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# Status of little spotted kiwi (*Apteryx owenii*) on Red Mercury Island (Whakau) in March 2016

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## Abstract

Little spotted kiwi (*Apteryx owenii*) were introduced to Red Mercury Island (Whakau) in 1983. The growth of the population, which initially comprised only 12 founders, was recorded intermittently until 1996 when a series of 5-yearly assessments began. Despite having low genetic diversity as a result of the small number of founders, the island population grew to an estimated 30 pairs and 70–80 birds in total by 2011. From 3 to 14 March 2016, we caught 20 different little spotted kiwi on Red Mercury Island. From plotting the locations of radio-tagged birds, sightings and calling birds, we estimated that the population in 2016 was 26 pairs and about 60–70 birds in total. Compared with earlier surveys, we caught few new birds which suggests that there had been poor recruitment in the previous 5 years. It is possible that survival and recruitment of little spotted kiwi were adversely affected by an extremely dry spell in early 2013. Following our population assessment, 10 new founders were introduced from Kapiti Island to increase the genetic diversity of the Red Mercury Island population. At the same time, 10 birds were transferred from Red Mercury to Cape Sanctuary to improve chances that the new birds will be recruited into the breeding population, as the island appears to be at or near carrying capacity. The success of this genetic management can be assessed by observing the development of genetic diversity in the population. We recommend that the 5-yearly monitoring programme continue, with the next trip scheduled for February 2021.

Keywords: little spotted kiwi, *Apteryx owenii*, population dynamics, territory mapping, drought, genetic rescue

# 1. Introduction

With the conservation status ‘At Risk: Recovering’ (Robertson et al. 2017), the little spotted kiwi is the second rarest of the five species of kiwi. Some evidence suggests that it was the most common kiwi species in New Zealand in the mid- to late-1800s but it then disappeared rapidly on the mainland and had all but gone by the mid-1900s. Fortunately, a secure population was established on Kapiti Island from five birds collected in South Westland in 1912 (Colbourne & Robertson 2004, Ramstad et al. 2013). Despite the small founder population and the resulting potential for inbreeding, this population on Kapiti Island flourished and reached a stable level of about 1200 birds (Holzapfel et al. 2008). In 2013, the total population of little spotted kiwi was estimated to about 1700 birds on seven offshore islands (Hen, Tiritiri Matangi, Motuihe, Red Mercury, Kapiti, Long and Chalky) and at one predator-free mainland site (Zealandia, Wellington) (Heather & Robertson 2015). Since 2013, new populations have been established on Anchor Island (Fiordland) and the establishment of new populations on the mainland at Cape Sanctuary (Hawkes Bay) and Shakepear Open Sanctuary (North Auckland) has been initiated.

In July 1983, six male and six female little spotted kiwi were transferred from Kapiti Island to 226-ha Red Mercury Island to establish a second stronghold of the species beyond Kapiti Island (Colbourne & Robertson 1997). The population had become well-established by the time Pacific rats (*Rattus exulans*) were eradicated from the island in 1992, and all nine birds radio-tagged before the poisoning operation survived their exposure to aerially sown brodifacoum (Robertson et al. 1993). By 1996, Colbourne & Robertson (1997) estimated that there were 13 pairs and at least 30 birds on the island, and the population continued to grow to an estimated 30 pairs and 70–80 birds in 2011 (Table 1).

Table 1. Releases, recaptures, captures and estimated population sizes (pairs and/or total population) of little spotted kiwi (*Apteryx owenii*) on Red Mercury Island (Whakau) between 1983 and 2011 (Colbourne & Robertson 1997, and unpublished data).

DATE	FOUNDERS RELEASED	1983 FOUNDERS RECAPTURED	ISLAND- BRED BIRDS RECAPTURED	ISLAND- BRED BIRDS CAPTURED	TOTAL CAPTURED	ESTIMATED PAIRS	ESTIMATED POPULATION
July 1983	12						12
Mar 1989							17
Sep 1992		3	0	8	11	11	
Mar 1996		2	0	8	10	13	30+
Mar 2001		1	1	8	10		c. 50
Mar 2006		1	4	12	17	22	60–70
Mar 2011		3	6	15	24	30	70–80

Although the numerical growth of the population on Red Mercury Island has been strong, there is potential for inbreeding problems because of the small founding populations on Kapiti Island and then on Red Mercury Island. Little spotted kiwi have the lowest genetic diversity of the five species of kiwi and among the lowest recorded genetic diversity of all birds (Jamieson et al. 2006; Ramstad et al. 2010, 2013). At 14 microsatellite loci isolated in kiwi, the little spotted kiwi had fewer alleles per locus (mean 2.4) than the other four kiwi species (2.7–3.9) and much lower heterozygosity (mean 0.38) than the other kiwi (0.58–0.71) (Ramstad et al. 2010). Further genetic diversity has been lost in the process of establishing each of the new translocated populations. Samples taken from island-bred birds on Red Mercury Island up to 2011 showed a 9% loss of heterozygosity and an 8% loss of alleles per locus relative to Kapiti Island (Ramstad et al. 2013) and the number of effective founders was estimated to be just 5 birds. The extremely low genetic diversity on Red Mercury Island makes it likely that the kiwi there are less well-equipped to

survive challenges such as exposure to a novel disease or environmental change (Ramstad et al. 2013), and that they could experience inbreeding problems, such as low hatching success or poor survival, as seen in the little spotted kiwi population on Long Island which came from just two founders (Taylor et al. 2017).

This 2016 population assessment is part of the long-term monitoring programme for little spotted kiwi on Red Mercury Island and was conducted at the same time of year and under similar dark (new moon) conditions suitable for night-time catching as the previous four major assessments. The main difference with this assessment was that at the end, ten of the radio-tagged birds (eight females and two males) were transferred to Cape Sanctuary and replaced with eight females and two males from Kapiti Island in an attempt to increase the genetic diversity and hence the long-term security of the population (Robertson et al. 2019).

## 2. Methods

Because helicopter engine problems and then bad weather reduced our survey by three of the planned 14 days, we concentrated our night-time efforts on catching, banding and radio-tagging birds rather than doing timed call counts and plotting locations of calling territorial birds. On one calm night, the team recorded the number of unsolicited kiwi calls from four established listening stations during a total of 8 hours of listening in the first 2 hours of darkness. We recorded the time, direction and estimated distance to the different-pitched male and female kiwi calls.

After these call counts had finished, and on seven other dry nights, birds were attracted by playing recorded calls and then caught by hand or in hand-nets when they approached the 'intruder'. We especially played calls after two night-certified kiwi conservation dogs had indicated the presence of a kiwi nearby. Most birds were fitted with a 12-g Sirtrack double-stage transmitter on their tarsus after being banded, having their tarsus and bill length measured and being weighed and condition scored according to the methods described by Robertson & Colbourne (2017). A sample of pin feathers was collected from each individual for genetic analysis. During each night, the approximate location of birds heard calling and the various sightings and captures were noted, then plotted on maps. We noted that the published Topo 50 map of Red Mercury Island has been displaced about 70 m west of where it should be according to all of our GPS units and satellite images.

During daytime, searches for birds were made with five certified kiwi conservation dogs. We also tracked the radio-tagged birds on most days to determine their exact location and to try to find partners with them, and we checked some burrows that were used by kiwi during previous surveys.

From locations of captures, sightings and radio-telemetry, and from projected call origins during timed counts, responses to recorded calls, and casual observations, we plotted the distribution of birds and estimated the minimum population size.

## 3. Results

### 3.1 Call rates

We recorded an average of 7.6 calls/hour during 8 hours of listening around the island. This average call rate was the highest yet recorded on Red Mercury Island. The sex ratio of the calls was strongly biased in favour of males: out of 61 calls, 55 were male and only 6 female. The resulting ratio of 9.2:1 is significantly higher (Binomial test,  $P < 0.001$ ) than the usual 3:1 call ratio in this species (Robertson & Colbourne 2017).

### 3.2 Captures

From 3 to 14 March, 20 little spotted kiwi were caught; 13 were caught at night, 5 were found by dogs during the day and 2 were found with radio-tagged partners (Table 2).

Table 2. Details of little spotted kiwi caught on Red Mercury Island in March 2016. Birds were aged as: adult (Ad), subadult (Subad) or juvenile (Juv). Condition was scored according to the criteria given by Robertson & Colbourne (2017) and ranged from medium (M) through medium-good (MG) and good (G) to very good (VG).

BAND	FIRST	AGE	SEX	DATE	EAST	NORTH	WEIGHT (g)	BILL (mm)	CONDITION	PARTNER
O-13983	1983	Ad	M	3/3/16	1862307	5942781	66.7	1270	G	O-32022
O-20735	1983	Ad	M	8/3/16	1863266	5942424	69.9	1260	G	R-62626
O-27487	1996	Ad	M	6/3/16	1861916	5943512	65.0	1090	M	
O-28534	2016	Subad	F	8/3/16	1862152	5943205	69.2	980	G	
O-28541	2016	Ad	F	5/3/16	1862335	5942399	78.9	1260	M	O-32012
O-28542	2016	Ad	M	8/3/16	1862420	5942398	61.7	1100	G	
O-31486	2006	Ad	M	8/3/16	1862535	5942630	65.5	1040	MG	
O-32012	2011	Ad	M	12/3/16	1862205	5942404	65.3	1200	G	O-28541
O-32013	2011	Ad	M	4/3/16	1861824	5942470	63.8	1140	MG	R-62688
O-32022	2011	Ad	F	5/3/16	1862349	5942694	78.8	1390	VG	O-13983
O-32031	2011	Ad	F	3/3/16	1862121	5942793	78.3	1380	G	O-32032
O-32032	2011	Ad	M	2/3/16	1862091	5943147	65.0	1150	MG	O-32031
O-32066	2011	Ad	M	5/3/16	1862125	5942386	67.6	1150	M	O-32067
O-32067	2011	Ad	F	5/3/16	1862125	5942386	76.8	1300	G	O-32066
O-32694	1992	Ad	F	7/3/16	1863054	5942477	86.1	1610	VG	O-32695
O-32695	1992	Ad	M	5/3/16	1862763	5942599	67.9	1300	VG	O-32694
R-62625	2016	Ad	F	8/3/16	1862040	5943128	83.6	1530	VG	
R-62626	2016	Ad	F	3/3/16	1863336	5942404	77.6	1240	M	O-20735
R-62688	2011	Ad	F	4/3/16	1861813	5942527	80.7	1340	M	O-32013
-	2016	Juv	U	9/3/16	1862849	5942918	49.7	430		

Fourteen of the birds had been captured on previous trips, including 2 of the 12 birds released onto the island in 1983. These two males (O-13983 and O-20735) were already adults when they were transferred to Red Mercury 33 years earlier, and so must have been at least 36 years old in 2016. Five of the six new birds were banded for individual recognition in the future while a 430 g juvenile was too small to band. All but three of the birds were radio-tagged, and two to eight daytime locations were subsequently determined for each of them.



The 20 birds captured in 2016 included seven pairs, four other adults (three males, one female), one subadult female and one unsexed juvenile (Fig. 1). We saw an unbanded female in the area occupied by one of the adult males we caught, and we heard a male several times in the area occupied by the adult female we caught (Fig. 1).

The sex ratio of birds caught (10 males, 9 females, one unsexed juvenile) was more balanced than in 2011 when 17 males and 7 females were caught.

The proportion of newly bred birds captured (30% or 6 out of 20) was significantly lower ( $\chi^2 = 7.22$ ,  $P = 0.027$ ) compared with the last two surveys on Red Mercury Island (63% or 15 newly bred birds out of 24 in 2011 and 71% or 12 out of 17 in 2006) (Table 3).



Figure 1. Distribution of little spotted kiwi (*Apteryx owenii*) territories on Red Mercury Island in March 2016.

Table 3. Releases, recaptures, captures and estimated population sizes of little spotted kiwi (*Apteryx owenii*) on Red Mercury Island (Whakau) between 1983 and 2016. The estimated number of pairs and/or total population was based on the number of birds captured, and others seen or heard.

DATE	FOUNDERS RELEASED	1983 FOUNDERS RECAPTURED	ISLAND-BRED BIRDS RECAPTURED	ISLAND-BRED BIRDS CAPTURED	TOTAL CAPTURED	ESTIMATED PAIRS	ESTIMATED POPULATION
July 1983	12						12
Mar 1989							17
Sep 1992		3	0	8	11	11	
Mar 1996		2	0	8	10	13	30+
Mar 2001		1	1	8	10		c. 50
Mar 2006		1	4	12	17	22	60–70
Mar 2011		3	6	15	24	30	70–80
Mar 2016	10	2	12	6	20	26	60–70

### 3.3 Population estimate

In addition to the nine pairs determined from captures and radio-telemetry, uncaptured pairs were seen or heard in five territories (in Shag Bay, Upper Te Awa Valley, south of the Te Huhu Stream, near Von Luckners Cove and in the east of South East Valley). Individual males were caught in two territories and heard in seven other territories (Fig. 1).

Based on all of these records, we detected 14 pairs and 9 other territorial males. Our coverage of the island was not complete, mainly because some of the tracks around the upper Te Awa Valley had become overgrown and were difficult to follow at night. It seems likely that two pairs detected on the northern coast near high point 150 in 2006 or 2011, and another pair in the northwest of the island near high point 73 might well have been missed because we traversed the Te Awa Valley and Folkert’s Valley only once at night.

By mapping daytime and nighttime locations of captures and radio-tagged birds, and locations of calling birds (Fig. 1), and allowing for our incomplete coverage, we estimate that there were at least 23, but most likely 26 territories, and hence likely pairs, in March 2016 (Table 2). Allowing for 10–20 juveniles (which are notoriously difficult to detect because they don’t call or approach recorded calls) the total population is likely to be around 60–70 birds. This represents a decrease of 4 pairs from the 2011 estimate of 30 pairs (-13%), and a decrease of 0–20 birds from the 70–80 birds estimated in 2011 (0–33%) (Table 2). Population density was about 1 pair/ 8.7 ha.

### 3.4 Measurements

We noticed that the bill lengths of island-bred adult little spotted kiwi we handled on Red Mercury Island seemed to be generally shorter than those we normally encounter on Kapiti Island. When we analysed all data collected on Red Mercury Island since 1992, this observation was confirmed (Table 4).

Body conditions of the birds caught in March 2016 ranged between Moderate and Very Good, and their mean weights were similar to or slightly heavier than those usually recorded on Red Mercury Island. Males were significantly heavier than their counterparts on Kapiti Island at the same time of year; females were also about 80 g heavier on average, but this was not significant. (Table 5).

Table 4. Bill lengths of male and female little spotted kiwi (*Apteryx owenii*) bred on Red Mercury Island compared with those of their counterparts on Kapiti Island. *P*-value determined from a t-test.

ISLAND	GENDER	MEAN (mm)	S.D. (mm)	n	<i>P</i> -VALUE
Red Mercury	Male	66.0	2.1	26	<0.001
Kapiti	Male	68.1	2.2	233	
Red Mercury	Female	80.1	4.0	23	<0.001
Kapiti	Female	83.7	2.9	179	

Table 5. Weights of male and female little spotted kiwi (*Apteryx owenii*) on Red Mercury Island in March 2016 compared with those of their counterparts on Kapiti Island in March 1992–2017. *P*-value determined from a t-test.

ISLAND	GENDER	MEAN (g)	S.D. (g)	n	<i>P</i> -VALUE
Red Mercury	Male	1170	86	10	0.007
Kapiti	Male	1093	86	163	
Red Mercury	Female	1381	130	8	0.071
Kapiti	Female	1299	123	110	

## 4. Discussion

Data from the 2016 survey confirm that the population of little spotted kiwi is well-established on Red Mercury Island, even though the population growth, which had been observed until at least 2011, did not continue. The population has apparently declined from an estimated 30 pairs to 26 pairs, and recruitment has been poor in the last 5-year period judging by the relatively low proportion of new birds caught in 2016. A similar decline in the little spotted kiwi population on Tiritiri Matangi Island between 2012 and 2017 was attributed to a severe drought in the summer of 2013, during which two birds were known to have died of dehydration (Robertson et al. 2019b).

Rainfall figures from the nearest meteorological station at Rings Beach, Kuaotunu, 24 km from Red Mercury Island, show that January 2013 was the driest month in the 31 years since records began in 1986 (NIWA CliFlo data). A total of 4.9 mm of rain fell in the month, which is only 6% of the average (83 mm) January rainfall. Out of this total, 2.8 mm fell on 3 January. February 2013 was also much drier than normal, with 16.9 mm of rainfall (18% of the long-term February average of 95 mm). Conditions on Red Mercury Island are likely to be generally drier than at Kuaotunu, but the severe drought conditions near Red Mercury Island did not last as long as they did on Tiritiri Matangi in the summer of 2013. Although kiwi can get all of their water needs through the invertebrates they eat, the severe dry spell in January and February 2013 may still have taken its toll on the population if litter and soil invertebrates became scarce and/or retreated deep into the soil, out of reach of kiwi. The population setback between 2011 and 2016 suggests that the carrying capacity on Red Mercury Island is well below the 1 pair per 4 ha observed on Kapiti Island. Carrying capacity is an often-quoted concept but is very hard to measure. A site may be sufficiently productive to allow positive population growth for many years; however, an environmental perturbation, such as this severe dry spell, may temporarily lower the carrying capacity of the site and many deaths may follow, and then the population resumes its growth until the next major perturbation. Flightless birds, such as kiwi, on islands and in fenced sanctuaries will be especially vulnerable to environmental stochasticity because they are unable to move to sites with better conditions.

In 2011, the population appeared to be male-biased and Robertson & Colbourne (2011) thought it was possible that they had over-estimated the number of pairs if some territorial males did not have partners. We recorded a fairly even sex ratio among the birds we caught, but we detected 23 territorial males and only 14 territorial females, and so the number of pairs may again be over-estimated.

The significantly shorter bill lengths, but not lighter weights, of birds on Red Mercury Island compared with the source population on Kapiti Island might indicate genetic drift in the small gene pool if bill length is a heritable trait. We note that one of the founding males (O-13986) had an exceptionally short bill (63.3 mm) and was still alive in 2011 and paired with the same female he had been with in 2001. Although this small founder stock has not prevented rapid population growth, the population has exceptionally low genetic diversity and this means that they are likely to be less well equipped to survive new challenges such as exposure to a novel disease or to environmental change (Ramstad et al. 2013). It is unknown if the low genetic diversity and/or shorter bills, which cannot penetrate the soil so deeply, have contributed to the possible poor survival and/or poor recruitment in the severe dry spell.

In an attempt to increase the genetic diversity of the little spotted kiwi population on Red Mercury Island, ten new founders were added at the end of our population assessment. To increase the chances of these new birds being recruited into a breeding population close to carrying capacity, a similar number and gender ratio of birds was removed from Red Mercury Island and translocated to Cape Sanctuary to act as part of that founder population. The success of this genetic management can be determined in the future from recaptures of the transferred birds and genetic assessments showing whether new recruits were produced by the recently transferred birds, and whether the number of alleles per locus, heterozygosity and mean bill lengths have increased as a result of this manipulation.

The increased total number of founders (22) is still well below the 40 founders recommended to ensure a good level of genetic diversity in an isolated population (Weiser et al. 2012), so further founders will need to be added in the future, either as a simple transfer from Kapiti Island to Red Mercury Island or as part of metapopulation management done by swapping birds between various secure sites.

We recommend that the 5-yearly monitoring programme continue, with the next trip scheduled for the new moon period closest to the end of February 2021.

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