1916 (Acanthocephala) with a key to species. J. Parasitol. 63:500-507.

Schwabe, C.W. 1950. Studies on Oxyspirura mansoni, the tropical eyeworm of poultry. III. Preliminary observations on eyeworm pathogenicity. Am. J. Vet. Res. 11:286-290.

Schwabe, C.W. 1951. Studies on Oxyspirura mansoni, the tropical eyeworm of poultry. II. Life history. Pac. Sci. 5:18-35.

Schwartz, C.W., and E.R. Schwartz. 1949. The game birds in Hawaii. Honolulu: Hawaii Board Comm. Agric. For., Terr. Hawaii.

Schwartz, C.W., and E.R. Schwartz. 1951. An ecological reconnaissance of the pheasants in Hawaii. Auk 68:281-314.

Schwartz, C.W., and E.R. Schwartz. 1953. Notes on the Hawaiian duck. Wilson Bull. 65:18-25.

Simons, T.R. 1983. Biology and conservation of the endangered Hawaiian dark-rumped petrel (Pterodroma phaeopygia sandwichensis). Univ. Wash. Coop. Natl. Park Resour. Stud. Unit Tech. Rep. 83-2. Seattle: Univ. Wash.

Smith, H.E. 1973a. A rhinonyssid mite in atypical loci of estrildine finches in Hawaii. J. Parasitol. 59:1148.

Smith, H.E. 1973b. Syngamus trachea: a first report in Hawaii. Elepaio 33:95-96.

Smith, H.E., and S.J. Guest. 1974. A survey of internal parasites of birds on the western slopes of Diamond Head, Oahu, Hawaii 1972-1973. Univ. Hawaii Island Ecosys. Tech. Rep. 37. Honolulu: Univ. Hawaii.

Sulkin, S.E., and E.N. Izumi. 1947. Isolation of western equine encephalomyelitis virus from tropical fowl mites, Liponyssus bursa (Berlese). Proc. Soc. Exp. Biol. Med. 66:249-250.

Swanson, L.E. 1939. A note on the parasitic fauna of the Hawaiian Islands. Proc. Helminthol. Soc. Wash. 6:29-30.

Takahashi, M., C.E. Yunker, C.M. Clifford, W. Nakano, N. Fujino, K. Tanifuji, and L.A. Thomas. 1982. Isolation and characterization on Midway Virus: a new tick-borne virus related to Nyamanini. J. Med. Virol. 10:181-193.

Tempelis, C.H., R.O. Hayes, A.D. Hess, and W.C. Reeves. 1970. Blood-feeding habits of four species of mosquito found in Hawaii. Am. J. Trop. Med. Hyg. 19:335-341.

Thompson, G.B. 1948. Mallophaga collected by the Tanager Expedition. B.P. Bishop Mus. Occ. Pap. 19: 195-200.

Throp, J.L. 1970. The Laysan finch bill in the Honolulu Zoo. Elepaio 31:31-34.

Todd, K.S., Jr., and D.M. Hammond. 1971. Coccidia of Anseriformes, Galliformes, and Passeriformes. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 234-281. Ames, Iowa: Iowa State Univ. Pr.

Tomich, P.Q. 1967. Arthropoda associated with a nest of the Hawaiian crow. Proc. Hawaii. Entomol. Soc. 19:431-432.

Turner, E.C., Jr. 1971. Fleas and lice. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 175-184. Ames, Iowa: Iowa State Univ. Pr.

T-W-Fiennes, R.N. 1982. Diseases of bacterial origin. In Diseases of cage and aviary birds, ed. M.L. Petrak, 497-515. Philadelphia, Penn.: Lea and Febiger.

U.S. Department of Agriculture and Southeastern Cooperative Wildlife Disease Study. 1980. APHIS/SCWDS Velogenic viscerotropic Newcastle disease surveillance Miami, Florida; Hawaii, Maui, and Kauai, Hawaii; San Diego, California; and Portland, Oregon (9/10/80-10/9/80). Spons. by Veterin. Serv. Anim. Plant Health Inspect. Serv., U.S. Dept. Agric., Washington, D.C. in collab. Southeast. Coop. Wildl. Disease Stud. Coll. Vet. Med., Univ. Georgia, Athens.

van Riper, C., III. 1975. Parasites of the Hawaii amakihi (Loxops virens virens). Univ. Hawaii Island Ecosys. Tech. Rep. 62. Honolulu: Univ. Hawaii.

van Riper, C., III. 1978. The breeding ecology of the amakihi (Loxops virens) and palila (Psittirostra bailleui) on Mauna Kea, Hawaii. Ph.D. Diss. Honolulu: Univ. Hawaii.

van Riper, C., III. 1980. Observations on the breeding of the palila (Psittirostra bailleui) of Hawaii. Ibis 122:462-475.

van Riper, C., III, and R.D. Barbee. 1978. Dark-rumped petrel at Hawaii Volcanoes National Park. Bird-Banding 49:372.

van Riper, C., III, S.G. van Riper, M.L. Goff, and M. Laird. In press. The epizootiology and ecological significance of malaria in Hawaiian landbirds. Ecology.

Vogue, M., and B.S. Davis. 1953. Studies on the cestode genus Anonchotaenia (Dilepididae, Paruterininae) and related forms. Univ. Calif. Pub. Zool. 59.

Wallace, G.D., D. Auai, A. Oda, R.E. Kissling, and W.B. Quisenberry. 1964. Arthropod-borne virus survey on the island of Oahu, Hawaii. Hawaii Med. J. 23: 364-386.

Wardle, R.A., J.A. McLeod, and S. Radinovsky. 1974. Advances in the zoology of tapeworms, 1950-1970. Minneapolis, Minn.: Univ. Minn. Pr.

Warner, R.E. 1968. The role of introduced diseases in the extinction of the endemic Hawaiian avifauna. Condor 70:101-120.

Washino, R.K., and C.H. Tempelis. 1983. Mosquito host bloodmeal identification: methodology and data analysis. Ann. Rev. Entomol. 28:179-201.

Wehr, E.E. 1971. Nematodes. In Infectious and parasitic diseases of wild birds, ed. J.W. Davis, R.C. Anderson, L. Karstad, and D.O. Trainer, 185-233. Ames, Iowa: Iowa State Univ. Pr.

Williams, I.C. 1960. The anatomy and some aspects of the biology of Urotocus rossittensis (Muhling, 1898) Looss, 1899 (Trematoda: Brachylaemidae) from the bursa Fabricii of the rock-pipit, Anthus spinoletta petrosus (Montagu). Ann. Mag. Nat. Hist. 13:65-86.

Wilson, N. 1964a. Ixodes laysanensis, a new species of tick from birds on Laysan Island (Metastigmata: Ixodidae). J. Med. Entomol. 1:165-168.

Wilson, N. 1964b. New records and descriptions of Rhinonyssidae, mostly from New Guinea (Acarina: Mesostigmata). Pac. Insects 6:357-388.

Wilson, N. 1966. New records and a new species of Mesonyssus (Mesostigmata: Rhinonyssidae) from pigeons and doves (Columbiformes: Columbidae). J. Parasitol. 52:1210-1213.

Yeager, R.H., and C.A. Gleiser. 1946. Trichomonas and Hemoproteus infections and the experimental use of DDT in the control of ectoparasites in a flock of

Signal Corps pigeons in the Territory of Hawaii. J. Am. Vet. Med. Assn. 109:204-207.

Zimmerman, E.C. 1944. A case of bovine auricular myiasis and some ectoparasites new to Hawaii. Proc. Hawaii. Entomol. Soc. 12:119-200.

Zimmerman, E.C. 1948. Insects of Hawaii. Vol. 1, Introduction. Honolulu: Univ. Hawaii Pr.

Zimmerman, E.C. 1948. Insects of Hawaii. Vol. 2, Apterigota to Thysanoptera. Honolulu: Univ. Hawaii Pr.