Disease outbreak amongst South Island saddlebacks (*Philesturnus carunculatus carunculatus*) on Long Island

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ABSTRACT

In February 2007, a disease outbreak occurred in an isolated population of South Island saddleback (*Philesturnus carunculatus carunculatus*) on Long Island, Marlborough Sounds, New Zealand. Four individuals within the campsite area of the island exhibited pox-like lesions on the face and legs. In March 2007, blood, faecal and scab samples were taken from saddlebacks on both Long Island and neighbouring Motuara Island to determine the type and prevalence of disease(s) affecting the populations. Autopsies of dead birds revealed that avian malaria and avian pox were present in the Long Island population, but not in the Motuara Island population, suggesting that both diseases are currently confined to the Long Island saddleback population and that the outbreak is localised within that population. However, since these diseases can spread rapidly, there is a high potential for them to have a large impact on both of these saddleback populations, as well as other native species on the islands. Thus, it is recommended that birds on both islands continue to be monitored over the long term. Since both diseases are spread by the introduced mosquito *Culex quinquefasciatus* and the native mosquito *Culex pervigilans*, it is also recommended that mosquito populations be controlled by replacing the large artificial water reservoirs currently existing on the islands with water sources that cannot host mosquito larvae.

Keywords: avian malaria, *Plasmodium*, avian pox, saddleback, *Philesturnus carunculatus carunculatus*, disease outbreak

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1. Introduction

Historically, diseases of wildlife populations have only received attention when they have threatened agriculture or human health (Daszak et al. 2000), e.g. the transmission of salmonella from birds to humans (Kapperud & Rosef 1983; Alley et al. 2002) and tuberculosis from possums to domestic stock (Roberts 1996; Kao & Roberts 1999). Today, disease is recognised as a contributing factor to the extinction of some wild animal populations, the most well-known example being the widespread elimination of Hawaiian land birds following the introduction of avian malaria (*Plasmodium* sp.) and avian pox (Warner 1968; van Riper et al. 1986). Parasitic organisms are now considered one of the greatest threats to the survival of many endangered species (Altizer et al. 2001). Island populations in particular are expected to be more prone to disease outbreaks and extinction than mainland populations, largely owing to inherent low genetic diversity due to bottlenecks during their establishment and because simple ecosystems such as islands are more susceptible to invasion by new diseases (Frankham 1998; Altizer et al. 2001).

South Island saddlebacks, which were once widespread across New Zealand, rapidly declined in the nineteenth century with the introduction of mammalian predators, particularly rats. By 1964, only 36 South Island saddlebacks remained on Big South Cape, a remote island situated southwest of Stewart Island/Rakiura. Numerous translocations have now created 15 additional island populations of this subspecies, all descendents of this original remaining population. While the conservation status of South Island saddleback has been downgraded to Near Threatened internationally (IUCN 2007), the species is still considered Nationally Endangered in New Zealand (Hitchmough et al. 2007), and remains a conservation issue due to the fact that it currently only exists on a select few, mostly small, offshore islands around the South Island and has low genetic diversity and apparent vulnerability to disease (Hale 2007).

1.1 BACKGROUND—TRANSLOCATIONS AND DISEASE OUTBREAKS

1.1.1 Jacky Lee Island (Pukeokaoka) and North Island (Pikaumamakau-iti) to Motuara Island

In March 1994, 26 saddlebacks were translocated from Jacky Lee Island (Pukeokaoka) and North Island (Pikaumamakau-iti) to Motuara Island (59 ha) in the Marlborough Sounds of the South Island. By 2001, the population of saddlebacks on Motuara Island had reached over 100 birds; however, a survey of the population in March 2002 revealed that there had been a catastrophic decline to only approximately 50 birds. Examination of surviving individuals revealed that these birds were infested with hippoboscid flies (*Ornithomya* spp. and *Ornithoica* spp.) (Hale 2007); many individuals exhibited symptoms of illness and skin lesions, and autopsy of two birds revealed that they had suffered from acute systemic coccidiosis. However, because few dead birds were recovered, and no blood or faecal samples were taken prior to and during the disease outbreak, the exact causative agent of the decline remains inconclusive. Despite this decline in 2002, the population made a full recovery and by January 2005 had reached over 150 individuals.

1.1.2 Motuara Island to Long Island

In 2005, a proposal was made to transfer saddlebacks from Motuara Island to neighbouring Long Island (142 ha), to establish a second saddleback population in the Marlborough Sounds. A pre-translocation disease screen was carried out to assess the health of the Motuara Island birds and to minimise the transfer of disease. In August 2005, 45 saddlebacks were translocated from Motuara Island to Long Island, with all birds treated for coccidia and gastrointestinal parasites prior to release. The saddlebacks were also dusted for external parasites, particularly hippoboscid flies. However, the yellow-crowned parakeets (*Cyanoramphus novaezelandiae*) on Long Island are known to host the fly (P. Gaze, Department of Conservation, pers. comm.). Therefore, given the apparent susceptibility of the Motuara Island saddlebacks to heavy loads of hippoboscid flies, it was likely that they would pick up the flies again soon after being transferred to Long Island. This translocation was successful, with approximately 45 individuals being sighted in May 2006, of which 26 were original founders. By January 2007, the population was estimated to be around 60 individuals (W. Cash, Department of Conservation, pers. comm.). However, in February 2007, a routine survey of the population found individuals exhibiting pox-like lesions on the legs and face and other signs of ill health. Consequently, it was a vital time to establish what disease was present and to what extent it was affecting the Long Island saddleback population.

1.2 OBJECTIVES

The objectives of this study were to identify the disease agent(s) affecting the Long Island saddleback population and to address the following questions:

- How prevalent is the disease?
- What are the likely impacts for the saddleback?
- What are the likely impacts for other species on the island?
- Are there implications for birdlife on adjacent islands?
- What action is recommended to mitigate the effects?

2. Methods

Between 8 and 22 March 2007, a total of 12 saddleback from Long Island and 25 saddlebacks from Motuara Island were caught using 28-mm-mesh mist-nets; birds were lured into the nets using playbacks of local saddleback calls. Saddlebacks were caught from different locations around each of the islands in an attempt to gain a representative sample from both islands. Once captured, each bird was banded with one metal band (which had a unique identification number engraved on it), and a unique combination of colour bands for individual identification. The bird was then weighed with a 300-g Persola scale and a measurement of the tarsus was taken. Saddlebacks were sexed based on weight and tarsus length.

2.1 VISUAL HEALTH ANALYSIS

Overall body condition (any visible symptoms or signs of infection such as skin lesions) was assessed while the bird was in the hand. The number of hippoboscid flies seen on or flying off the bird was also counted. Any dead birds were sent to the Institute of Veterinary, Animal and Biomedical Sciences (IVAB) at Massey University (Palmerston North) for autopsy.

2.2 BLOOD AND BLOOD PARASITE ANALYSIS

A small blood sample (c. 200 μL) was taken from each bird via brachial venipuncture of the left wing. A sub-sample of this was used to make a blood smear, which was later stained and viewed under a light microscope to measure the estimated total leukocyte number (leukocyte count) and leukocyte differential (see Hale (2007) for full blood smear methodology). The remainder of the blood collected was preserved in lysis buffer and sent to Landcare Research for avian malaria screening.

2.3 FAECAL ANALYSIS

Faecal samples were collected from holding bags (the birds usually defecated while being held in cloth bags) and sent to IVAB at Massey University for screening for coccidia and gastrointestinal parasites, which included strongylid, nematodirus, trichuris and ascarid.

2.4 OTHER AVIAN SPECIES AND POPULATIONS

Other avian species on the island that were caught as bycatch were given a visual health screen, including a check of overall condition and for the presence of lesions or hippoboscid flies.

Due to the close proximity of Motuara Island to Long Island and the disease history of the saddlebacks from Motuara Island, the Motuara Island population was also sampled for avian malaria, avian pox, coccidia and gastrointestinal parasites.

3. Results

Four of the 12 saddlebacks captured on Long Island exhibited lesions on the legs and/or face (Fig. 1). All four resided within the camping area (within less than a c. 50 m radius of the camping area) on the eastern side of the island. One of the individuals (D182445, Table 1) appeared extremely lethargic and had large pox-like lesions on the head and legs. This individual, which later died, was sent to IVAB for autopsy and was diagnosed as being infected with acute avian malaria and avian pox. PCR analysis and blood smear analysis verified the avian malaria (*Plasmodium* sp.) infection and identified a further individual (D182441, Table 1) as being infected with the blood parasite. Thus, 2 of the 12 individuals sampled were found to host avian malaria. The four individuals with lesions all had elevated white blood cell counts and lymphocyte counts compared with healthy individuals. The eight other individuals caught on Long Island appeared healthy, with normal white blood cell counts and no lesions, and tested negative for avian malaria, although two had mosquito bites on the feet. All 12 individuals caught were heavily infested with hippoboscid flies (≥ 10 flies/individual). Only

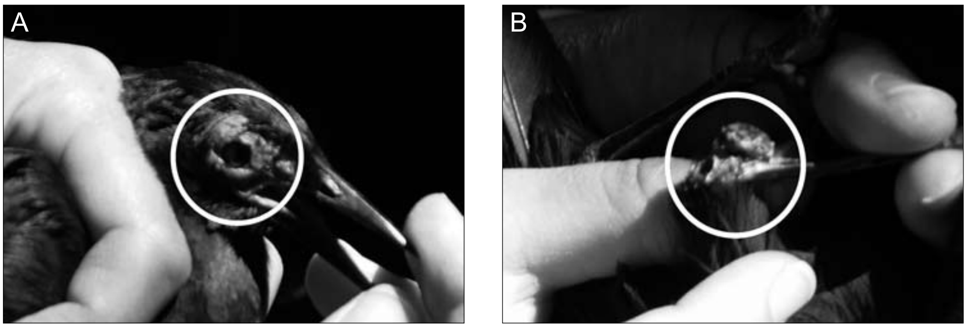

Figure 1. Pox lesions (circled) on A. the face of a juvenile saddleback (*Philesturnus carunculatus carunculatus*) and B. the 'elbow'. Photographs courtesy of Peter Hale.

TABLE 1. PARASITE ANALYSIS RESULTS FOR SADDLEBACKS (*Philesturnus carunculatus carunculatus*) SAMPLED ON LONG ISLAND BETWEEN 8 AND 11 MARCH 2007.

Birds were tested for malaria, coccidia and gastrointestinal (gastro) parasites: + or value = positive; – = negative.

ID	AGE	SEX	WEIGHT (g)	TARSUS LENGTH (mm)	MALARIA	COCCIDIA (OOCYSTS/g)	GASTRO PARASITES (EGGS/g)	COMMENTS
D182440	Juvenile	Male	79	43.00	–	–	–	Pox lesions present
D182441	Juvenile	Female	70	40.68	+	–	–	Pox lesions present
D182442	Juvenile	Male	79	44.98	–	–	–	Pox lesions present
D169197	Juvenile	Male	84	43.68	–	1 192 500	–	Bite on left middle toe
D182443	Juvenile	Female	74	41.73	–	–	–	
D182444	Adult	Female	83	37.25	–	–	72 (pinworm)	
D182434	Adult	Male	84	43.90	–	–	–	
D182445	Juvenile	Male	62	42.60	+	–	–	Anemic, pox lesions; died
D182446	Juvenile	Male	82	44.40	–	–	–	
D179705	Adult	Male	79	43.88	–	–	–	Original founder
D155018	Adult	Female	74	41.50	–	–	–	Original founder
D182420	Adult	Female	76	41.15	–	–	–	Small bite on left foot

one individual sampled was found to harbour coccidia (1 192 500 oocysts/g), and only one individual was diagnosed with pinworm (72/g) (Table 1). Other species caught on Long Island included robins (*Petroica australis*), bellbirds (*Anthornis melanura*) and yellow-crowned parakeets (*C. novaezelandiae*). All were free of lesions and appeared healthy, but harboured hippoboscid flies.

None of the saddlebacks caught on Motuara Island exhibited any visual signs of ill health and all tested negative for avian malaria. Of the 22 faecal samples obtained from saddlebacks on Motuara Island, 13 were found to have low to moderate levels of coccidia oocysts (3–158 570 oocysts/g; Table 2) and three had various gastrointestinal parasites present (Table 2).

TABLE 2. PARASITE ANALYSIS RESULTS FOR SADDLEBACKS (*Philesturnus carunculatus carunculatus*) SAMPLED ON MOTUARA ISLAND BETWEEN 19 AND 22 MARCH 2007.

Birds were tested for malaria, coccidia and gastrointestinal (gastro) parasites: value = positive; – = negative; N/A = no test.

ID	AGE	SEX	WEIGHT (g)	TARSUS LENGTH (mm)	MALARIA	COCCIDIA (OOCYSTS/g)	GASTRO PARASITES (EGGS/g)	COMMENTS
D182447	Juvenile	Male	89	44.05	–	3	–	
D182448	Juvenile	Female	75	41.35	–	2650	–	
D182449	Juvenile	Female	76	37.43	–	153 000	–	
D182450	Juvenile	Male	78	43.5	–	10 833	–	
D182451	Adult	Male	80	41.6	–	–	3 (ascarid)	
D182452	Adult	Male	80	40.5	–	–	–	
D182453	Adult	Male	82	42.35	–	–	–	
D182454	Adult	Female	74	39.55	–	–	12 600 (cysts/g)	Possibly amoebic cysts
D182455	Adult	Male	92	44.23	–	N/A	N/A	Faecal sample not obtained
D182456	Juvenile	Female	70	40.28	–	220	–	
D182457	Juvenile	Female	73	40.45	–	2308	–	
D182458	Juvenile	Male	81	43.5	–	12 330	–	
D182459	Juvenile	Male	82	43.85	–	96 136	–	
D182460	Adult	Female	76	41.45	–	8	–	
D182461	Adult	Male	88	42.7	–	–	–	
D182462	Juvenile	Female	70	41.6	–	–	69 (large 'eggs')	Possibly trematode egg
D182463	Adult	Male	82	43.45	–	N/A	N/A	Faecal sample not obtained
D182464	Juvenile	Female	70	40.65	–	–	–	
D182465	Juvenile	Female	76	40.58	–	1323	–	
D182466	Juvenile	Female	72	40.45	–	5000	–	
D182467	Juvenile	Female	69	41.2	–	158 570	–	
D179806	Adult	Male	80	44.35	–	N/A	N/A	Faecal sample not obtained
D182468	Adult	Female	76	40.75	–	22	–	
D182469	Adult	Male	90	43.45	–	–	–	
D182470	Juvenile	Female	70	41.15	–	–	–	

4. Discussion

Avian malaria (*Plasmodium* sp.) and avian pox were identified as affecting saddlebacks on Long Island. Both these diseases can potentially have serious detrimental effects on individual and population survival. However, at the time of sampling, both diseases appeared to be confined to one area of the island, with 4 saddlebacks in this area exhibiting the pox-like lesions and 2 out of 12 birds testing positive for avian malaria. The malaria was present as an acute infection in both birds in which it was detected, suggesting that this was not a background infection and thus is unlikely to have been succumbed to as a secondary infection due to initially being infected with avian pox. Furthermore, earlier malaria screening of the birds on Long Island in January 2007 yielded negative results, suggesting that the emergence of the disease on this island is quite recent (D. Tompkins, Landcare Research, pers. comm.). In contrast to the birds on Long Island, all saddlebacks from Motuara tested negative for avian malaria and avian pox, and the population appeared healthy. At this stage, the disease appears to be confined to the Long Island saddleback population.

Avian malaria has been present in New Zealand for several decades, following the introduction of the exotic mosquito *Culex quinquefasciatus*. However, it is only recently that it has been emerging at a higher prevalence (Massey et al. 2007). Massey et al. (2007) recently determined that the native mosquito *Culex pervigilans* now carries at least one species of the *Plasmodium* malarial parasite; it is thought to have picked up the malarial parasite from introduced birds, creating a potential transmission pathway between introduced and native birds. This poses a serious problem for the New Zealand native avifauna for two main reasons. First, since the native bird life in New Zealand has little prior history of exposure to *Plasmodium*, many populations, including the saddleback, are likely to be highly susceptible to the disease. Second, introduced species such as blackbirds (*Turdus merula*), which are known to be reservoirs of avian malaria (Tompkins & Gleeson 2006), may enable malaria to persist in endangered native populations even if that population declines below the density threshold necessary for the parasite to survive (Lyles & Dobson 1993). In this situation, there is a high risk that if the disease becomes prevalent in populations of introduced species, it will drive sympatric native populations to extinction. Indeed, it has been shown that most local extinctions and population crashes in endangered species elsewhere around the world follow this pattern (Cleaveland et al. 2002). Although it is not yet clear how native New Zealand species cope with malaria, there is a risk that malaria may impact on the native birdlife in a similar way as occurred in Hawaii, where over half the terrestrial native bird species became extinct following the introduction of avian malaria (Warner 1968; van Riper et al. 1986).

Both avian pox and avian malaria were restricted to one small area on the eastern side of Long Island at the time of sampling. The reason for this is unclear. The only notable difference observed between this area and the rest of the island is the presence of little blue penguins (*Eudyptula minor*) in this area. Penguins could potentially be a reservoir of both diseases and may have introduced both to Long Island, although no samples were taken from the penguins to confirm this suggestion. Nevertheless, it appears that malaria is a recent disease to emerge on Long Island and it is likely that at this stage only mosquitoes within this one area are carrying the parasites, possibly explaining why saddlebacks from other parts of the island were uninfected. Since the saddleback population on Long Island is at a relatively low density due to its recent introduction, the spread of avian pox and avian malaria from one individual to another may be quite low. However, saddlebacks are mobile birds and if individuals, particularly juveniles, disperse further around the island, then both the pox and *Plasmodium* parasite could be picked up by other previously pox- and parasite-free mosquitoes, which would then spread the diseases to other saddlebacks and potentially other avian species on the island.

It is uncertain whether these results indicate the beginning of a widespread outbreak or a localised outbreak in one species. Thus, ongoing monitoring of saddlebacks and other bird populations on both Motuara and Long Islands is recommended. Previous research on the Motuara Island saddleback population suggests that both saddleback populations may be particularly vulnerable to a new disease such as avian malaria, because both have been through several sequential bottlenecks (Hale 2007). There is growing evidence to suggest that populations that are inbred as a result of passing through severe bottlenecks exhibit lower levels of immunocompetence than those with comparatively higher levels of heterozygosity (Reid et al. 2003; Hawley et al. 2005; Hale 2007; Hale & Briskie 2007), and saddlebacks in both populations are showing signs of compromised immune systems (Hale 2007). The loss of genetic variation also means that populations are less adaptable to environmental change (Meagher et al. 2000; Keller & Waller 2002; Hedrick & Kalinowski 2003). Thus, the combination of inbreeding and environmental stress may prove to be highly detrimental.

A significant number of New Zealand's endangered bird species survive solely on offshore islands that are free of mammalian predators. The small size of most island populations of endangered birds, together with their high population density, low genetic diversity, and naivety to introduced parasites and pathogens, may render them vulnerable to disease outbreaks and extinction. Based on the previous disease outbreak on Motuara Island and the apparent susceptibility of saddlebacks to avian malaria, it is likely that if the disease emerged on the island, there could be a decline in the population and perhaps even localised extinction.

5. Recommendations

The author recommends that:

- The concrete water reservoirs on Long Island, which provide an ideal breeding ground for mosquitoes, should be emptied and filled in with soil to prevent refilling. These should then be replaced with other water sources that do not allow mosquitoes to breed.
- Since avian malaria appears to have only recently emerged on Long Island, the Long Island and Motuara Island saddleback populations and other bird

species on the islands (particularly little spotted kiwi, *Apteryx owenii*) should be closely monitored through regular malaria blood screens, to track the spread of malaria and determine the extent to which it is affecting the native birdlife.

- It would be beneficial to determine how avian malaria and avian pox arrived on Long Island. It is vital to know whether the blue penguin and other mobile species that frequent the islands are reservoirs for either or both diseases.

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