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PEREGRINE FALCON PREDATION OF ENDANGERED LAYSAN TEAL AND LAYSAN FINCHES ON REMOTE HAWAIIAN ATOLLS

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ABSTRACT

We report the first records of Peregrine falcon (*Falco peregrinus*) predation on endangered Laysan teal (or duck; *Anas laysanensis*) and predation on endangered Laysan finches (*Telespiza cantans*). At Midway Atoll, vagrant Peregrine falcons killed ≥4% of a newly translocated Laysan teal population in 2006 and ≥2% in 2008. On Laysan Island during 2008–2009, remains of >76 Laysan finches (<1% of the population) were found at peregrine perches. On Midway Atoll, all depredated Laysan teal and other seabirds were recovered at kill sites on tarmac (runways). If the frequency or duration of vagrant raptors visitation increases at small atolls, this could pose a mortality risk to consider, especially during proposed translocations of endangered species. Vegetation restoration of abandoned runways near wetlands at Midway Atoll would provide cover and may help reduce mortality of endangered species due to vagrant raptors.

INTRODUCTION

Fauna on remote oceanic islands are typically naive to novel predators, and endemic bird populations restricted to small islands are vulnerable to stochastic threats (Duncan and Forsyth 2006, Johnson and Stattersfield 2008, Reynolds *et al*. 2015). Infrequent visitation or occasional overwintering by vagrant raptorial predators is an uncommon source of mortality for species on remote islands with no resident birds of prey (i.e., Accipitriformes, Strigiformes, and Falconiformes). However, increases in visitation by migratory birds of prey, some populations of which are recovering after historical declines, may impact island endemic endangered birds.

Pacific Islands are unique ecosystems home to many endangered endemic plant and animal species. The Northwestern Hawaiian Islands (NWHI), which extend 1,930 kilometers (km) beyond the main Hawaiian Islands, are a World Heritage Site and part of the Papahānaumokuākea Marine National Monument. These NWHI support the largest tropical seabird rookery in the world, providing breeding habitat for 22 species of seabirds and 4 endemic land bird species and essential foraging, breeding, or stop-over and overwintering habitat for other resident and migratory birds (Friedlander *et al*. 2009; Appendix I). The remote NWHI are part of the National Wildlife Refuge system and are protected from most direct human disturbance. With the exception of piscivorous Great frigatebirds (*Fregata minor*) that occasionally prey on juvenile birds (Metz and Shreiber 2002), no aerial bird predators are residents in the NWHI (Pyle and Pyle 2009). However, vagrant and occasional overwintering raptors are observed at these remote islands (Pyle and Pyle 2009); the presence of which is made conspicuous by mobbing seabirds (MHR and KNC personal observation). Raptors reported and substantiated from the NWHI since the 1960s include: Osprey (*Pandion haliaetus*), Black kite (*Milvus migrans*), Steller's sea-eagle (*Haliaeetus pelagicus*), Northern harrier (*Circus cyaneus*), Gray frog-hawk (*Accipiter soloensis*), Rough-legged hawk (*Buteo lagopus*), Merlin (*Falco columbarius*), and Peregrine falcon (*Falco peregrinus*; Pyle and Pyle 2009).

The Laysan teal (*Anas laysanensis*; Figure 1) and Laysan finch (*Telespiza cantans*; Figure 2) are endangered Hawaiian endemic birds whose distributions were once widespread (James and Olson 1991, Olson and James 1991), but the last extant populations persisted on Laysan Island (4.1 km^2, mean elevation 2.3 m, maximum elevation 10.7 m [Reynolds *et al*. 2012a]; Figure 3). Over the recent decades the teal and finch populations on Laysan Island have fluctuated around

Figure 1. Laysan teal (*Anas laysanensis*) at Laysan Island, Northwestern Hawaiian Islands. Photo credit: James Breeden (US Geological Survey [USGS]).

Figure 2. Laysan finch (*Telespiza cantans*) at Laysan Island, Northwestern Hawaiian Islands. Photo credit: James Breeden (USGS).

their carrying capacity of 434 ± 72 and 10,580 ± 3,513 birds, respectively (Morin and Conant 2002, Seavy *et al*. 2009, Berkowitz *et al*. 2012). Anthropogenic disturbances causing extirpation of Laysan teal included multiple shipwrecks to Lisianski Island and subsequent invasions of mice (*Mus musclus*) during the mid-1800s (Olson and Ziegler 1995). In 1903 introduced rabbits

(*Oryctolagus cuniculus*) denuded Laysan Island, causing the near extinction of Laysan teal and finches (Dill and Bryan 1912, Olson 1996). Laysan finches were translocated to Midway Atoll in 1905, but in 1943 a rat (*Rattus rattus*) introduction caused their extirpation (Fisher and Baldwin 1946, Berger 1972).

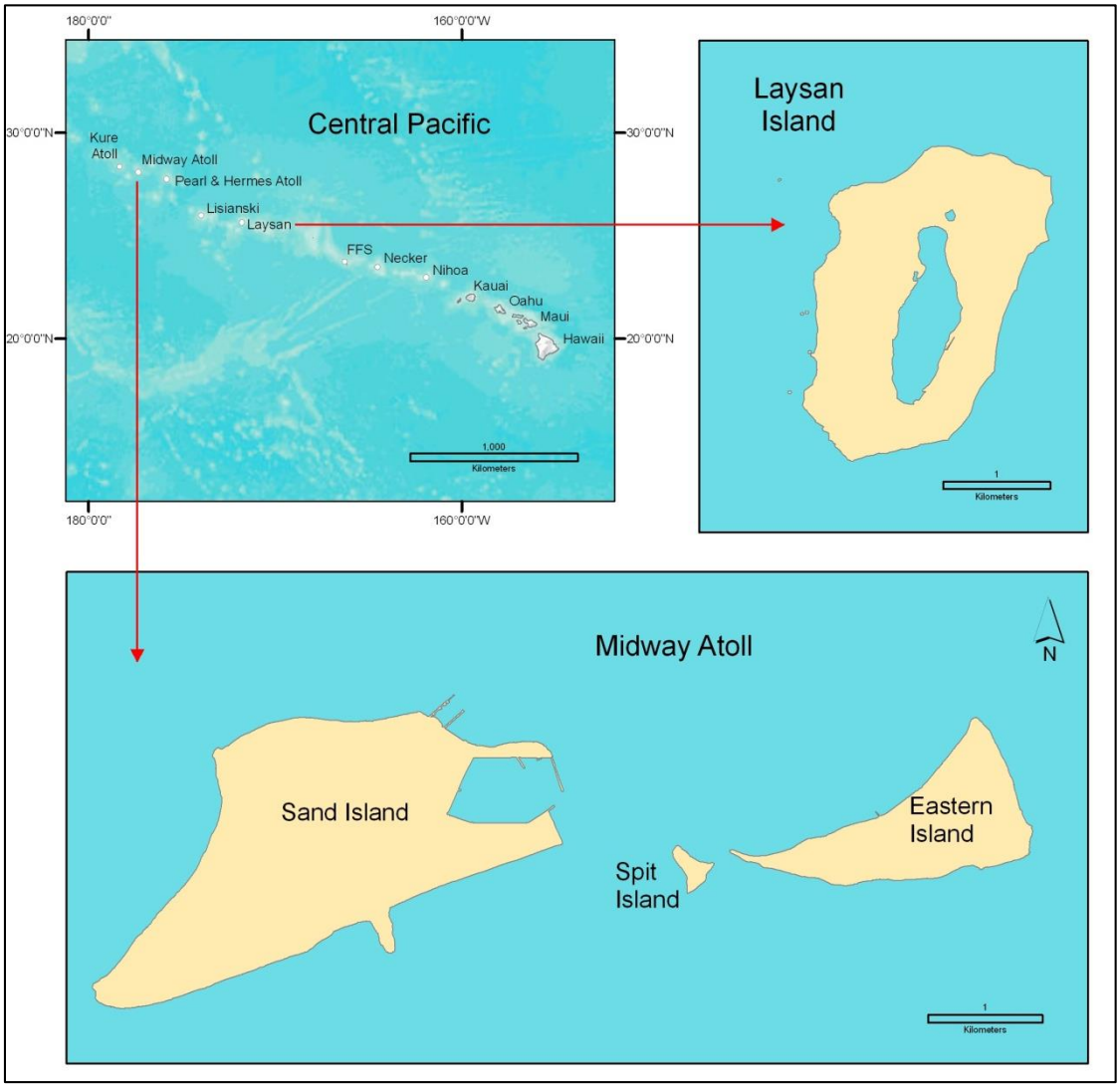

Figure 3. Map of the Hawaiian Archipelago with detailed views of Midway Atoll and Laysan Island.

Stochastic events that caused sudden population declines included an epizootic in 1993 on Laysan Island (Work *et al.* 2004), consecutive winter storms, and a tsunami that overwashed habitat on Laysan Island and Midway Atoll in 2011 (USFWS 2011, Reynolds *et al*. 2015). As a part of conservation and recovery efforts, Laysan teal and finches were translocated to Pearl and Hermes Atoll (0.5 km^2; Figure 3) in 1967 (n = 12 teal, 108 finches). The finch population became established on four islands of Pearl and Hermes and averaged about 410 birds (Morin

and Conant 2002). However, translocated Laysan finches were extirpated from all but the largest island, Southeast (18.4 ha, mean elevation 1.0 m, maximum elevation 2.5 m [Reynolds *et al*. 2012a]), since 2011, and the last Pearl and Hermes population is at risk of inundation from sea-level rise, sudden inundation events, and other catastrophes (Tarr *et al*. 1998, Reynolds *et al*. 2012a). The Laysan teal translocated to Southeast Island did not become established at Pearl and Hermes Atoll. Laysan teal were translocated again in 2004–2005 (2004: *n* = 20, 6 female; 2005: *n* = 22, 10 female; Reynolds *et al*. 2008) to Midway Atoll (6.0 km^2, mean elevation 3.0, maximum elevation 11.7 m [Storlazzi *et al*. 2013]; Figure 3), which expanded their range and increased their abundance by more than 400 birds within five years (Reynolds *et al*. 2012b).

The Peregrine falcon is a cosmopolitan raptor whose breeding range extends from the Arctic to the tropics (White *et al*. 2002). The species was removed from the U.S. Endangered Species List in 1999 (USFWS 1999) and populations have been increasing (White *et al*. 2002, USFWS 2003). Formerly known as the "Duck hawk" (Friedmann 1950), Peregrine falcons are crepuscular hunters; they typically hunt from altitude and engage in direct pursuit where there is little ground cover, diving toward prey at high speeds, and finally killing with a bite to the neck (White *et al*. 2002). Peregrine falcons prey mainly on birds; typically stripping the pectoral muscles of kills, while remains of larger birds also show one or more notches in the keel. Parts of the skull, vertebral column, wings, pelvic girdle, and legs are usually left uneaten. Small prey may be killed in flight and then consumed at a perch (White *et al*. 2002).

Here we present the first records of predation by Peregrine falcons on Laysan teal in addition to predation of Laysan finches at Laysan Island during 2006–2009.

STUDY AREA

Midway Atoll (28°11'41"–28°16'50" N and 177°18'38"–177°25'38" W; 604 ha) is near the westernmost end of the NWHI, approximately 1,930 km from Honolulu, Hawai'i (Figure 3). Midway's ecosystem is highly altered, with extensive non-native vegetation, including tree cover. Midway has had relatively continuous human presence since 1859 and significant military activity prior to its designation as a National Wildlife Refuge in 1996 (Speulda-Drews 2010). One result of the military presence is nearly 161 ha of anthropogenic land cover, including active or abandoned tarmac and roads (Reynolds *et al*. 2012a).

Laysan Island (25°46' N, 171°44' W; 415 ha) lies approximately 1,600 km northwest of Honolulu (Figure 3). Laysan lacks any paved surfaces and is dominated by native, low herbaceous vegetation, primarily bunchgrass and shrubs (nearly 40% of the island's area). An interior hypersaline lake and mudflats make up 18% of the island (Reynolds *et al*. 2012a).

OBSERVATIONS

A Peregrine falcon (hereafter, peregrine) was observed at Midway Atoll on 29 December 2006, and biologists made repeated observations of the bird through the first week of January 2007. A peregrine was next observed at Midway Atoll on 28 October 2008. Concomitant with these 2006–2008 peregrine observations, 12 Laysan teal carcasses were recovered with evidence of peregrine predation (2006–2007: *n* = 4, 2008: *n* = 8; Table 1, Figure 4). Of the 12 recovered carcasses, three teal were molting feathers, and six teal were young of the year (i.e., hatch

year; Table 1). The remains of Brown noddies (*Anous stolidus*) and White terns (*Gygis alba*) were also recovered with evidence of peregrine predation during this time. Feather and tissue removal, especially in the pectoral region, along with neck vertebrae separation and bite marks on the keel were considered diagnostic of raptor predation. Of these predations, a peregrine was observed on tarmac eviscerating a teal; while on another occasion, a peregrine swooped by a biologist collecting its abandoned prey, a Brown noddy. Carcasses were recovered almost exclusively in open tarmac areas near wetlands. No other predators were detected during the time periods when peregrines were observed (Pyle and Pyle 2009); therefore, predation on teal was considered unlikely to have resulted from other causes. Vagrant peregrine kills amounted to a ≥4% reduction of the reintroduced teal population (population size = 104; Reynolds *et al*. 2007) during 2006–2007 and ≥2% reduction in 2008 (population size = 481 ± 28 [95% confidence interval]; Reynolds *et al*. 2011).

Table 1. Records of endangered Laysan teal (*Anas laysanensis*) carcasses depredated by Peregrine falcons (*Falco peregrinus*) at Midway Atoll, 27 October 2006–12 November 2008.

Carcass recovery date	Laysan teal carcass count	Age	Condition notes
27–28 Oct 2006	2	HY	One with radio transmitter
23 Jan 2007	2	SY	One with radio transmitter
27–31 Oct 2008	3	HY	
	1	ASY	In molt
7–12 Nov 2008	1	HY	Tail in molt
	2	ASY	One in partial molt
	1	UNK	

HY = hatch year; (A)SY = (after) second year; UNK = unknown

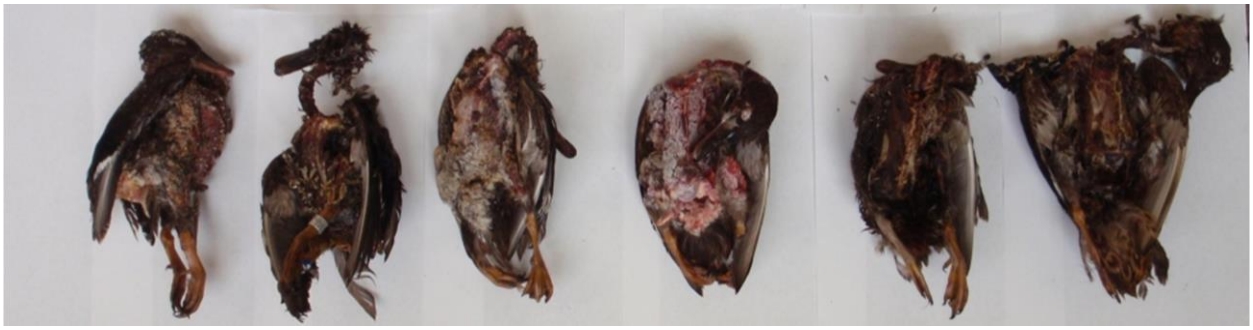

Figure 4. Six Laysan teal (*Anas laysanensis*) carcasses recovered at Sand Island, Midway Atoll, Hawai'i, that had been depredated by a Peregrine falcon (*Falco peregrinus*), October–November 2008. Denudation of neck and pectoral tissues along with keel notching are consistent with Peregrine falcon predation. Photo credit: Jonathan Shore (USGS).

At Laysan Island, USFWS personnel documented the presence of a juvenile peregrine from 12 December 2008–10 January 2009 and an adult peregrine from 27 January–14 April 2009 (Boyd

et al. 2009, Chastant *et al.* 2009). The remains of ≥18 Laysan finches were collected from the perch where a juvenile peregrine was regularly observed and photographed (Table 2, Figure 5). From the adult peregrine's perch, the remains of ≥58 Laysan finches were collected (Table 2, Figure 6). The adult peregrine was observed predating two Laysan finches that were perched on shrubs when taken (M. Mudge and M. Henschen, USFWS, personal communication). Heads, wings, and legs found at known perches were used to infer peregrine predation; no other predators were detected at these times. To avoid duplicate counts, only skulls were tallied. Seabird and shorebird (Bonin petrel [*Pterodroma hypoleuca*], Tristram's storm-petrel [*Oceanodroma tristrami*], Brown noddy, Ruddy turnstone [*Arenaria interpres*], and Pacific golden plover [*Pluvialis fulva*]) carcasses were also recovered from perches (Figure 6) or observed being predated, however, no evidence of Laysan teal predation was observed at Laysan Island (J. Chastant, M. Henschen, and M. Mudge, USFWS, personal communication).

Table 2. Records of endangered Laysan finch (*Telespiza cantans*) carcasses depredated by Peregrine falcons (*Falco peregrinus*) at Laysan Island, 10 December 2008–18 March 2009 (Chastant *et al*. 2009).

Carcass recovery date	Laysan finch carcass count
10–16 Dec 2008	18
28–29 Jan 2009	12
20–28 Feb 2009	33
4–18 Mar 2009	13

Figure 5. Peregrine falcon (*Falco peregrinus*) observed at Laysan Island, Hawai'i, January–April 2009. Photo credit: McKenzie Mudge (USFWS).

Figure 6. Bird remains collected from Peregrine falcon (*Falco peregrinus*) roosts at Laysan Island, Hawai'i, January–April 2009. From remains recovered at perches and direct observations of predation events, six species (Bonin petrel, Tristram's storm-petrel, Brown noddy, Laysan finch, Ruddy turnstone, and Pacific golden plover) were identified as Peregrine falcon prey at Laysan Island. Photo credit: McKenzie Mudge (USFWS).

DISCUSSION

The only apparent historical report of a Peregrine falcon predating endangered terrestrial birds in the NWHI is from 1995 when 11 Laysan finches were taken by a visiting peregrine on Laysan Island (Morin and Conant 2002). Peregrine visits were reported five times from 1994 to 2009 on Laysan Island and thirteen times from 1967 to 2007 on Midway Atoll (Pyle and Pyle 2009, this report), but only the visits from 1995, 2006–2007, and 2008–2009 coincided with the discovery of endangered bird carcasses with evidence of peregrine predation. After these reports, a peregrine was also observed at Midway Atoll from November 2011 through February 2012 (P. Leary, USFWS, personal communication). More recently at Laysan Island, biologists recovered remains of migratory shorebirds (Ruddy turnstone, Pacific golden plover, and Sanderling [*Calidris alba*]) and two Laysan finches from roosts of a peregrine that was observed during November 2011–April 2012 (C. Rutt, personal communication, https://abcbirds.wordpress.com/2012/03/21/a-whirlwind-of-a-finale/).

Peregrine predation on Laysan teal at Midway Atoll may have been greater than 4% of the population in 2006 and 2% in 2008 because it is unlikely every predated carcass was found. Had mortality occurred during the first year of translocation (2004) when there were only 19 birds and a male-biased sex ratio, predation on founder teals could have undermined population establishment. In contrast, the predation of Laysan finches at Laysan from 2008–2009 was

<1% of the estimated population abundance. Thus, while these predation events did not result in significant population declines, we infer that sustained mortality from vagrant raptor predation could adversely affect small or newly established populations, especially if combined with other stochastic catastrophes such as tsunamis, droughts, or disease epizootics.

Novel predators, pathogens and catastrophic events are significant threats to Hawaiian birds (Reynolds 2002, McClung 2005). The frequency and duration of avian predator visitation should be monitored as they may influence demographic stochasticity of island endangered species. Further, because most Laysan teal carcasses at Midway Atoll were found on tarmac, vegetation restoration of abandoned tarmac might reduce fatalities by providing cover for teal to hide from hunting falcons.

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APPENDIX I

Appendix I. Known breeding distribution of extant native bird species in the Northwestern Hawaiian Islands. Data compiled from published and unpublished sources (US Fish and Wildlife Service [USFWS] data). See atoll- and island-specific footnotes for sources. Table modified from Reynolds *et al*. 2012a.

		Kure Atoll[a]	Midway Atoll[b]			Pearl and Hermes Atoll[c, d]							French Frigate Shoals (FFS)[e]							
Species	Scientific name	Green Island	Sand Island	Spit Island	Eastern Island	North Island	Southeast Island	Grass Island	Seal-Kittery Island	Lisianski Island[c]	Laysan Island[f]	Gardner Pinnacles[c]	Tern Island	Trig Island	East Island	La Perouse Pinnacle	Gin Island	Little Gin Island	Mokumanamana[c]	Nihoa[c]
Black-footed albatross	*Phoebastria nigripes*	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X
Laysan albatross	*Phoebastria immutabilis*	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Short-tailed albatross	*Phoebastria albatrus*				X															
Bonin petrel	*Pterodroma hypoleuca*	X	X	X	X		X	X	X	X	X		X		X					
Bulwer's petrel	*Bulweria bulwerii*	X					X			X	X	X	X		X				X	X
Wedge-tailed shearwater	*Puffinus pacificus*	X	X		X		X	X	X	X	X	X	X		X				X	X
Christmas shearwater	*Puffinus nativitatis*	X			X		X	X	X	X	X		X		X					X
Tristram's storm-petrel	*Oceanodroma tristrami*	X				X	X	X	X		X		X		X				X	X
Red-tailed tropicbird	*Phaethon rubricauda rubricauda*	X	X	X	X	X	X	X	X	X	X	X	X		X				X	X
White-tailed tropicbird	*Phaethon lepturus dorotheae*		X																	
Masked booby	*Sula dactylatra personata*	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Brown booby	*Sula leucogaster plotus*	X			X		X			X	X	X				X			X	X
Red-footed booby	*Sula sula rubripes*	X		X	X	X	X			X	X		X		X	X			X	X
Great frigatebird	*Fregata minor palmerstoni*	X		X	X	X		X		X	X		X		X				X	X
Little tern	*Sternula albifrons*		X				X													
Least tern	*Sternula antillarum*		X																	
Gray-backed tern	*Onychoprion lunatus*	X		X	X		X		X	X	X	X	X		X				X	X

Sooty tern	*Onychoprion fuscatus oahuensis*	X			X	X	X			X	X	X	X					X	X
Blue noddy	*Procelsterna cerulea saxatilis*											X			X			X	X
Brown noddy	*Anous stolidus pileatus*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Black noddy	*Anous minutus marcusi*	X	X		X		X			X	X	X	X					X	X
White tern	*Gygis alba candida*	X	X		X		X		X	X	X	X	X		X			X	X
Laysan teal[g]	*Anas laysanensis*		X		X						X								
Laysan finch	*Telespiza cantans*						X				X								
Nihoa finch	*Telespiza ultima*																		X
Nihoa millerbird	*Acrocephalus familiaris kingi*										X								X

[a]Vanderlip *et al.* (2008); [b]USFWS unpublished data, Klavitter (2006), P. Leary [USFWS] written communication (2011); [c]Friedlander *et al.* (2009); [d]Wegmann and Kropidlowski (2002); [e]P. Hartzell [USFWS] written communication (2011); [f]Hammond *et al.* (2010), Kristof *et al.* (2011); [g]Twenty-eight individuals translocated to Green Island, Kure Atoll in September 2014 (PMNM 2014).