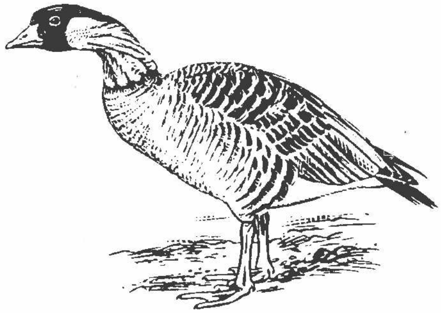
Parasites of wild and captive Nene *Branta sandvicensis* in Hawaii



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The risk of introducing disease or parasites into the wild has long concerned managers involved in the Nene recovery programme. In this initial survey helminth eggs were found in samples from 17 of 77 free-ranging Nene and eight of 28 captive Nene, giving an overall prevalence of 22%. Percent prevalence, estimated for each of the nine collection sites, was not correlated with bird density. No haemoparasites were detected on microscopic examination of the blood smears. A longer term study to determine the dynamics of the Nene-parasite relationship is needed to confirm the initial suggestion that the birds' recovery probably is not limited by heavy parasite infection.

Keywords: Nene, Hawaiian Goose, Parasites, Threatened Species

The Hawaiian Goose or Nene *Branta sandvicensis* is the only endemic goose surviving on the Hawaiian archipelago and, in 1951, there were just 30 Nene left in the wild (Smith 1952). An intensive international captive breeding and release programme has succeeded in reintroducing many Nene to the wild. Restocking began in 1960 and there are 500 Nene currently living in the wild on three of the larger Hawaiian islands (Black *et al.* 1991). The release programme has prolonged effectively the extinction process, but potent limiting factors in Hawaii are still active and inhibiting recovery (Black & Banko 1994, Black 1995). Managers and researchers concerned with the management of wild Nene have suggested that parasitic infections and/or other diseases may be factors responsible for the Nene's poor productivity (Kear & Berger 1980, Stone *et al.* 1983).

Disease has long been recognised as a potent selective factor in the evolution of all organisms (Loye & Zuk 1992). Hudson (1986) has shown that the nematode parasite *Trichostrongylus tenuis* can reduce the productivity of wild populations of Red Grouse *Lagopus scoticus*. Conservationists are also becoming increasingly concerned about the risk of disease in threatened populations, especially where captive animals are involved through reintroduction programmes (Scott *et al.* 1986, Seal 1991). Endemic Hawaiian avifauna evolved in the absence of many diseases common in continental areas and it is believed that a reduction in the effectiveness of immunogenic mechanisms has occurred (van Riper & van Riper 1985). Thus, when native birds encounter introduced pathogens they may be affected more severely than introduced birds. Malaria has played a significant role in reducing native Hawaiian birds' populations (van Riper *et al.* 1982, Warner 1986, Cooper 1989). Current studies on the impact of disease on Hawaiian avifauna on Big Island are finding that 75% of native passerines dying in National Parks are infected with both avian pox and malaria (C. Atkinson, pers. comm.).

The risk of infecting a susceptible wild population with a disease originating in captive stock is a serious concern. In 1987, an outbreak of gapeworm *Cyathostoma bronchialis* caused mortality in a Nene flock at the Hawaiian Breeding Centre (Gassman-Duvall 1987). It was considered that this parasite, previously unreported from the Hawaiian Islands, was introduced by migratory geese or via the introduction of Rio Grande Turkeys *Meleagridis gallopavo* near to the Centre (although there was no evidence in the literature that turkeys are infected by gapeworms). Introductions of native species bred elsewhere must be examined carefully and this applies especially to the Nene reintroduction programme because several potentially serious diseases, that have not yet been reported on the Hawaiian Islands, have been found in the captive Hawaiian Geese in England (van Riper & van Riper 1985, Kear & Berger 1980).

This project was one of 13 studies aimed at assessing the causes of the low productivity and survival of Hawaiian Geese that have been released into the wild (see Nene Recovery Initiative – Black 1990, Black *et al.* 1991, Black 1995). The initiative, launched in November 1990, is a collaborative project between The Wildfowl & Wetlands Trust, four organisations in Hawaii (Division of Forestry & Wildlife, National Park Service, National Biological Survey and US Fish & Wildlife Service) and the National Zoological Park, Smithsonian Institute.

Managers and scientists have suggested several, potential biological factors that may be limiting the growth of the Hawaiian Goose population (see Black 1995). The aim of this study was to begin to assess the distribution of parasites in free-living and captive Hawaiian Geese in Hawaii. This baseline information provides a foundation for future health monitoring and screening programmes for the Nene restoration programme.

Materials and methods

This study was carried out from 18 November to 7 December 1992 on the Hawaiian islands of Oahu, Maui and Hawaii. Wild birds (many of which were marked individually with colour leg bands) were sampled in a variety of habitats, notably release sites, supplementary feeding sites, areas with the largest flocks and at a variety of captive flocks in Hawaii. Galliforms occurred in all of the wild areas.

Faecal samples were collected from Nene in the field during the course of behavioural observations. When birds were observed defecating, the faecal samples were collected and, where possible, the bird's identity was recorded. Fresh faecal samples were collected from 113 different geese and preserved in 10% formal saline. They were examined for helminth eggs and coccidian oocysts using the standard methods of coverslip flotation and McMaster's technique (Bailey 1989). The coverslip flotation method detected those samples infected with helminth eggs and McMaster's technique was performed on all helminth positive samples to estimate the number of eggs per gramme of faeces.

Birds that were handled were given a clinical examination and checked for ectoparasites. Blood samples were collected in EDTA paediatric tubes from the brachial vein. Blood smears were prepared, stained and examined microscopically for blood parasites according to the method of Gulland & Hawkey (1990). Packed cell volumes (PCV) were measured using a field centrifuge (Ames, Microspin, Bayer Diagnostics).

Accounts of other diseases, including parasitic infections, were gathered from meetings with avian veterinarians who have examined wild and captive Nene over the years.

Results

Helminth eggs and/or cestode eggs were detected by coverslip flotation in 22% of the 113 samples (**Table 1**). Eggs were found in samples from 17 of 77 free-ranging Nene and eight of 28 captive Nene; the difference between samples was not significant statistically (χ^2=0.00, df=1, NS). Few eggs were found in infected samples by coverslip flotation and all coverslip flotation positive samples were McMaster's negative, which indicated that the birds were not burdened heavily with helminth parasites. Between one and 15 eggs were counted per faecal sample (mean=2.8, SD=3.4) and in most cases only one egg was found using the coverslip flotation technique; single eggs were found in 16 of the 27 positive samples where the egg number was quantified. Six nematodes were identified using parasite identification guides (Janssen Pharmaceuticals

Table 1. Frequency of Hawaiian Goose faecal samples that contained helminth eggs from various locations in Hawaii.

Site (birds in region)	Samples (bird density) *n (ha)*	Samples containing helminth eggs *n*	Prevalence %
Hawaii			
Kipuka Ainahou [b]	3	2	67
Pu'u 6677 [b]	2	0	0
Pu'u Lani Ranch	1	0	0
Keauhou [bc]	6	1	17
Ainapo Corral	6	1	17
Kaaua [bd]	6	3	50
Volcanoes National Park	27	5	19
'Ainahou Pens[a]	5	3	60
Kahuku Pens[a]	5	1	20
Maui			
Haleakala National Park	20	3	15
Haleakala Pens[ab]	2	0	0
Headquarters Area [d]	6	2	33
Olinda ESF[a]	15	2	13
Oahu			
Honolulu Zoo[a]	7	2	29
Waimea Falls[a]	2	0	0
Total	113	25	22

[a] = Nene housed in a captive situation.
[b] = collected near feeder where other birds visit
[c] = recent release from Olinda
[d] = not strictly a wild area

Note: Sites visited in Volcanoes Park included Kipuka Nene Campsite, 'Ainahou free-ranging birds, golf course, observatory nest, Keanakakoi Crater. Sites visited in Haleakala National Park included Kapalaoa cabin, Paliku cabin, Lau'ulu trail, Holua cabin.

Note: Three indices of bird density estimated as 1) number of droppings per $10m^2$, 2) number of birds found in collection areas at any one time and 3) flock size in the area: Kipuka Ainahou (3.5 droppings, 2 birds, 10 birds), Pu'u 6677 (1.5, 5, 15), Pu'u Lani Ranch (0.5, 2, 15), Keauhou (0.5, 4, 10), Ainapo Corral (2, 4, 15), Kaaua (3, 10, 30), Volcanoes National Park (0.4, 2.5, 130), Haleakala National Park (1, 3.3, 130), Headquarters Area (0.5, 0.8, 130).

Table 2. Packed cell volume (PCV) results, clinical examination findings and blood smear readings for haemoparasites from five Hawaiian Geese at the Kahuku Ranch pens.

Bird ID	PCV/%	Clinical examination	Haemoparasite result
VP	56	no abnormality detected	negative
VS	54	no abnormality detected	negative
JB	46	no abnormality detected	negative
ZX	58	no abnormality detected	negative
JA	48	no abnormality detected	negative

Diagnosing Helminthiasis): *Ascaridia* spp., *Heterakis* spp., *Amidostomum anseris, Trichostrongylus tenuis, Echinuria uncinata* and *Capillaria* spp. *Echinuria uncinata* which had not been identified previously on the Hawaiian Islands (van Riper & van Riper 1985). The presence of cestode eggs and coccidian oocysts was also recorded, but these were not counted or identified; coccidia were recorded in 18 of 113 faecal samples. All these species have a direct lifecycle, except *Echinuria uncinata* which infect an intermediate *Daphnia* spp. host (Davis *et al.* 1977). The single bird from which the *Echinuria uncinata* was found lived near the 'Ainahou Breeding Pens where a large, untreated water catchment is found. It is likely that *Daphnia* are found there.

Percent prevalence of nematodes, estimated for each of the nine collection sites in the wild, was not correlated with the indices of bird density (**Table 1**): number of droppings per $10m^2$ (Spearman Rank Correlation r_s=0.35, n=9, NS), number of birds found in collection areas at any one time (r_s=-0.17, n=9, NS) and total flock size in the area (r_s=-0.25, n=9, NS).

No physical or clinical abnormalities and no ectoparasites were observed in the five birds that were examined clinically. No haemoparasites were detected on microscopic examination of the blood smears (**Table 2**). Standard PCV values for clinically normal Nene are reported as 46%+/-2% (Fowler 1986). The average PCV for the five Nene was 52.4%+/-5.2%.

Discussion

The health of the 150 strong flock of captive Nene at The Wildfowl & Wetlands Trust Centres has been monitored closely since 1960 by M.J. Brown. Gizzard worm *Amidostoma* spp. was the most common parasite in a sample of 280 birds (Kear & Berger 1980) and Nene are considered to be more susceptible to gizzard worms than other species of waterfowl (M.J. Brown, unpublished data, Avery 1966). Fortunately, Nene in Hawaii do not seem affected adversely by these parasites. Nene at Slimbridge also succumb to avian tuberculosis which may reduce further their ability to resist parasite infection (Kear & Berger 1980). Work on Pheasants *Phasianus colchicus* has shown that, although wild and captive reared birds are often infected equally with parasites, the captive-reared birds are less able to cope perhaps due to their lower immunity (Woodburn 1992). Strategic anthelmintic treatment of Pheasants has been shown to have a dramatic effect on male mating success, particularly captive-reared birds (Hillgarth 1991). With regard to the Nene, we suggest that further studies are needed in order to assess the effect of parasites on their survival and reproduction before advising that drugs are

Table 3. Previous parasitic investigations. Dr R. Gassman-Duvall (unpublished health reports at Olinda ESF) has reported the following nematodes (and *coccidia*) on examination of various Nene between 1988-1991 (a=Nene housed in a captive situation).

Site	Parasites detected
Pohakuloa ESF[a]	*Amistostomum anseris* *Cyathostoma bronchialis* *Strongyloides* spp
Keauhou Sanctuary	*Heterakis* spp *Coccidia* spp
Paliku Corral	*Ascaridia* spp *Capillaria* spp *Coccidia* spp
Haleakala Park Headquarters Pens[a]	*Syngamus bronchialis* *Heterakis* spp *Ascaridia* spp *Giardia*spp *Coccidia* spp
Olinda Endangered Species Facility[a]	*Capillaria* spp *Ascaridia* spp *Giardia* spp *Cyathostoma bronchialis* *Lice & mites* (species not specified)

administered to wild birds (also see Robertson & Hillgarth in press).

Parasite burdens could be prevented by better pasture management, as Nene tend to congregate on small grass pastures (less than one hectare) in an attempt to obtain sufficient nutrient reserves for breeding (Black *et al.* 1994). Nene keep small areas of grass cropped to short heights in order to take advantage of the new tender shoots. Droppings tend to build up in these areas thus increasing the possibility that goslings will become infected soon after hatching. When the goose droppings disintegrate, parasite eggs can be transferred to the grass so that geese become infected during grazing (Bailey *et al.* 1990). One way to remedy this situation is to provide larger feeding areas so that the density of birds is reduced – a technique that will not only lessen parasite problems but also increase feeding opportunities. Another management technique that may limit parasite infection is to mow overgrown pastures on a regular basis in order to make more of the vegetation suitable for goose grazing (see Black *et al.* 1994).

It is possible that wild Nene become infected from other avian species. In particular, several species of galliform birds make use of the artificial feeders in the Nene Sanctuaries (Santos, pers. comm., Black, pers. obs.). At Olinda Endangered Species Facility, Pheasants that were found near the Nene pens were infected with *Capillaria* spp., *Heterakis* spp., *Coccidia* and gapeworm (Duvall, unpublished report).

No blood parasites were found in the five Nene sampled. The captive Nene at Honolulu Zoo were blood sampled recently and checked for blood parasites; all were negative (Okamoto, pers. comm.). During the study period there was an epizootic of pox and malaria in the native forest birds on Big Island and dead native birds were being recovered on trails in the forest. Seventy-five percent of these dead birds were found to have both pox and malaria (Atkinson, pers. comm.). Some workers are concerned that, if goslings are released into areas where blood parasites are present in the local avifauna, they may be more susceptible to infection; however, it is not known whether Nene are prone to blood parasites (Nakamura, pers. comm.). The University of Hawaii is working on a serological test for both avian malaria and avian pox (Atkinson, pers. comm.) and it may be possible to adapt this test for use on Nene in the future.

In July 1992, A.P. Marshall (pers. comm.) recorded ten Nene with pox-like lesions around the bill of the geese in Haleakala Crater. Banko (pers. comm.) also reported seeing pox in wild Nene on Big Island. On 1 December 1992, while in Haleakala Crater, we observed that five of eight Nene on the Lau'ulu trail had pox-like lesions around their beaks. These lesions may have been caused by the avian pox virus. Although there are no mosquitoes in the crater, flies or physical contact could be responsible for the spread of the disease. A pox-like condition was reported among Nene in England, and it was considered that the Nene was more susceptible to this disease than other species of waterfowl kept by The Wildfowl & Wetlands Trust (Kear & Brown 1976).

Although no evidence of heavy parasite infection was found in the geese sampled in this first survey, thus suggesting that endoparasites are not limiting the Nene recovery, longer term studies that determine the dynamics of Nene-parasite relationships are needed to validate these findings. Other diseases, such as avian pox, may also be important in the poor survivability and productivity of the Nene; we advocate that a thorough Nene health screening programme should be initiated. A protocol for further work may be found in the Nene Recovery Team Report Number 13 (Bailey & Black 1993).

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Products mentioned in the text

Ames Microspin Field Centrifuge, Bayer Diagnostics, Evans House, Hamilton Close, Houndmills, Basingstoke, Hampshire, UK.

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