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An Overview of Infectious and Parasitic Diseases in Relation to the Conservation Biology of the Japanese Avifauna

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Abstract. An understanding of the infectious and parasitic avian disease organisms that are present in Japan and surrounding areas is an essential conservation tool. This paper provides an overview of infectious and parasitic avian disease organisms (e.g. viruses, bacteria, fungi, protozoa, helminths, arthropods), and outlines and discusses briefly potential strategies for risk reduction.

Key words: Avian disease, Infectious disease, Japanese wild birds.
キーワード: 鳥類の疾病, 感染症, 日本産野鳥.

Introduction

In our increasingly managed environment, where the maintenance of many ecosystems, habitats and species rests largely in human hands, disease control is now an important process in the active conservation of wild bird populations. Individual disease outbreaks are known to have killed many tens of thousands of a wide range of wild bird species. Generally, it is often technically easier to eliminate the cause of a non-infectious disease, such as lead poisoning, or pesticide contamination, than it is to eliminate an infectious agent. Theoretically, a toxin will eventually disappear from the environment over time if no more is added, whereas an infectious agent is capable of replicating itself and spreading without new additions (Wobeser 1994).

Most infectious agents, namely, parasitic and/or commensal viruses, bacteria, protozoa and helminths, are component parts of the ecosystems in which their wild avian hosts occur, they have co-evolved, and the infectious agents do not necessarily cause diseases in the hosts carrying them. Sometimes, however, tens of thousands of birds have become sick and in extreme cases have died, in various parts of the world, because of an outbreak of an epidemic disease. For example, duck plague, Newcastle disease, and avian cholera have killed wild waterfowl including ducks, geese, swans, and cormorants in North America (Friend & Franson 1999, Table 1). The causes of such outbreaks seem to be related to changing ecosystems, and to changes in avian behavior and/or physiology (Friend & Franson 1999), themselves considerably influenced by human activities.

Considerable environmental change has occurred in Japan over the last 150 years. With the increased availability of firearms following the Meiji Restoration (1860s) the populations of a wide range of species including cranes (*Grus* spp.), ducks (*Anas* and

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Table 1. Infectious diseases of wild birds in North America (from Friend & Franson 1999).

Viral Diseases	Parasitic Diseases
Duck Plague	Hemosporidiosis
Inclusion Body Disease of Cranes	Trichomoniasis
Avian Pox	Intestinal Coccidiosis
Eastern Equine Encephalomyelitis	Renal Coccidiosis
Newcastle Disease	Sarcocystis
Avian Influenza	Eustrongylidosis
Woodcock Reovirus	Tracheal Worms
Bacterial Diseases	Heartworm of Swans and Geese
Avian Cholera	Gizzard Worms
Anian Tuberculosis	Acanthocephaliasis
Salmonellosis	Nasal Leeches
Chlamydiosis	Biotoxins
Mycoplasmosis	Algal Toxins*
Fungal Diseases	Mycotoxins
Aspergillosis	Avian Botulism
Candidiasis	

*: These toxins are produced not only by cyanobacteria but also by some protozoa such as dinoflagellates.

Aythya spp.), geese (*Anser* and *Branta* spp.), and swans (*Cygnus* spp.) were dramatically depleted during the late 19th and early 20th centuries. Furthermore, considerable impact as a result of industrial development during the 20th century (particularly during the post 1945 rapid development phase) led to extensive environmental damage to marine, coastal, lowland, freshwater, and montane ecosystems, with extensive areas of the natural habitat being entirely destroyed (coastal and lowland wetlands have been particularly hard hit). As a consequence of this, avian habitats have been greatly altered and populations mostly reduced. Although waterfowl populations steadily increased during the latter part of the 20th century as persecution declined (Japanese Association for Wild Geese Protection 1994), continued habitat loss has led to the considerable concentration of certain populations. Not only are waterfowl populations greatly concentrated at a shrinking number of wetland sites, both during stop-overs on migration and during the main winter period, but they are also remaining at fewer sites for longer periods of time, thus greatly increasing the risk of, and facilitating, bird-to-bird spread of pathogens. Fortunately, so far, there have been no severe outbreaks of infectious diseases among waterfowl in Japan. Japan is, however, host to internationally famous concentrations of Hooded *Grus monachus* and White-naped *G. vipio* cranes in southwest Kyushu (both species considered vulnerable; Bird Life International 2000) and of Japanese Cranes *G. japonensis* in east Hokkaido (considered endangered; Bird Life International 2000), and of ducks, geese and swans in Kyushu, Honshu and Hokkaido, each of which is potentially at risk from the spread of infectious diseases.

Furthermore, Japan is an important transit country for a wide range of migratory species. Japan is situated on the East Asian Flyway, a migratory route connecting northeast Asia with southeast Asia, with important branches passing through the Japanese southwest Islands, Nansei Shoto, Kyushu, Honshu and Hokkaido into northeast Russia and also via Kyushu and the Korean Peninsula into eastern China. In addition to the waterfowl groups already mentioned, considerable numbers of migrant passerines, shorebirds and raptors pass through the Japanese islands (Brazil 1999). The fact that outbreaks of infectious diseases have not so far significantly impacted populations of birds in Japan must be seen as fortunate, but unlikely to continue as larger numbers of individuals are concentrated in fewer and fewer areas. An understanding of the infectious and parasitic avian disease organisms that are present in Japan, their ecology, transmission and symptoms is an essential conservation tool. Our aim in writing this paper is, therefore, to provide an overview of infectious and parasitic avian disease organisms, their recognition, their implications for avian populations in Japan, and potential strategies for risk reduction, in the hope of helping to prevent a severe epidemic event among bird concentrations in Japan.

The Changing Status of the Japanese Avifauna and Infectious Diseases

About 50 species of birds were added to the Japanese list during the latter half of the 20th century (Brazil 1991, Ornithological Society of Japan 2000), and in future years more species will no doubt be added to the list from Asia, the Pacific, and North America, due not only to increasing numbers of Japanese birdwatchers finding them, but also to environmental change in the east Asian region and to global climate change forcing or encouraging more species to wander or to shift their patterns of distribution.

The Japanese avifauna cannot be viewed in isolation. It is intricately interconnected with the avifaunas of other parts of Asia, the North Pacific region, and North America through regular migration of a wide range of species and the vagrancy of an unpredictable number of others. Despite the distances involved, indirect migratory links between bird populations in North America and East Asia bring the inherent risk that avian disease organisms already known among populations in North America may be transferred to East Asia including Japan. A wide range of infectious diseases has been reported among wild birds in North America (Friend & Franson 1999); bird populations in Japan are, by virtue of the potential for transmission between migrant birds, at risk from these and other disease organisms (see Table 1) making it essential that conservationists in Japan are aware of the risks involved.

Viral Diseases

DNA viral diseases: Viral diseases have not been recognized as major causes of illness and death of wild birds in Japan, however, there has been significant concern about such diseases in the USA since the 1970s because of severe outbreaks of Duck plague there (Friend & Franson 1999), although it is not deemed indigenous there. Duck plague, or duck viral enteritis, is caused by a herpes virus (Family Herpesviridae). It has been described as occurring among captive and free-ranging populations of various Anseriformes including dabbling ducks (*Anas, Aix, Cairina*), diving ducks (*Aythya, Bucephala*), sea ducks (*Somateria, Mergus*), geese (*Anser, Branta*), and swans (*Cygnus*) (Ritchie & Carter 1995). It is considered most likely that the duck plague virus was introduced to North America and Asia from Europe among imports of infected waterfowl (Ritchie & Carter 1995). So far, there have been no records of this disease in Japan, however, its occurrence both in the USA and China (Nuttall 1997) indicates that Japanese avian populations may also be at risk, thus monitoring for its presence should be instigated at wetland sites.

Although duck viral enteritis has not yet been recorded from Japan, there has been a case of another lethal herpes viral infection among wild birds in Japan, namely of Marek's disease virus (MDV) (Family Herpesviridae). In spring, prior to breeding in Russia, and in autumn, prior to wintering in Honshu, most of approximately 60,000 individual White-fronted Goose (*Anser albifrons*) spend several weeks feeding on the Ishikari River plain in west Hokkaido, near Bibai City, with the majority of them roosting each night at one particular swamp - Miyajima-numa (approximately 30 ha) (Brazil 1991, Hayashi 2001). From an ornithological and conservation perspective Miyajima-numa is a remarkably important site for the White-fronted Goose and for a wide range of other waterfowl species. It is also a highly significant site from an epidemiological viewpoint as a lethal case involving a tumor lesion caused by Marek's disease, in an adult female White-fronted Goose was diagnosed from Miyajima-numa in November 2001 (Zoo and Wildlife Medical Group of Rakuno Gakuen University *et al.* 2001). Marek's disease is caused by a highly contagious herpes virus with a worldwide distribution, and it is normally found amongst chickens (Shimizu *et al.* 2002), but lesions resembling those caused by MDV also have been reported in wild and/or captive owls, pheasants, partridge, ducks, geese, swans and a kestrel (Ritchie & Carter 1995, Yonemaru unpubl.). In Japan, MDV is most commonly found among domestic chickens especially among battery chickens (e.g. Zoo and Wildlife Medical Group of Rakuno Gakuen University *et al.* 2001). As MDV has been shown to be transmitted through direct and indirect contact with contaminated aerosols (Ritchie & Carter 1995), the extreme congestion of geese at communal sites such as Miyajima-numa places them at considerable risk. Hence, a preliminary epidemiological survey was made of 45 geese utilising Miyajima-numa during April 2002 (Asakawa *et al.* unpubl.). Molecular biological results, based on feather analyses will be published somewhere.

Since 1973, many captive cranes including Sandhill (*G. canadensis*), Hooded, Japanese, and Stanley (*Anthropoides paradisea*) in Austria, the United States, France, China, and the former Soviet Union have died due to infection by a herpes virus referred to as "inclusion body disease of cranes" (Ritchie & Carter 1995, Friend & Franson 1999). There have been cases of this infection from Japan too. According to Suzuki *et al.* (1997, 1998), one captive Stanley Crane and four captive Japanese Crane in Tama Zoo, Tokyo, died in 1992 because of this disease. In addition to the diseases resulting from infections of the herpes virus mentioned above, there are many other infectious diseases caused by other herpes viruses throughout the world (cf. Appendix 1), thus it is likely that others will occur in Japan in the future.

There have been three recent cases of other diseases caused by DNA viruses among captive birds in Japan. These involved the avian pox viral disease in Japanese Crane and Rosy-faced Lovebirds (*Agapornis roseicollis*), goose parvoviral disease in Muscovy Duck

(*Cairina moschata*), and circoviral disease in racing pigeons (*Columba livia*) (Morimoto *et al.* 1983, Tsai *et al.* 1997, Sato *et al.* 2000, Takehara 2000, Shimizu *et al.* 2002).

RNA viral diseases: Both Newcastle disease virus (NDV) (Family Paramyxoviridae) and Influenza A virus (also known as Fowl plague virus and Avian influenza virus) (Family Orthomyxoviridae) belong to a common phylogenetic group in the Mononegavirales order (Van Regenmortal *et al.* 2000). Both are severely infectious agents among birds (Ritchie & Carter 1995, Friend & Frason 1999, Shimizu *et al.* 2002). NDV is capable of infecting a wide range of avian species. In addition to domestic poultry, amongst which it is particularly virulent, more than 230 species of birds from more than half of the avian orders have been found to be susceptible to natural or experimental infections with NDV. Epornitic outbreaks of NDV appear to occur every 10 to 12 years. In a well-documented outbreak of NDV in the Great Lakes region of Canada and the United States during 1990 and 1992, total mortality attributed to the disease exceeded 20,000 wild birds including Double-crested Cormorants (*Phalacrocorax auritus*) (Friend & Frason 1999). NDV has been reported among both wild and captive birds in Japan, with documented outbreaks of Newcastle Disease among feral pigeons (*Columba livia*) and captive peacocks (*Polyplectron emphanum*) at Ueno Zoo, Tokyo (Nakagawa *et al.* 1967, Arias-Ibarrondo *et al.* 1978, Abenes *et al.* 1982, Shirai *et al.* 1986, Kawamura *et al.* 1987).

Although wild birds have been the focus of concern as a source for influenza infections in poultry and humans (Friend & Frason 1999, Shimizu *et al.* 2002), this infectious disease is not considered so significant from a wildlife conservation perspective because of the low rates of mortality typically involved. This assumption is based, however, on mortality being the only significant impact of a disease. There may indeed be additional factors involved rendering a nonfatal disease significant. Reduced health levels may: contribute negatively to incidental mortality (by facilitating easier predation), prevent effective migration, or even reduce the capacity to compete and breed. The influenza virus has been isolated from many species of water birds and shorebirds in Japan (Abenes *et al.* 1982), almost all of which are migratory.

Within the poultry industry, infectious bursal disease is also important (Shimizu *et al.* 2002). Serum samples collected from 739 free-living wild birds of 44 species of 32 genera from Honshu, Japan, were tested for antibodies to this disease virus. Serological evidence of infection was found in 2% of six resident species and 4.9% of 11 migratory species belonging to the genera *Anas, Columba, Corvus, Egretta, Falco, Gallinago, Larus, Ninox*, and *Scolopax* (Ogawa *et al.* 1998).

Bacterial Diseases

More than 11,000 Baikal Teal (*Anas formosa*; listed as vulnerable by Bird Life International 2000) died from avian cholera in South Korea in October 2000 (Lee 2001), a particularly critical loss as this vulnerable species has declined dramatically already since the 19th century (Brazil 1991) and the few remaining wetlands in South Korea currently provide its main wintering area. Avian cholera is an extremely contagious disease resulting from infection by the bacterium Pasteurella multocida (Shimizu *et al.* 2002). The proximity of the sites in South Korea, where the outbreak occurred, to Japan and the fact taht migratory bird more between these two countries indicates that there is the very real possibility of a future outbreak of avian cholera among waterfowl wintering in Japan, a number of which migrate by way of the Korean Peninsula. The wintering concentration of more than 10,000 White-naped and Hooded cranes at Arasaki, Kagoshima Prefecture in Kyushu may be at particular risk.

There have been various occurrences of several other bacterial diseases, and instances of isolation of such agents among wild birds in Japan, including small-scale outbreaks of botulism in Tokyo and in Saitama Prefecture (see Appendix 2, Kokubo *et al.* 1987, Sasaki & Sasaki 1990).

Certain cyanobacteria, such as the genera *Microcystis, Anabaena, Aphanizomenon, Nodularia*, and *Oscillatoria*, produce hepatotoxins and/or neurotoxins that are known to have affected a wide range of avian species including free-ranging ducks (*Anas* spp.), geese (*Anser* spp.), Eared Grebes (*Podiceps nigricollis*), gulls (*Larus* spp.), and various songbirds in the USA (Friend & Franson 1999). Although there have, as yet, been no reports of such problems in Japan, attention should be paid to such possibilities because of the common presence of such organisms in natural freshwater bodies (Hashimoto 1977).

Fungal Diseases

Several fungal genera, in particular *Candida, Cryptococcus, Aspergillus, Microsporum, Trichophyton, Fusarium, Ochroconis*, and *Absidia* have been reported as causing disease, including large-scale mortality events and/or mycotoxicosis, in a range of avian species from various parts of the world (Nuttall 1997, Friend & Frason 1999, Shimizu *et al.* 2002). As yet, however, despite some opportunistic infections such as in a captive Japanese Crane and penguins (Morimoto *et al.* 1983, Yonemaru unpubl.), there have been no severe outbreaks caused by fungal infection among wild bird populations in Japan, however, avian fungal agents have been examined for public health purposes (e.g. Sasaki *et al.* 1999).

Parasitic Protozoan Diseases

There are several genera of avian flagellates and amoeba (Phylum Sarcomastigophora), including *Trypanosoma, Hexamita, Histomonas, Parahistomonas, Monocercomonas, Trichomonas, Tetratrichomonas, Chilomastix, Entamoeba*, and *Endolimax* (Janovy 1997, Shimizu *et al.* 2002).

Among these, *Histomonas* and *Trichomonas* are serious pests of poultry or pet species and captive Rock Ptarmigan (*Lagopus mutus*) (Inoki 1981, Yamaguchi *et al.* 2002), but there have been no reported cases of outbreaks among wild birds in Japan. *Trypanosoma* spp. have, however, been found in wild and/or captive passerines (Passeriformes) and owls (Strigiformes) in Japan (Fukui *et al.* 2002, Hisada *et al.* unpubl.), but they seem to have been non-pathogenic.

It is important that we also pay attention to avian coccidia and haematozoa (Phylum Apicomplexa), such as *Eimeria, Isospora, Tyzzeria, Wenyonella, Caryospora, Cryptosporidium, Sarcocystis, Toxoplasma, Hepatozoon, Haemoproteus, Leucocytozoon, Plasmodium, Babesia*, and *Atoxoplasma* (Bennett *et al.* 1982, Janovy 1997, Forbes & Simpson 1997), because certain species can cause severe diseases. It is well known, for example, that the introduction of avian malaria *Plasmodium* spp. led to the decline and extinction of a number of bird species endemic to the Hawaian islands and of other island populations (Dobson & McCallum 1997). Avian malaria has also proven to be a lethal disease among captive penguins such as Magellanic (*Spheniscus magellanicus*), Jackass (*S. demersus*), and Rockhopper (*Eudyptes chrysocome*) penguins at Noichi Zoological Park, Kochi Prefecture, Japan (Shimazu *et al.* 1994). Although the agents for avian malaria are commonly found among various genera of wild birds in Japan, such as among the night herons *Nycticorax*, bulbuls *Hypsipetes*, crows *Corvus* and so on, there seem to have been no outbreaks of the disease among wild birds in Japan so far (McClure *et al.* 1978, Murata 1990, 2002). Recently, however, *Leucocytozoon* sp. was found in wild Rock Ptarmigan in Toyama Prefecture (Hagiwara *et al.* 2002).

Among wild and/or captive cranes, cases of disseminated visceral coccidiosis, caused by *Eimeria reichenowi* and *E. gruis*, and fatal coccidiosis, caused by *Hepatozoon*-like organisms, have been reported at Arasaki in Kagoshima Prefecture, Kyushu, the wintering place of more than 10,000 wild White-naped and Hooded cranes (Murata *et al.* 1996, Inamoto *et al.* 1998). Control of the visceral coccidian species is more difficult than that of intestinal coccidian species, since the levels of anticoccidial drugs given orally may be reduced prior to reaching the site of infection such as the liver, muscles, spleen, and lungs, as a result of poor absorption into those particular tissues and because of detoxification by the host (Carpenter *et al.* 1979).

Within the arenas of both public health and captive animal health, toxoplasmosis among poultry is also very important. Serological evidence of infection has been found so far among five wild bird species in Honshu, namely the feral pigeon, the Black-crowned Night-heron *N. nycticorax*, the Striated Heron *Butorides striatus*, the Carrion Crow *Corvus corone*, and the Thick-billed Crow *C. macrorhynchos* (Murata 1998).

The protozoan *Sarcocystis*, most commonly found among waterfowl in the United States, is nonfatal, but severe infections can cause loss of muscle tissue and result in lameness, weakness, and even, in rare cases, paralysis (Friend & Franson 1999, see Table 1). Because the debilitating effects of severe protozoan infections among birds could increase their susceptibility to predation and/or to other causes of mortality, it is important that we should know about the natural distribution of the final hosts of *Sarcocystis* in order to be able to take practical measures for the conservation of avian species. Although there have been no records of protozoa among wild birds in Japan, Murata (1986) reported a case of fatal Sarcocystis infection in a Lesser Flamingo (*Phoenicopterus minor*) in captivity.

Certain free living protozoa such as diatoms (Phylum Bacillariophyta: genera *Nitzschia* and *Pseudonitzschia*) and dinoflagellates (Phylum Dinoflagellata: genera *Alexandrium* and *Gymnodinium*) produce neurotoxins such as domoic acid, saxitoxin, and brevetoxin, that can affect seabirds. Most reports of mortality in birds have been die-offs occurring in conjunction with protozoan blooms in the USA (Friend & Franson 1999). Although no such mortalities have been reported yet in Japan, many protozoan blooms occur around Japan making it essential that we pay attention to such events because of their potential for causing mortality.

Parasitic Helminth Diseases

Uchida *et al.* (1991), in their review of avian parasites, listed about 170 trematode, 110 cestode, 70 nematode, and 20 acanthocephalan species from Japanese birds, including domestic fowl and experimental hosts. According to Uchida *et al.* (1991) and Hasegawa and Asakawa (in press), 27 new cestodes were described, and five new trematode species were also added during the period from 1960 to 1990, however, no new nematode or acanthocephalans were added during that period. Following Uchida *et al.*'s (1991) review, 11 new cestodes have been added (Hasegawa & Asakawa in press). It seems probable that most of these helminths are common among Chinese, Far East Russian or Southeast Asian birds because in most cases their bird hosts are migratory. Moreover, many of the helminths recorded among the birds resident in Japan may also be shared by Eurasian species because allied hosts occur on the Eurasian continent as non-pathogenic commensal organisms inside the bodies of wild birds. The presence of such helminths in an avian species can provide us with important ecological information pertaining to the species' foraging or dietary habits, or its migration route, acting as a biological tag (Asakawa *et al.* 1991, Hasegawa & Asakawa in press).

During the 1990s, several cases of helminthiasis, including fatal cases, were reported among wild waterfowl in Japan, including, for example, a young male Little Grebe (*Tachybaptus ruficollis*), which died in Hyogo Prefecture of a severe nematode infection with *Eustrongylides tubifex* (Family Dioctphymatidae) (Murata *et al.* 1997, Asakawa *et al.* 1997). Numerous nematodes were found in the lumen of the proventriculus, attaching to the mucosa, and some were penetrating into the muscle layer causing a severe inflammatory reaction. The nematode genus *Eustrongylides* is commonly found among piscivorous birds such as herons (*Ardea* spp.), egrets (*Egretta* spp.) and various ducks (*Mergus* spp. etc), because fish play a role as paratenic hosts of this nematode. It is well-known that eustrongylidosis is one of the factors contributing to the mortality of such piscivorous birds (Friend & Franson 1999, Table 1). Recently, fourth-stage larvae of the genus *Eustrongylides* were found among freshwater fishes of the genera Rhinogobius and Channa in artificial ponds in Tokyo (Shimazu *et al.* 2000), thus we must pay careful attention to the deaths of any piscivorous birds.

The spirurid genera *Oxyspirura* and *Thelazia* parasitize the eye (conjunctivae, nictitating membrane and lacrimal duct) and can cause conjunctivitis. Recently one such nematode species, *Thelazia* (*Thelaziella*) *aquillina* was obtained from a captive Oriental White Stork (*Ciconia boyciana*) and endangered species restricted to east Asia in the Japanese Stork Centre (Murata & Asakawa 1999, Asakawa *et al.* 2000, Bird Life International 2000). Since this bird-specific subgenus, *Thelaziella* is well-known as a pathogen causing conjunctivitis (cf. Murata & Asakawa 1999), a program aimed at preventing infection by the nematode at the Japanese Stork Centre should be established in order to protect these rare storks.

The spirurid genera also include gastrointestinal parasites such as *Acuaria, Cosmocephalus, Dispharynx, Synhimantus*, and *Tetrameres*, which can cause ulceration, hemorrhaging, and proliferative inflammatory nodular lesions on the mucosal surface of the gastrointestinal tract. Such nematodes have been found among various avian species, especially seabirds including the Black-tailed Gull (*Larus crassirostris*) and the Slaty-backed Gull (*L. schistisagus*) (Asakawa *et al.* 1999, Matsumoto & Asakawa 2001).

The genera *Trichostrongylus* and *Amidostomum* are among the most important strongylid nematode groups of the avian gastrointestinal tract. It is well known, for example, that *T. tenuis* can even serve to regulate the population of Red Grouse (*Lagopus lagopus*) in the United Kingdom causing reduced fecundity and survival among wild grouse (Hudson *et al.* 1992), however, the genus *Trichostrongylus* has not yet been recorded from among wild birds in Japan. In contrast, the genus *Amidostomum*, which can cause serious intestinal disorders in both domestic and wild waterfowl, has been obtained from wild species such as the Mallard (*Anas platyrhynchos*), Bewick's Swan (*Cygnus bewickii*), and Whooper Swan (*C. cygnus*) in Hokkaido, Japan (Nakamura & Asakawa 2001).

Furthermore, there have been two cases of trematodiasis among swans in Hokkaido; namely of the shistosomatid (probably *Trichobilharzia* sp.) from C. bewickii and the cyclocoelid *Hyptiasmus* sp. from *C. cygnus* (Asakawa *et al.* 1997, 2000). It was reported recently that larvae of one species of *Trichobilharzia* migrates to, and develops in, the central nervous system of both birds and mammals (Horak *et al.* 1999).

Bloodsucking leeches (Families Hirudinidae and Haemadipsidae) including the genera *Hirudo, Myxobdella, Macrobdella, Ornithobdella, Hirudobdella, Haemadipsa, Chtonobdella* and *Planobdella*, affect many aquatic bird species (Janovy 1997). Nevertheless, there have been no reports of disease caused by these 'nasal leeches' (Friend & Franson 1999, Table 1) in Japan despite the leeches being very widely distributed (Imajima 1997).

Parasitic Arthropod Diseases

Infestations of avian parasitic arthropods, namely ticks, mites, bugs, fleas, and flies (see Appendix 3) directly cause or increase the likelihood of anaemia, feather damage, nestling mortality, and nest desertion. Their indirect effects include the transmissal by some species of microbial, protozoan, or helminth infections. Unfortunately, there have been few studies or epidemiological surveys in relation to avian parasitic arthropods in Japan.

Conclusion

Successful disease outbreak prevention will need to be based not only on an understanding of avian ecology but also of pathogen ecology. In general, the various infectious agents described above may be divided into two broad categories, viz. endogenous and exogenous ones. Endogenous agents are either present in normal hosts without causing obvious disease, or they are ubiquitous in nature but only produce disease opportunistically, such as fungi or most helminths. Exogenous agents are not present in normal hosts, produce clearly defined disease when introduced, but do not persist in the natural environment; examples include Newcastle disease virus, avian influenza virus, and exotic parasites such as alien helminths (see Asakawa 2002). Exogenous agents typically cause severe outbreaks of disease.

A wide range of non-native avian species have been reported in Japan, many of these are originally derived from the pet bird trade and have escaped or been released. Some of these species have also been confirmed as breeding in Japan, and some are known to have carried disease (Brazil 1991, Eguchi & Amano 1999, Ornithological Society of Japan 2000). Indian Ring-necked Parakeets (*Psittacula krameri*) imported into Japan in 1998, for example, are known to have died of Newcastle disease (Sanada & Sanada 2001). If such infected pet birds were to escape in Japan they could become the source of a Newcastle disease epidemic among wild birds.

If it is necessary to prevent an infection of nematode parasites with indirect life cycles (see Anderson 2000), then removing animals that serve as intermediate and/or paratenic hosts by means of pesticide spread in the target area is one preventative method. Although it is very difficult to administer drugs to wild species, an alternative method of nematode eradication is to use anti-nematode drugs (e.g. Fenbendazole, Mebendazole, Thiabendazole, Levamisole, Ivermectin). These are periodically administered to birds in order to treat and prevent further infection. It is essential that we understand, however, that any program based on the widespread and repeated use of chemotherapy or biocides to attack living agents, or their vectors, is likely to stimulate the development of acquired resistance in the target organisms. Consequently, such methods rapidly lose their effectiveness and eventually defeat the very object of the control program. Instead, using minimal amounts of various chemicals and/or antibiotics alongside other forms of epidemic management, such as: inducing single large avian colonies, roosts, or gatherings to break into several smaller entities; immediate carcass removal from the site of an epidemic; exterminating suspiciously infectious birds with symptoms of the disease, are likely to be more effective than mass treatment with a single agent, in a long-term control program. Clearly, any disease control program requires precise ecological and behavioural knowledge of the target bird population (including its migration routes and the locations of its resting and breeding sites) and of the targeted infectious organisms.

In order for medical researchers to be able to prepare for future epidemic outbreaks amongst birds, they must perform epidemiological surveys of the probable agents mentioned above in wild bird populations both in Japan and its surrounding areas; international and inter-agency cooperation is, therefore, essential in disease prevention. Very careful attention should be paid to the possibility of infection by zoonotic agents during monitoring surveys.

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[ ] denotes English translations of Japanese titles.

日本産野鳥保護施策に関連する感染症と寄生虫病の概要

本総説では，まず緒論で感染症と非感染症の性質の違いについて述べ病原生物は人工的な中毒物質とは異なり，自然界で増殖することが可能なため，根本的な解決がより難しいことを指摘した。また，アヒルペスト，ニューカッスル病，鳥コレラなどが北米で発生し，非常に多数の野生のガン・カモ類やハクチョウ，ウを死滅させたが，その遠因として環境の人為的改変であることも指摘した。日本の自然環境は，明治維新以降，著しい改変が進行しており，飛来する水鳥類や野鳥の個体数は急減したが，最近，増加傾向に転じている。しかし，同時に，日本の飛来地において多数個体の一極集中化，高密度化を引き起こしている。これは，感染症の発生という点からみると，非常に危険な状態にある。東アジアを主分布域にしているガンカモ類

やツル類では，その個体群の大部分が日本で越冬する種も少なくないことから，種の保全活動において，日本での対策が希求される。よって，日本およびその周辺地域で報告されている，あるいは発生するであろう野生鳥類の感染症と寄生虫症の発生状況把握と病原体の生態などは保護活動において重要な知見である。そこでこの総説では，これまでに日本で発生した，あるいは将来，発生が懸念される鳥類の感染症あるいは寄生虫症について，病原生物（ウイルス，細菌，真菌，原虫，蠕虫および節足動物）別に分け，概要を述べることにした。

第2節では，日本産鳥類相の変化について概略を紹介した。ここ半世紀ほどで，約50種の鳥類が，新たな日本における分布種として追加されたが，今後，同様に東アジア，太平洋地域，北米などからの種の流入が予想される。また，地球温暖化現象やアジア地域における急激な経済活動活性化に伴う人為的な環境改変などが作用して，個々の種の地理的分布なども変化していくことも考えられる。このような鳥類相の変化は新たな病原生物の日本への侵入も引き起こすことも考えられるので，警戒が必要である。

第3節以降では，病原生物の分類群ごとに総説を展開した。まずウイルスは，DNA ウイルスと RNA ウイルスとに大別され，前者にはガンカモ類に病原性の高いヘルペスウイルス科のアヒルペストウイルスが知られる。日本では未報告であるが，北米，アジア，ヨーロッパなどのカモ類（家禽含む）からの感染が懸念される。このほかのヘルペスウイルス科としては，マレック病ウイルスやツル類の封入体病ウイルスなどが含まれ，いずれも日本での発生が知られる。特に，前者は養鶏業に多大な被害を与える感染症として知られるが，その感染により腫瘍を形成し死亡したマガンが2001年10月，北海道宮島沼で発見された。日本でもある種の病原体が野鳥から検出されることは稀ではないが，その死亡例が確認されることは少なく，貴重な症例となった。RNA ウイルスでは，ニューカッスル病ウイルスとインフルエンザ A ウイルス（鳥ペストウイルス）が重要である。特に前者により北米では，1990年代，数万のオーダーの水鳥類が死滅した。日本では，野鳥の大規模な死亡例はないが，動物園飼育種や野外のドバトなどで散見されている。この他のウイルスについては，Appendix 1 に分類群ごとに列挙した。なお，最近，北米を中心に問題となっている西ナイルウイルス（Flaviviridae: Appendix 1 の「RNA virus (3) ssRNA＋ virus 参照」）の我が国における疫学調査は，空港における蚊の調査を厚生労働省が，またカラスなどの鳥類の調査を国立感染症研究所や東京都が主体となり実施中である。

細菌性疾患としては，まず，2000年10月に韓国で発生した鳥コレラ（あるいは家禽コレラ）によるトモエガモ11,000羽以上の死亡例が注目される。この種は絶滅が危惧される種の一つであり，今後の個体数の回復が懸念されるが，日本との地理的近接性を考慮した場合，無視できない事例であった。ボツリヌス菌による中毒死亡例は，東京や埼玉などのカモ類で知られているものの，多くは野鳥が何らかの細菌の媒介者であることを前提に調査される例が多い (Appendix 2)。中には，人で問題となるオウム病クラミジアやサルモネラ菌などが不顕性感染しているので注意が必要である。最近，我が国で悪性水腫菌の一種 *Clostridium* 感染と考えられる急性出血性腸炎によるカラスの複数の死亡例が報告されている。真菌性疾患としては，アスペルギルス症が良く知られるが，ほかの属としては *Candida, Cryptococcus, Microsporum, Trichophyton, Fusarium, Ochroconis, Absidia* などが鳥類に疾患を起こすものとして報告されている。

原虫性疾患としては，鞭毛虫やアメーバのグループ（肉質鞭毛虫門）である *Trypanosoma, Hexamita, Histomonas, Parahistomonas, Monocercomonas, Trychomonas, Tetratrichomonas, Chilo-*

mastix, Entamoeba, Endolimax の各属が知られ，日本では（家禽・ペットを除けば）飼育下のライチョウでヒストモナス症やトリコモナス症による死亡例が知られる。*Trypanosoma* spp. は血液原虫の一グループで，日本でもスズメ目やフクロウ目の野鳥から報告されているが，病原性は低いと目されている。しかし，コクシジウム類やマラリヤ原虫のグループ（アピコンプレックス門），鳥類寄生性の属名として *Eimeria, Isospora, Tyzzeria, Wenyonella, Caryospora, Cryptosporidium, Sarcocystis, Toxoplasma, Hepatozoon, Haemoproteus, Leucocytozoon, Plasmodium, Babesia, Atoxoplasma* などは，病原性が高いので警戒すべきである。特に日本の野鳥でも報告されている *Plasmodium* や *Leucocytozoon*，あるいはツル類の播種性内臓型コクシジウムなどの分布や宿主域などは今後注意すべきであろう。

寄生蠕虫類（条虫類，吸虫類，線虫類，鉤頭虫など）については，特に獣医学や野生動物医学あるいは寄生虫分類学などの側面から，日本では既に優れた総説はある。一部では，地域の自然史としての寄生蠕虫相や寄生蠕虫を生物標識として用いた鳥類生態学などからの視点も試みられつつある。しかしながら，全般的に未調査の鳥類種が多いことも事実で，最近，我々が経験した症例だけでもカイツブリのエウストロンギリデス症，コウノトリの眼虫症，カモ類のアミドストマム症，コハクチョウの住血吸虫症などがある。しかし，鼻腔に寄生し重篤な蛭症を起こすことが知られるヒル類の調査はない（注：ただし私信によると，1985 年 4 月，北海道宮島沼で星子廉彰氏がヒル類の寄生したオオハクチョウを収容）。Hirudinidae 科や Haemadipsidae 科の種は日本でも普通に生息するので，今後は，こういったヒル類の水鳥類などにおける寄生状況の調査も必要となろう。その他，節足動物性の寄生生物については，Appendix 3 に列挙し，日本で記録されたものについては文献を明示した。

一般に病原体は endogenous 型と exogenous 型の二タイプに大別されることを，まず理解する。前者の病原生物は，宿主特異的な寄生蠕虫類のように臨床症状を示さないことが普通で，時に日和見的な感染症を惹起する程度である。一方，後者のものは重篤な症状を引き起こすことが多く，ニューカッスル病や鳥ペストなどが含まれる。最近では，ペット動物として日本に持ち込まれ，外来種化した鳥類から，「エイリアン・ヘルミンス（外来種化した寄生蠕虫類）」が在来鳥類へ寄生することにより生ずる蠕虫症も警戒されている。これも後者の例である。このような蠕虫症を防ぐためには，たとえば中間宿主の除去を行うなど，病原体の生態に準じた方法を取り入れる必要がある。特に，薬剤にだけ頼る方法は，野鳥では投与法が難しいこと，薬剤耐性株出現の可能性があることなどから，この点は十分に留意すべきである。いったん大規模な感染症が発生した場合，死体の早急な回収や焼却，感染の疑われる個体の収容と殺処分なども実行する必要がある。以上を勘案すると，効果的な感染症あるいは寄生虫症蔓延防止策としては，鳥類と病原体双方の生態に準じ，標的を絞った複合的な方策が望まれ，これまで行ってきたような単一薬剤の大量投与などは効果が薄いことを理解すべきであろう。また，予防という観点から，日本と周辺地域における感染症の情報収集と継続的な疫学調査は不可欠である。ただし，その場合，一部病原体はヒトにも感染して，ズーノシスを引き起こすこともある。したがって，調査にあたる研究者は，そのような危険性を防止する方策が必要である。

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Appendix 1. Virus families, subfamilies, and genera associated with disease in birds based on recent viral systematics (from Ritchie & Carter 1995, Nuttall 1997, Van Regenmortal *et al.* 2000).

DNA virus (1) ds DNA virus
- Poxviridae
  - Chordopoxvirinae
    - *Avipoxvirus*: Pigeonpox virus (abbreviated to v.), Juncopox v., Fowlpox v., Canarypox v. (=Kikuth's v.), etc.
- Herpesviridae
  - Alphaherpesvirinae
    - "Infectious laryngotracheitis-like viruses (abbreviated to vs.)": Gallid herpesv. 1
    - "Marek's disease-like vs.": Gallid herpesv. 2 (=Marek's disease v. 1), Gallid herpesv. 3 (=Marek's disease v. 2), Meleagrid herpesv.
    - undetermined genus: Psittacid herpesv. 1., probably, Falcon herpesv. (=Inclusion body disease of falcons), Owl herpesv., Pacheco's disease v., Inclusion body disease of cranes, Pigeon herpes encephalomyelitis v.
  - Gammaherpesvirinae
    - unclassified herpesv.: Anatid herpesv. 1 (=Duck plague v. or Duck enteritis v.), Columbid herpesv. 1 (=Pigeon herpesv.)
- Adenoviridae
  - *Aviadenov*.: Goose adenov., Fowl adenov. A–E, Pigeon adenov. (=Inclusion body hepatitis in pigeons), (Crane adenov.? cf. Morimoto *et al.* 1983)
  - unclassified adenov.: Egg drop syndrome v., Pheasant adenov. (=Marble spleen diease v.), Turkey hemorrhagic enteritis v. etc.
- Polyomaviridae
  - *Polyomav*.: Budgerigar fledgling polyomav.
- Papillomaviridae
  - *Papillomav*.: Chaffinch papillomav.

DNA virus (2) ss DNA virus
- Circoviridae
  - *Circov*.: Chicken anemia v., (Psittacine) Beak and feather disease v., Pigeon circov.
- Parvoviridae
  - Parvovirinae
    - *Parvov*.: Goose parvov. (=Derzsy's diease v., Goose hepatitis v., Goose influenza v., Goose plague v., Hepatonephritis-ascites v. etc.), Muscovy duck parvov., Chicken parvov.
    - *Dependov*.: Avian adeno-associated v.

Reverse transcription DNA/RNA virus
- Hepadnaviridae
  - *Avihepadnav*.: Duck hepatitis B v., Heron hepatitis B v.
- Retroviridae
  - *Alpharetrov*.: Avian leukosis v., Rous sarcoma v., Avian carcinoma Mill Hill v. 2, Avian myeloblastosis v. etc.
  - *Gammaretrov*.: Chick syncytial v., Reticuloendotheliosis v.

RNA virus (1) dsRNA virus
- Reoviridae
  - *Orthoreov*.: Avian orthoreov.
  - *Rotav*.: Avian rotavs. D and F (or Rotaviral enteritis, Viral arthritis)
- Birnaviridae
  - *Avibirnav*.: Infectious bursal disease v.

Appendix 1. (Continued)

RNA virus (2) ssRNA− virus
  Paramyxoviridae
    Paramyxovirinae
      Rubulav.: Newcastle disease v. (=Avian paramyxov 1), Avian paramyxov 2–9
    Pneumovirinae
      Metapneumv.: Turkey rhinotracheitis v., Swollen head syndrome in chickens
  Rhabdoviridae
      Lyssav.: Rabies v.
  Orthomyxoviridae
      Influenzav. A: Influenza A v. (=Fowl plague, Fowl pest or Avian influenza v.)
      Bunyaviridae: Soldado v.
RNA virus (3) ssRNA+ virus
  Picornaviridae
      Hepatov.: Avian encephalomyelitis-like v.
      unclassified picornav.: Avian entero-like v. 2–4, Avian nephritis v. 1–3, Duck hepatitis vs. 1 and 3, Turkey hepatitis v.
  Caliciviridae
      unclassified caliciv.: Fowl caliciv.
  Astroviridae
      Astrov.: Turkey astrov.
  Coronaviridae
      Coronav.: Infectious bronchitis v., Turkey coronav. (=Bluecomb in turkeys), Coronaviral enteritis v.
  Flaviviridae
      Flaviv.: (Tick-borne) Tick-borne encephalitis v., Louping ill v., Russian Spring Summer encephalitis v. etc.
        (Mosquito-borne) West Nile v., Israel turkey meningoencephalomyelitis v., Japanese encephalitis v.
  Togaviridae
      Alphav.: Eastern equine encephalitis v., Western equine encephalitis v., Fort Morgan v. etc.

Appendix 2. Bacterial families and genera associated with disease in birds (from Nuttall 1997).

Spirochaetaceae
Borrelia spp.: Avian borreliosis, septicaemia, Lyme spirochetes* (cf. Miyamoto *et al.* 2000)
Enterobacteriaceae
Escherichia coli: Septicaemia, enteritis, respiratory tract disease ect. (cf. Shimakura 1992, Yamaguchi *et al.* 2000)
Shigella spp.: Enteritis
Salmonella spp.: Salmonellosis (septicaemia, enteritis), avian typhoid (cf. Maeda *et al.* 2001, Yamaguchi *et al.* 2002)
Yersinia pseudotuberculosis: Pseudotuberculosis (tubercular infection etc.) (cf. Fukushima & Gomyoda 1991)
Vibrio spp.* (cf. Hayashitani *et al.* 2002)
Pasteurellaceae
Pasteurella multocida: Avian cholera (chronic respiratory disease etc.)
Haemophilus paragallinarum: Infectious coryza (respiratory disease)
Micrococcaceae
Staphylococcus spp.: Staphylococcosis (septicaemia, arthritis, bumblefoot)
Streptococcus
Streptococcus spp.: Septicaemia, arthritis
Clostridium
Clostridium botulinum: Botulism (poisoning) (cf. Kokubo *et al.* 1987, Sasaki & Sasaki 1990)
Clostridium spp.: Enteritis
Listeria
Listeria monocytogenes: Septicaemia, encephalitis, chronic wasting (cf. Yoshida *et al.* 2000)
Erysipelothrix
Erysipelothrix rhusiopathiae: Erysipelas (septicaemia)
Mycobacteriaceae
Mycobacterium avium: Avian tuberculosis (cf. Morita *et al.* 1997, 1999, Yonemaru unpubl.)
Chlamydiaceae
Chlamydia psittaci: Avian chlamydiosis (pneumonia, conjunctivitis, diarrhoea) (cf. Tsuji *et al.* 1997, Michikoshi *et al.* 2002)
Mycoplasmataceae
Mycoplasma spp.: Tracheitis, air sacculitis, arthritis etc.

*: Carrier state

Appendix 3. Parasitic arthropods from birds (from Turner 1971, Janovy 1997, Takada 2000, Nagahori 2001).

Class Arachnida, Subclass Acari (ticks and mites)
- Order Parasitiformes
  - Suborder Metastigmata (ticks, larvae, nymphs, adults)
    - Family Argasidae (soft ticks): *Argas, Ornithodoros* (*cf. Yamauchi 2001, National Institute of Infectious Diseases *et al.* unpubl.)
    - Ixodidae (hard ticks): *Amblyomma, Boophilus, Haemaphysalis, Ixodes* (cf. Miyamoto *et al.* 2000, Yamauchi 2001)
  - Suborder Mesostigmata
    - Family Rhinonyssidae (respiratory [nasal] mites): *Haemolaelaps, Rhinonyssus, Mesonyssus* etc. (Kaneko 1981)
    - Dermanyssidae (nest mite, nymph & adult): Dermanyssus (*cf. Uesugi *et al.* 1994)
    - Macronyssidae (ditto): Ornithonyssus (*cf. Miyamoto & Sakaino 1997)
    - Laelapidae (ditto)
- Order Acariformes
  - Suborder Prostigmata
    - Family Trombiculidae (chigger mite, larvae): *Trombicula, Leptotrombidium, Mackiena* etc.
    - Harpyrhynchidae (skin mites, under cuticle): *Harpyrhynchus*
    - Cheyletidae (skin mites, construct silken 'nests' on skin): *Cheyletus, Bakericheyla* etc.
    - Syringophilidae (quill mites): *Syringophilus*
    - Ereynetidae (nasal cavity): *Trispeleognathus, Neoboydaia* (Kaneko 1981)
    - Cloacaridae (lung): *Epimydodex*
  - Suborder Astigmata
    - Family Hypoderatidae (subcutaneous mites, nymphs): *Phalacrodectes, Hypodectes* (cf. Shichiri *et al.* 1981, Nakamura & Asakawa in press)
    - Laminosioptidae (subcutaneous and quill wall mites): *Laminosioptes*
    - Knemidocoptidae (skin [scaly leg/face and depluming] mites): *Knemidocoptes, Procnemidocoptes, Neocnemidokoptes* (cf. Nagahori 2001)
    - Cytoditidae (respiratory [air sac] mites): *Cytodites*
    - Turbinoptidae (respiratory [nasal] mites): *Turbinoptes, Rhinoptes* (Kaneko 1981)
    - Epidermoptidae (skin mites, embedded in and under skin or in feather bulbs): *Epidermoptes, Myialges, Microlichus*
    - Dermationidae (ditto):
    - Freyanidae (feather [outside] mites): *Freyana*
    - Analdidae (ditto): *Analges, Megninia, Bychovskiata* (cf. Mironov & Dabert 1997)
    - Pterolichidae (ditto): *Pterolichus, Ascetolichus, Aralichus*
    - Alloptidae (ditto): *Alloptes*
    - Proctophyllodidae (ditto): *Proctophyllodes, Trouessartia* and other Fams. Avenzoariidae, Trouessartiidae, Falculiferidae, Kramerellidae
    - Dermoglyphidae (quill mites, or feather [inside] mites): *Dermoglyphus, Falculifer* and other Fams. Apionacaridae, Gaudoglyphidae, Syringobiidae

*: Accidental parasitism to human from wild birds.

Appendix 3. (Continued)

Class Insecta
  Order Mallophaga (feather, biting, chewing lice)
    Suborder Amblycera
      Family Menoponidae: *Menacanthus, Menopon, Trinoton* etc. (cf. Kaneko 1965)
        Laemobothriidae: Laemobothrion (cf. Kaneko 1965)
        Ricinidae: *Ricinus* (cf. Kaneko 1965)
    Suborder Ischnocera
      Family Philopteridae: *Acidoproctus, Anaticola, Anatoecus, Columbicola, Craspedonirmus, Cuculoecus, Lagopoecus, Lipeurus, Strigiphilus, Sturnidoecus* etc. (cf. Kaneko 1965, Brooke *et al*. 1998, Tsurumi 2000)
        Heptapsogasteridae: *Heptapsogaster*
  Order Hemiptera (true bugs)
      Family Cimicidae: *Oeciacus, Cimex, Haematosiphon* etc.
  Order Siphonaptera (fleas)
      Family Pulicidae: *Pulex*
        Ceratophyllidae: *Orneacus, Ceratophyllus, Dasypsyllus* (cf. Sakaguti 1962) etc.
        Leptopsyllidae: *Leptopsylla, Frontopsylla, Callopsylla* (cf. Sakaguti 1962)
        Pulicidae: *Ornithopsylla, Acetenopsylla, Echidnophaga, Xenopsylla*
        Pygiopsyllidae: *Stivalius, Notiopsylla*
        Rhopalopsyllidae: *Listronius, Parapsyllus*
        Tungidae: *Hectopsylla*
  Order Diptera (flies)
      Family Calliphoridae (blowflies): *Trypocalliphora, Protocalliphora* (Iwasa & Hori 1990)
        Hippoboscidae (louse flies): *Ornithoica, Ornithomya, Crataerina, Ornithoctona, Ornithophila, Stenepteryx, Icosta, Pseudolynchia* (cf. Maa 1969, Mogi *et al*. 2002)
        Carnidae (milichiid flies): *Carnus* (*cf. Iwasa *et al*. 2000)
        Muscidae (botflies): *Philornis*
        Sarcophagidae (flesh flies): *Wohlfahrtia*
        Neottiophilidae (neottiophid flies): *Neottiophilum* and other Fams. Culicidae (mosquitoes), Simuliidae (blackflies), Ceratopogonidae (biting midges), and Tabanidae (horseflies and deerflies) (feeding on blood during ephemeral visits)
Class Crustacea
  Order Pentastomida (tongue worms)
      Family Reighardiidae: *Reighardia* (Ooi & Ohbayashi 1982, Nakamura & Asakawa In press)

*: Accidental parasitism to human from wild birds.