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Status of Rakiura tokoeka (*Apteryx australis lawryi*) near Port Adventure Hunter's Hut, Stewart Island/Rakiura, in 2017

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Abstract

The Rakiura tokoeka (*Apteryx australis lawryi*) population at Mason Bay, Stewart Island/Rakiura, experienced a serious decline between 1993 and 2008. To assess whether this decline was widespread and likely due to predation by wild cats (*Felis catus*) or localised and likely driven by habitat change as a result of retired farmland reverting to flax, tussock and scrub, we established a second long-term monitoring site in mature coastal forest at Port Adventure in 2011. In January 2011, 20 adult birds were caught and banded, and 1 chick was wing-tagged in the 115-ha study area near Port Adventure Hunter's Hut. The adult-biased age structure suggested that recruitment failure was a problem at Port Adventure, thus favouring the cat predation hypothesis. In a reassessment of this population in February–March 2017, we found that one of the nine original territories at Port Adventure had been lost. However, among the 28 kiwi that were caught in the study area (which included 10 recaptures from 2011), 3 were subadults and 5 were juveniles or chicks of the year. Furthermore, 1 additional subadult and 3 adults were seen but not caught. Since productivity had been good in recent years, particularly in 2016/17, and one territory held at least 7 adults and 1 subadult, we concluded that the population at Port Adventure was at least stable and perhaps even close to carrying capacity. Consequently, we now consider it is more likely that the population decline observed at Mason Bay was localised and driven by habitat change rather than predation by feral cats. Further territory mapping is required at both sites to determine whether Rakiura tokoeka have occasional island-wide pulses of good productivity.

Keywords: Rakiura tokoeka, *Apteryx australis lawryi*, population dynamics, territory mapping

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1. Introduction

The Rakiura tokoeka (*Apteryx australis lawryi*) has long been considered the least threatened of all kiwi taxa due to its large population of c. 20 000 birds on Stewart Island/Rakiura (Heather & Robertson 2005), where there are few mammalian predators: kiwi here are not exposed to predation by mustelids, and dogs (*Canis familiaris*) are confined to a small area around the only settlement at Oban, leaving only cats (*Felis catus*), which are known to prey on kiwi chicks and juveniles, but with a relatively low impact (McLennan et al. 1996; Robertson et al. 2011).

In the 15-year interval between 1993 and 2008, the number of occupied kiwi territories in a 125 ha study area of retired rough farmland at Mason Bay declined from 17 to 13 – a rate of 1.8% per annum (H. Robertson & R. Colbourne, unpubl. data). In addition, relatively few chicks, juveniles or subadults were found at Mason Bay during this period (i.e. 13 (9%) of 147 birds detected), resulting in Holzapfel et al. (2008) predicting that the Rakiura tokoeka population would decline from a revised figure of 15 000 birds in 2008 to 12 500 birds by 2018, and Robertson et al. (2013) classifying the subspecies as 'Nationally Endangered'.

Two hypotheses have been proposed for the observed decline at Mason Bay: habitat change or cat predation. The study area is retired rough farmland, reverting to mixed red tussock (*Chionochloa rubra*), flax (*Phormium tenax*) and mānuka (*Leptospermum scoparium*)-dominated shrubland following the removal of livestock in the mid-1980s. These changes provide good cover for tokoeka, but may also have reduced their feeding opportunities, particularly in areas dominated by flax. The potential impact of cats on kiwi populations may have been underestimated in the past due to stoats (*Mustela erminea*), ferrets (*M. putorius furo*) and dogs killing so many chicks and adults on the New Zealand mainland (McLennan et al. 1996; Robertson et al. 2011). Consequently, Colbourne & Robertson (2008) recommended that an additional long-term monitoring site be established in more stable forest habitat to assess whether the population was stable or declining in the presence of feral cats.

Between 1 and 10 January 2011, we caught 21 Rakiura tokoeka in a 115 ha area near Port Adventure Hunter's Hut, which is located on the northeastern shores of Port Adventure on the east coast of Stewart Island/Rakiura (Colbourne & Robertson 2012). Based on the capture locations, subsequent radio-telemetry records, and maps of sightings and bird calls heard, we estimated the number and shape of territories in the study area. Furthermore, the discovery of no subadults and only 1 recently-hatched chick among 21 captures suggested that the age structure was skewed heavily in favour of adults, indicating that recruitment failure, probably as a result of cat predation, was a likely problem.

In February 2017, we used the same methods to repeat our assessment of the Rakiura tokoeka population at Port Adventure. The urgency of this assessment was heightened by the apparent loss of two further territories at Mason Bay between 2008 and 2013, reducing the number from 13 to 11 territories, a continued low subadult capture rate (8% of 25 captures) and ongoing classification of Rakiura tokoeka as 'Nationally Endangered' (Robertson et al. 2017). This paper reports on the findings of the 2017 population assessment at Port Adventure.

2. Methods

Fieldwork was undertaken from 18 February to 5 March 2017 in the 115 ha study area near Port Adventure Hunter's Hut (47° 03' S, 168° 11' E), Stewart Island/Rakiura. The study area ran from the headland northeast of the hut to c. 250 m beyond high point '70', and c. 700 m (two territory widths) inland from North Arm. During the 16-day study period, we caught, banded and radio-tagged as many kiwi as possible, and determined the number and approximate boundaries of territories within the study area.

2.1 Field methods

At night, we played recorded calls at suitable catching sites that were identified during daytime searches. We then caught any kiwi that approached the 'intruder' by hand or in hand-nets. We also used a night-certified kiwi dog, Jade, to indicate the presence of kiwi near tracks and played the calls at the best nearby catching site. We checked the location of radio-tagged birds at night, particularly before playing recorded calls to catch new birds in a territory or when a bird called within a territory where birds had already been radio-tagged, to determine whether new birds were likely to be captured.

During the daytime, we searched the study area with certified kiwi dogs (Breeze, Cara, Duke, Jade and Peg), tracked radio-tagged birds to determine their locations and to try to find other birds sheltering with them, and checked some well-used sites that had been occupied by radio-tagged birds on previous days.

All captured birds were measured and weighed, and their body condition was scored using the methods described by Robertson & Colbourne (2017). Adult birds were banded with individually numbered metal bands supplied by the Department of Conservation (DOC) Banding Office, and these were covered with coloured reflective tape to help distinguish birds seen at night or in daytime shelters. All but one of the chicks was marked by inserting a fish fingerling tag in the patagium. A 12 g two-stage Sirtrack transmitter was attached to the tibia of most birds using a single hospital baby band (Miles & McLennan 1998) so that the transmitter would soon fall off if we failed to recapture the bird.

Birds that had been captured for the first time were sexed using a combination of bill length and weight, or by using DNA sexing from collected pin feathers (Huynen et al. 2003). They were also classified as adult, subadult or chick (hatched in the 2016/17 breeding season) based on a combination of known sex, bill length and weight.

2.2 Population distribution and size

We used a combination of capture locations, sightings, radio-telemetry locations and projections of where calls came from to plot the distribution of birds and estimate the minimum population size. Although we did not catch every bird in the study area, we caught birds in every territory and believe that we handled or saw most of the adult birds in most of the territories.

3. Results

Between 18 February and 5 March 2017 we caught a total of 28 Rakiura tokoeka in the 115 ha study area and 1 additional adult male from a territory adjacent to the study area. The 28 birds caught in the study area comprised 8 adult females, 12 adult males, 3 subadults, 4 juveniles of the year and 1 chick (Table 1). Of the 18 adults, 10 were recaptures from our 2011 population assessment.

Twelve of the birds were caught at night, 1 was caught walking around during the day, 9 were found by dogs during the day, 3 were found in shelters with radio-tagged birds and 3 (all subadults or chicks) were found in burrows that had been used by radio-tagged birds a few days earlier.

Based on the capture locations, 108 daytime locations of 19 radio-tagged birds and four close encounters at night with 3 radio-tagged birds, we determined that the 28 birds we caught in our 115 ha study area occupied eight territories (Fig. 1).

Table 1. Details of the 29 Rakiura tokoeka (*Apteryx australis lawryi*) captured at Port Adventure, Stewart Island/Rakiura, in February–March 2017. M = male, F = female, U = unknown, WT = wingtag. DNA sexing results are shown in bold.

DATE	AGE	SEX	BAND	NEW?	BILL (mm)	WEIGHT (g)	TERRITORY
18/02/17	Adult	**M**	RA 3701	Yes	107.6	2270	D
18/02/17	Adult	M	RA 3079	No	116.0	2790	C
19/02/17	Chick	**F**	WT S2101	Yes	48.8	210	F
19/02/17	Adult	F	RA 3709	Yes	149.2	3240	F
20/02/17	Adult	F	RA 3031	No	153.0	3550	H
20/02/17	Adult	**M**	RA 3710	Yes	110.2	2480	H
21/02/17	Subadult	**F**	RA 3705	Yes	124.0	2050	C
21/02/17	Subadult	**F**	WT S2299	Yes	87.2	1140	C
22/02/17	Juvenile	**M**	WT S2297	Yes	55.1	520	D
22/02/17	Juvenile	**M**	WT S2220	Yes	58.2	720	G
23/02/17	Adult	M	RA 3032	No	112.6	2620	A
24/02/17	Adult	F	RA 3075	No	150.0	2910	D
24/02/17	Juvenile	**F**	WT S2289	Yes	62.3	750	F
25/02/17	Adult	**M**	RA 3702	Yes	112.0	2620	H
25/02/17	Adult	F	RA 3083	No	156.6	3390	E
26/02/17	Adult	F	RA 3712	Yes	148.1	3450	H
26/02/17	Adult	**M**	RA 3703	Yes	110.4	2150	H
27/02/17	Adult	M	RA 3076	No	105.2	2250	A
27/02/17	Adult	F	RA 3714	Yes	150.3	2625	C
27/02/17	Adult	**M**	RA 3715	Yes	122.3	2925	I
28/02/17	Adult	M	RA 3072	No	112.0	2750	D
28/02/17	Adult	F	RA 3074	No	167.1	3800	A
28/02/17	Adult	M	RA 3716	Yes	116.6	2390	Outside*
1/03/17	Adult	F	RA 3081	No	158.1	3200	I
2/03/17	Adult	M	RA 3071	No	115.6	2820	H
2/03/17	Adult	**M**	RA 3717	Yes	119.0	2250	H
2/03/17	Juvenile	U	nil	Yes	55.9	595	C
2/03/17	Adult	**M**	RA 3719	Yes	109.4	3025	G
2/03/17	Subadult	**M**	RA 3720	Yes	110.7	1990	A

* Note that RA3716 was caught in a territory outside the study area.

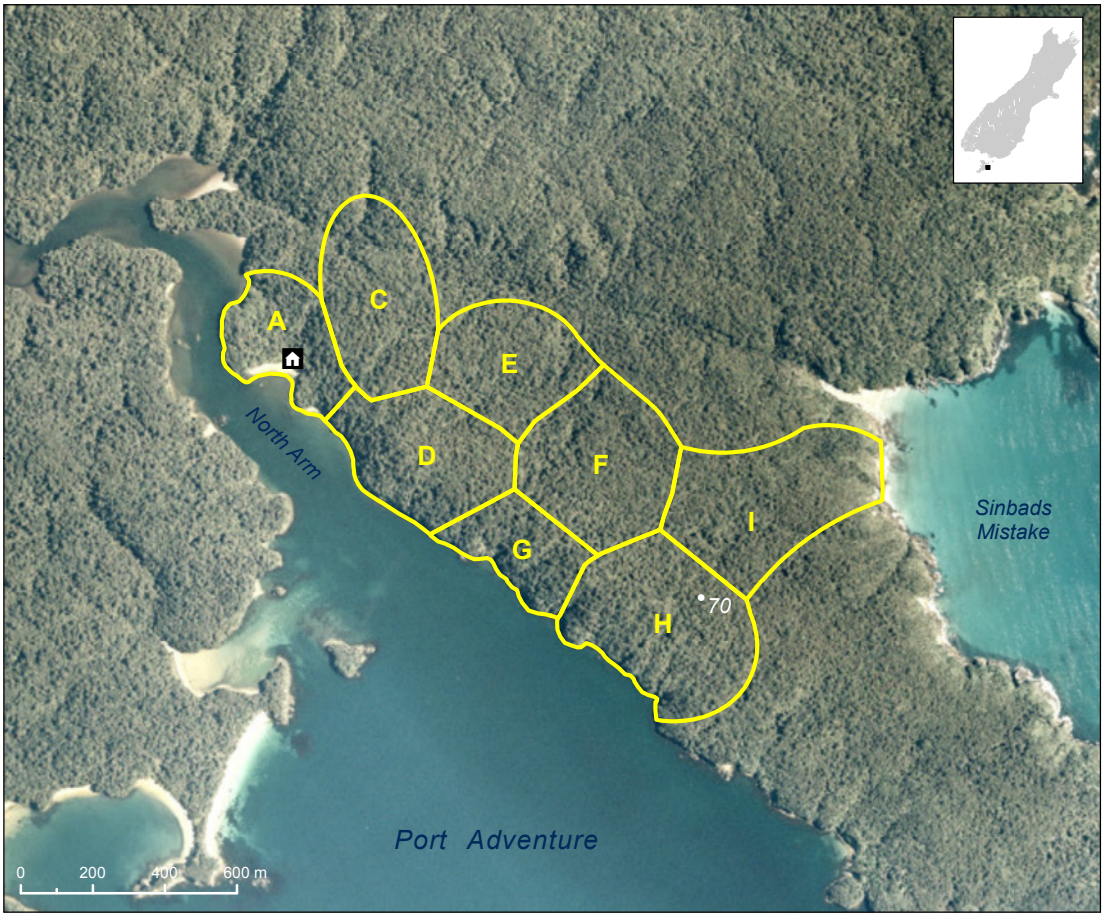

Figure 1. Locations of eight Rakiura tokoeka (*Apteryx australis lawryi*) territories at Port Adventure, Stewart Island/Rakiura, in February–March 2017 determined from captures, radio-telemetry locations and sightings of birds that were seen but not caught.

The territory size ranged from 9 ha (Territory G) to 23 ha (Territory I) (mean = 14.4 ha). In addition to the 28 captured birds, we saw, but failed to catch, additional adults in territories E, F and G, and a subadult in Territory H, giving a minimum population in 2017 of 32 birds (23 of which were adults) at a density of 1 adult per 5.0 ha and 1 tokoeka per 3.6 ha. The mean group size across the eight territories, which was measured as the minimum number of adult birds caught, seen or heard in a territory (i.e. excluding chicks, juveniles and subadults) was 2.88 birds per territory. A maximum of seven adult birds was detected in a single territory (H) (Table 2).

Three territories had multiple adult males, whereas only one (Territory H) had multiple adult females; however, it is possible that we failed to detect some adult females in other territories because they are usually less responsive to playback calls than males. Two birds, weighing 220 g and 750 g, and therefore both hatched in the 2016/17 breeding season, were found in Territory F, indicating that either the resident pair had two successful clutches or a second female had gone undetected.

Table 2. Age and sexes of Rakiura tokoeka (*Apteryx australis lawryi*) caught or seen in each territory at Port Adventure, Stewart Island/Rakiura in February–March 2017. Age classification follows Robertson & Colbourne (2017); i.e. Adult = bird > 4 years old, subadult (Subad) = bird > 6 months old but < 4 years; juvenile (Juv) = bird 50 days to 6 months old, Chick = bird < 50 days old. ♀ = female, ♂ = male, unk = unknown gender.

TERRITORY	ADULT ♀	ADULT ♂	SUBAD ♀	SUBAD ♂	SUBAD unk	JUV ♀	JUV ♂	JUV unk	CHICK ♀	TOTAL
A	1	2		1						4
C	1	1	2					1		5
D	1	2					1			4
E	1	1								2
F	1	1				1			1	4
G	1	1					1			3
H	2	5			1					8
I	1	1								2
Total	9	14	2	1	1	1	2	1	1	32

4. Discussion

The population of Rakiura tokoeka near Port Adventure Hunter's Hut is at a moderate to high density, making it very suitable for monitoring long-term changes in population density. The forest habitat in this area is deteriorating through lack of regeneration of deer-palatable species but is essentially stable compared with the rapidly regenerating farmland at Mason Bay, and sightings of feral cats are frequently noted in the hut logbook.

In 2011, we thought that we had caught and radio-tagged birds in 9 of 11 territories, and that we had seen a group of 3–4 birds in one of the two remaining territories and a single bird in the other territory (Robertson & Colbourne 2012). However, the findings of our much longer trip in 2017, during which we obtained nearly twice as many radio-telemetry locations, indicated that we had overestimated the number of territories in 2011. Two territories that we believed had contained uncaptured birds were likely parts of larger neighbouring territories. Robertson & Colbourne (2012) stated 'there is a slight possibility that one or both of the territories in which we failed to catch any birds, but saw non-transmittered birds, are part of adjacent territories; however, this would require that neighbouring territories were abnormally large or contained an unusually high number of adult occupants'. Based on the present assessment, it does indeed seem that one of the territories (I) was very large, encompassing the area shown as territories I and J in the maps of Robertson & Colbourne (2012), while the other territory (H) contained an unusually high number of adults, which were depicted by Robertson & Colbourne (2012) as belonging to territories H and K.

It was clear that Territory B had genuinely disappeared by 2017, with the only bird that was banded in this territory in 2011 not being seen in 2017, and parts of the old territory being used by birds from three adjacent territories (A, C and D) in 2017.

Accepting that we overestimated the number of territories in 2011, one out of nine territories was lost over the 6-year period to 2017, equating to a 1.9% loss of territories per annum. However, the discovery of 9 (28%) subadults out of 32 birds, the finding that one territory contained at least seven adult-sized birds, a second territory contained subadults of sizes indicating recruitment in three successive seasons, and a third territory had two chicks from the 2016/17 season suggested that the population at Port Adventure has done well in recent years despite the presence of feral cats.

The mean territory size of 14.4 ha was slightly larger than the 11.4 ha observed at Mason Bay in 2013 (Colbourne & Robertson 2013) and twice the mean territory size of 7.4 ha at Mason Bay in 1993, before the population decline was observed there. The mean of 2.88 adults detected per territory was similar to the 2.73 detected across 11 territories at Mason Bay in 2013. However, the maximum of seven adults in a territory was much greater than the maximum of four adults in a territory at Mason Bay.

The proportion of subadults or chicks caught was considerably higher in 2017 (29%) than in 2011 (5%) and was also higher than that observed at Mason Bay during five population assessments between 1993 and 2013 (mean = 10%, range = 6–18%). Of the eight subadults or chicks caught, three were detected by dogs, three were using burrows previously used by adults, one was found sheltering with an adult and one was encountered at night without using playback. The age structure of kiwi populations detected by dogs has been used as a measure of their conservation status (Colbourne 1992; McLennan & Potter 1993; Robertson & Fraser 2009) and has been shown to be similar to that predicted by life table models (Robertson & Fraser 2009).

The three young birds that were found by our dogs during the day represented 33% of the nine birds that were first found by dogs. This is similar to the proportion of young little spotted kiwi (*Apteryx owenii*) detected by a dog on mammalian pest-free Kapiti Island (41% of 87 birds; Colbourne 1992), but much higher than the 3% of 63 kiwi that were detected by six dogs in unmanaged areas of the New Zealand mainland (McLennan & Potter 1993). The age structure of kiwi populations detected by dogs has previously been used as a measure of their conservation status (Colbourne 1992; McLennan & Potter 1993; Robertson & Fraser 2009), and, for example, Robertson & Fraser (2009) found that the proportion of subadult birds in a Northland study site increased from 15% before management to 40–49% after 8–10 years of pest control, at which time the population growth rate was calculated to be 8.6% per annum (Robertson & de Monchy 2012). The high proportion of young birds detected at Port Adventure in 2017 suggests that this population is likely to be at least stable, while the marked difference in the proportions of young birds found in 2011 and 2017 suggests that productivity at the site, and perhaps on Stewart Island/Rakiura as a whole, is highly variable from year to year. It is also possible, however, that the higher proportion of young birds detected in 2017 was partly due to the survey being 1 week longer, resulting in twice as many checks on the locations of radio-tagged birds and the daytime shelters they had used previously; indeed, this repeated checking of shelters resulted in three of the nine detections of subadults.

One of the ten adults we recaptured (RA 3074) had shifted to a neighbouring territory (from C to A) to replace the original female, which was not encountered in 2017. All of the other banded birds were in their original territories. None of the recaptured birds had significantly longer bills (i.e. >1.5 mm growth; Robertson & Colbourne 2017) than we recorded in 2011, confirming that they had all been correctly aged as adults at the time of initial capture. The recapture rate of adults after 6 years (50%) was much lower than anticipated based on an expected adult mortality rate of c. 2–3% in the absence of dogs and ferrets (Robertson & de Monchy 2012). We believe that some banded adults were reluctant to approach our broadcast calls and thus avoided being recaptured. Future monitoring at the site should improve estimates of the minimum number alive in 2017 and will give a more robust estimate of survival rates in the study population.

Measurements of the new adults that were caught in 2017 confirmed our 2011 observation that adults at Port Adventure have longer bills that those at Mason Bay. The bills of the 15 adult females that have been handled at Port Adventure to date (153.6 ± 7.2 mm) were by far the longest of kiwi recorded anywhere in New Zealand and were also significantly (7.7%) longer than those of the 34 adult females handled at Mason Bay, only 48 km away (142.6 ± 5.6 mm; $t = 5.60$, $P < 0.001$) (Colbourne & Robertson, unpubl. data). Six of the females had longer bills than the longest recorded at Mason Bay (156.4 mm) and four had longer bills than the longest bill previously recorded on any kiwi (157.4 mm for a brown kiwi (*A. mantelli*) at Trounson, Northland; T. Coad, unpubl. data), with the new record (167.6 mm) being >10 mm (6.5%) longer than the previous

record. The 13 males also had significantly longer bills than the 38 males measured at Mason Bay (112.8 ± 4.4 mm v. 104.7 ± 4.5 mm; $t = 5.50$, $P < 0.001$), with a longer maximum length also being recorded at Port Adventure (122.3 mm) compared with Mason Bay (118.0 mm). By contrast, the mean weights of both adult females and males were within 30 g (1%) of the mean weights recorded at around the same time of year at Mason Bay (Colbourne & Robertson, unpubl. data). It is unclear why the birds at Port Adventure have much longer bills than those at Mason Bay, but this observation suggests either some strong genetic structuring within Rakiura tokoeka or phenotypic differences within the island as a result of habitat quality and/or diet.

Although the forest habitat at Port Adventure appears at first glance to be stable, we noted that the forest composition has been highly modified by deer browsing since they were liberated on Stewart Island/Rakiura in 1905 (Stewart & Burrows 1989). The understorey, seedling and ground layer is now being dominated by unpalatable plants such as crown fern (*Blechnum discolor* = *Lomaria discolor*), inaka (*Dracophyllum longifolium*) and some seedling podocarps, and canopy species such as broadleaf (*Griselinia lateralis*) and kāmahi (*Weinmannia racemosa*) are absent from the deer browse zone. Since hunting pressure from recreational hunters has not been sufficient to allow natural forest regeneration to occur, the forest habitats of the peninsula, and presumably also much wider areas across the island, will continue to change unless deer populations are reduced substantially.

We recommend that this study site is re-visited in 2022, to remap territories and band birds. Given that the annual survival rate of kiwi in the absence of significant adult predation is usually 97–98% per annum (Robertson & de Monchy 2012), there should be a high probability of obtaining a meaningful number of recaptures after this time period. Furthermore, this interval will also provide opportunities to observe some recruitment into the adult population and to determine whether Rakiura tokoeka have occasional pulses of good productivity, which will help us to better determine the conservation status of this kiwi.

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