SURVIVAL OF LITTLE SPOTTED KIWI AND OTHER FOREST BIRDS EXPOSED TO BRODIFACOUM RAT POISON ON RED MERCURY ISLAND

By HUGH A. ROBERTSON, ROGAN M. COLBOURNE & FOLKERT NIEUWLAND

ABSTRACT

Twelve Little Spotted Kiwi (*Apteryx owenii*) were introduced to Red Mercury Island in July 1983. We radio-tagged nine Little Spotted Kiwi on Red Mercury Island before brodifacoum rat poison ('Talon') was air-dropped and hand-spread to eradicate kiore (*Rattus exulans*). All nine birds survived the apparently successful eradication operation. We expect that the population of Little Spotted Kiwi will continue to grow from the 11 pairs we estimated in September 1992, as the absence of rats should improve the availability of invertebrate prey. Populations of other forest birds did not appear to be harmed by the poison either.

INTRODUCTION

The Little Spotted Kiwi is the rarest species of kiwi. Its total population has diminished to a little over 1000 birds, of which about 95% are on Kapiti Island. In July 1983, six males and six females were transferred from Kapiti Island to Red Mercury Island to establish a new population and make the species less vulnerable to extinction. The transfer was successful as, from the locations of calling birds, the population was estimated to have reached 17 birds by March 1989 (Jolly & Colbourne 1991).

Red Mercury Island is the second largest (220 ha) and easternmost island in the Mercury Islands Group, off the north-east coast of the Coromandel Peninsula (Figure 1). The terrain inland is moderately gentle, with two major valley systems extending from the southern coast towards the highest point (156 m) on the northern coast. Steep cliffs surround much of the island, except at Te Roroi where the streams reach the sea, at Roly Poly Bay on the western shore, and at the mouth of East Valley (Figure 2). The island has been substantially modified by human habitation and associated fires during the last 1000 years, the most recent major fire being in the 1930s (Millener 1972). The vegetation on the slopes and ridges is dominated by second-growth scrub of mapou (*Myrsine australis*), mahoe (*Melicytus ramiflorus*) and hangehange (*Geniostoma ligustrifolium*); in the valleys and around the coast, pohutukawa (*Metrosideros excelsa*) dominates the canopy, with some groves of karaka (*Corynocarpus laevigatus*) and kohekohe (*Dysoxylum spectabile*). The ground layer is dominated by *Astelia solandri*, the ferns *Doodia media* and *Asplenium lucidum*, with some patches of bracken (*Pteridium esculentum*) and flax (*Phormium tenax*).

The Mercury Islands Group consists of seven major islands ranging from 3 ha to 1860 ha. Most of the larger islands (>15 ha) have been modified

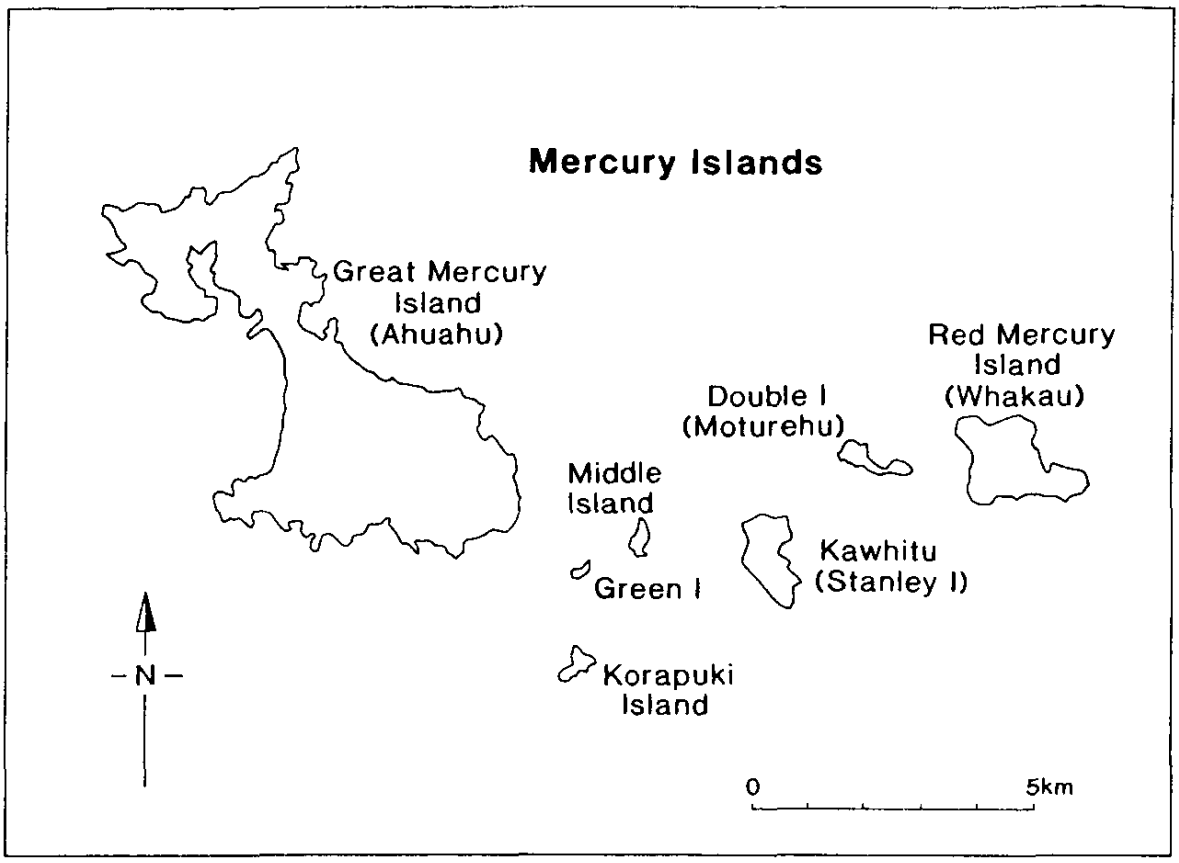

FIGURE 1 — Mercury Islands Group

over the last 1000 years through fire and the introduction of mammals. The Department of Conservation, in association with the Zoological Societies of Dallas and San Diego, Victoria University and ICI Crop Care, has been systematically restoring the terrestrial biota of the Mercury Islands Group. The overall aim is to manage the group so that some islands have minimal human interference and minimal influence from introduced plants and animals; some islands are restored to a community thought to be similar to that before human contact 1000 years ago; some, such as Red Mercury Island, are managed as refuges, not only for the survival of species and biotic communities of the island, but for threatened species that are compatible with the island's biota; and the privately owned Great Mercury Island could have multiple use, including being a refuge for threatened species (Towns *et al.* 1990).

At the core of the programme is the eradication of introduced rabbits (*Oryctolagus cuniculus*) and kiore (*Rattus exulans*) from progressively larger islands. Then ecological communities are being restored by transferring animals from the relatively unmodified smaller islands in the group which have remained free from introduced mammalian predators. Rabbits and kiore were eradicated from Korapuki (18 ha) in 1986-87 (McFadden & Towns 1991) and from Stanley Island (100 ha) in 1991 (Towns *et al.* 1993). Red Mercury Island (220 ha) is the largest island in the world on which an apparently successful attempt has been made to eradicate rodents.

A "second generation" of anticoagulant poisons is now being used widely for rodent control and for eradicating rodents from islands (Godfrey 1985,

Moors *et al.* 1992). Using them may often expose non-target species to the risk of primary poisoning by eating toxic baits or secondary poisoning by eating poisoned prey. In an aerial application of poisoned pellets, the baits are scattered in the open and so are especially available to a wide range of non-target animals. Few field studies have assessed the survival of non-target species which have been exposed to primary or secondary poisoning from applications of second generation anticoagulants. In New Zealand, Rammell *et al.* (1984) gave brodifacoum residue levels in tissue from four species of bird: Paradise Shelduck (*Tadorna variegata*), Black-backed Gull (*Larus dominicanus*), Harrier (*Circus approximans*), and Magpie (*Gymnorhina tibicen*) plus an unspecified "passerine" found dead after rabbit poisoning trials, and Towns *et al.* (1993) reported that, although a few birds were found dead after the aerial poisoning of rabbits and kiore on Stanley Island, there was no evidence of a detrimental effect on the population of any species, including the ground-feeding Saddleback (*Philesturnus carunculatus*) and Red-crowned Parakeet (*Cyanoramphus novaezealandiae*) and the predatory Morepork (*Ninox novaezealandiae*).

On Red Mercury Island, ground-feeding birds such as Little Spotted Kiwi, Saddleback, Red-crowned Parakeet, Blackbird (*Turdus merula*), and possibly Kaka (*Nestor meridionalis*) were thought to be at most risk from primary poisoning and Moreporks at most risk from secondary poisoning.

Because of the endangered status of the Little Spotted Kiwi and because the Department of Conservation is investigating the feasibility of eradicating rats from Kapiti Island, the stronghold of Little Spotted Kiwi, we studied the survival of Little Spotted Kiwi through the rat poisoning operation. One of us (FN) is a veterinary surgeon who could administer vitamin K1, the antidote to brodifacoum poisoning, to any bird affected by the poison. We also assessed the effects of the poison bait drop on populations of other forest birds.

LITTLE SPOTTED KIWI

Bait trials

Otorohanga Kiwi House holds two pairs of Little Spotted Kiwi in outdoor aviaries. By using infrared night-vision goggles, we watched the behaviour of these birds when presented with non-toxic pollard pellets. The pellets were similar to Talon 20 P but lacked the brodifacoum poison and the odourless green dye used to make the baits less attractive to birds. The baits were laid at high density (20/m^2 compared with about 1/m^2 planned for the island) in open areas of the pen where the birds frequently moved about and fed, and where we could see whether they picked up the baits.

Over a total of about six hours' observation on two nights, the Little Spotted Kiwi were not attracted to pollard baits. Although the four birds sometimes investigated the baits and fed from the soil nearby, they ate no bait during our observations.

Radio-tracking

Between 1 September and 21 September 1992, we caught and radio-tagged nine Little Spotted Kiwi – three pairs and three more females, all judged to

be adult. Four of these birds were caught by hand at night and the other five were located by a trained dog during the day. The 27 g leg-mounted Sirtrack transmitters had an internal aerial because the usual external aerial might get entangled in thick ground vegetation.

On 21 September 1992, 3.5 tonnes of Talon 20 P pollard pellets were spread by helicopter at an average rate of 15.5 kg/ha. Because the spread of baits was uneven across the island, some areas were supplemented by about 100 kg of Talon 50 WB wax blocks spread by hand.

For up to six weeks after the poison drop, we checked the kiwi on average 3-4 times each week, either at their day-time roosts or as they moved about at night. All nine birds with radio-transmitters survived the immediate effects of the rat poisoning (Table 1), and at least three were alive over 5 months after the poisoning. When examined by FN (6 birds), Clinton Waghorn (1 bird) and HAR (2 birds) all nine birds were showing no ill-effects of the poisoning or of carrying a radio-transmitter. One male began incubation at

TABLE 1 — Dates when transmitters (tx) attached to and removed from the nine Little Spotted Kiwi followed through the rat poisoning operation on Red Mercury Island. The poison was air-dropped on 21 September 1992.

Band	Sex	Date tx attached	Date tx removed	Days tx on after poisoning
O-13986	♂	18.09.92	26.02.93	158
O-20851	♀	16.09.92	27.10.92	36
O-32692	♂	03.09.92	28.11.92	68
O-32693	♀	03.09.92	28.10.92	37
O-32694	♀	06.09.92	28.10.92	37
O-32695	♂	06.09.92	27.02.93	159
O-32696	♀	10.09.92	20.10.92	29
O-32697	♀	13.09.92	18.10.92	27
O-32698	♀	18.09.92	26.10.92	35

TABLE 2a — Mean ± s.d. Little Spotted Kiwi calls per hour from (n) nights of listening for one hour or more after dark at two listening points before (7 September to 20 September) and after (24 September to 30 November) the poison drop

Listening Point	Before	After
Hugh's Lookout	1.9 ± 1.15 (4)	4.9 ± 3.44 (9)
Trig	5.0 (1)	6.2 ± 4.17 (8)

TABLE 2b — Mean ± s.d. Little Spotted Kiwi calls per hour on Red Mercury Island from (n) counts in early April 1986, March 1989 and February/March 1993

April 1986	0.7 ± 0.95 (21)
March 1989	1.0 ± 0.82 (3)
Feb/Mar 1993	5.0 ± 4.42 (11)

a nest on 10 September, and he continued to incubate until continuous observations ceased on 3 November, 43 days after the poison drop and 54 days after incubation began, but he had left the nest site by 28 November when his transmitter was removed. Another male began incubation on 26 October, 35 days after the poison drop, and he continued to incubate until after 26 November, but we found on 26 February that the nest had been abandoned as the egg (115.1 mm x 71.5 mm) had been cracked longitudinally early in incubation.

Call counts

Standard counts, noting the direction and distance of kiwi calls during the first hour after darkness, were made from vantage points around the island to help map the distribution of birds and as another method to monitor any population changes. More kiwi calls on average were heard in the first hour of darkness during the two months after the poison drop than in the 2 weeks before (Table 2a). Although probably due to a seasonal change in the rate of calling, this increase indicated no serious decline in the population. In February/March 1993, the call rate was higher than the average recorded by parties on the island in April 1986 and March 1989 (Table 2b); this follows the growth of the population on the island.

Population estimate

From radio tracking by day and at night, and from the position of calling birds and occasional sightings of other birds, we estimated a minimum of 11 pairs of Little Spotted Kiwi on Red Mercury Island. These pairs covered the entire island, with an average territory size of 20 ha (Figure 2). Eight of the nine birds we caught in September had no band and so had been raised on the island since 1983. In March 1993, we caught two more birds from the original transfer, and saw a banded female from the original transfer. In February/March 1993, a minimum of 19 birds were present, apparently occupying similar territories to those we had found in September 1992. The three birds present in September which were not located in the five nights we had on the island in autumn 1993 were all females, but given that they call less often than males, they are easily overlooked during such a brief search.

OTHER FOREST BIRDS

Five-minute bird counts (Dawson & Bull 1975) were made from 6 to 20 September 1992 leading up to the poison drop, and from 17 October to 2 November, 4-6 weeks after the drop. A small series of counts was done in February/March 1993, 5 months after the drop. The six counting sites were 200 m apart and covered a variety of aspects – two sites in the main Te Roroi valley, two on a ridge, and two in side valleys.

Shortly after the poison drop there was a significant decrease in the number of Bellbirds (*Anthornis melanura*) and Grey Warblers (*Gerygone igata*), but a significant increase in the number of Saddleback, Blackbird, Silvereye (*Zosterops lateralis*), Kingfisher (*Halcyon sancta*) and Shining Cuckoo (*Chrysococcyx lucidus*) (Table 3, Figure 3). Although not strictly comparable because of the seasonal variation in conspicuousness, in February/March

Pair	Male	Female
A	O-13986 (1983)	O-32698 (1992)
B	?	?
C	?	O-20851 (1992)
D	?	O-32696 (1992)
E	?	O-20734 (1983)
F	?	?
G	O-32692 (1992)	O-32693 (1992)
H	?	banded (1983)
I	O-32695 (1992)	O-32694 (1992)
J	?	O-32697 (1992)
K	O-20735 (1983)	?

FIGURE 2 — Band numbers (and year of banding) and approximate territories of the 11 pairs of Little Spotted Kiwi on Red Mercury Island in September 1992 - March 1993

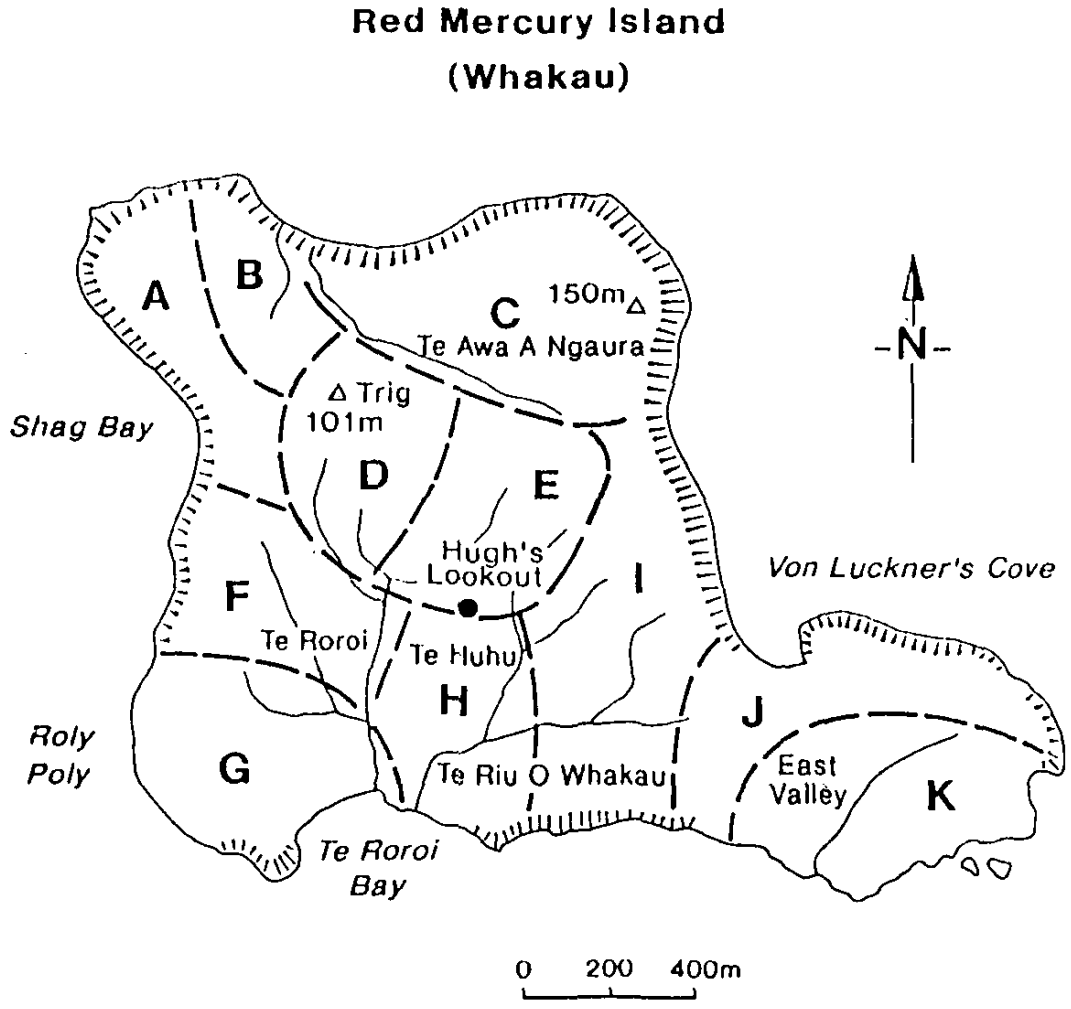

TABLE 3 — Mean number of birds per 5-minute count on Red Mercury Island before and after the poison drop on 21 September, and 5 months later in autumn 1993. Comparison of pre- and post-poisoning (Sept 1992 versus Oct 1992) by X^2-test: ? = sample too small, ns = no significant change detected ($P>0.05$), + = significant increase ($P<0.05$), + + + = very highly significant increase ($P<0.001$),- = significant decrease ($P<0.05$), - - - = very highly significant decrease ($P<0.001$).

Species	Sept 1992 (n = 198)	Oct 1992 (n = 120)	Mar 1993 (n = 30)	Comparison Sept/Oct
Harrier	0.04	0.07	0.00	ns
NZ Pigeon	0.03	0.07	0.17	ns
Kaka	0.07	0.04	0.03	ns
Red-crowned Parakeet	1.02	0.83	1.70	ns
Shining Cuckoo	0.00	0.28	0.00	+ + +
Morepork	0.00	0.01	0.00	?
Kingfisher	0.01	0.38	0.07	+ + +
Welcome Swallow	0.00	0.06	0.00	?
Dunnock	0.01	0.00	0.00	?
Blackbird	0.26	0.77	0.70	+ + +
Song Thrush	0.01	0.00	0.00	?
Grey Warbler	2.39	1.99	1.70	-
Fantail	0.19	0.18	0.97	ns
Silvereye	0.34	0.50	2.80	+
Bellbird	6.27	4.19	7.63	- - -
Tui	0.11	0.05	0.00	ns
Chaffinch	0.03	0.00	0.27	?
Starling	0.00	0.00	1.43	?
Saddleback	1.50	1.92	2.23	+

1993 most common species.(especially Starling) were recorded more often than before the poison drop in September (Figure 3), except for a significant decline in Grey Warbler ($X^2 = 5.4$, $P<0.05$) and the absence of Tui (*Prosthemadera novaeseelandiae*) (not statistically significant). All ground-feeding forest birds which were considered to be at risk from poisoning had increased significantly, and we noted many young Saddlebacks and Blackbirds. We recorded few Kaka during five-minute bird counts and could detect no significant change; however, we found a minimum of two birds (apparently a pair) before the poison drop, and again in March 1993.

Moreporks were the most likely species to suffer from secondary poisoning through eating poisoned rats; however, FN found a nest containing chicks on 30 October 1992, 39 days after the poison drop, and many Morepork were present in February/March 1993, including a fledged juvenile that was seen most nights in the Te Roroi Valley.

DISCUSSION

Our observations showed that Little Spotted Kiwi were not affected significantly by primary poisoning from the aerial sowing of pollard baits containing brodifacoum or by hand-sowing of wax blocks containing brodifacoum. Trials at Otorohanga Kiwi House had given us some confidence that Little Spotted Kiwi would not be attracted to the pollard poison baits, but the larger (and probably less attractive) wax blocks had not been tested previously. There was likewise no sign that the birds suffered any ill-effects

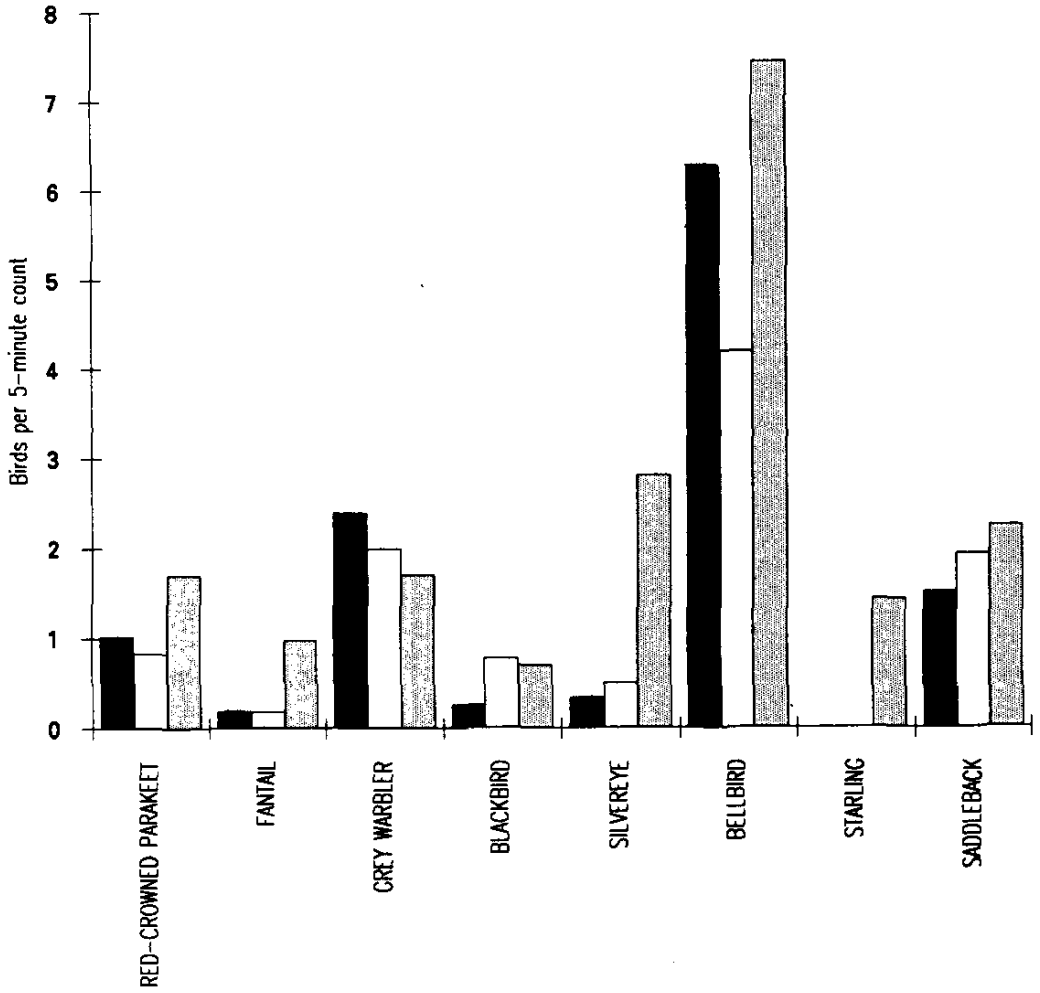

FIGURE 3 — Mean number of birds per 5-minute count for the eight most common species on Red Mercury Island. Black bars are counts (n = 198) from September 1992, immediately before the poison drop; white bars are counts (n = 120) from October - early November 1992, 4 - 6 weeks after the poison drop; grey bars are counts (n = 30) from February/March 1993. For statistical results on these data, see Table 3.

from secondary poisoning via invertebrates, although some transmitters were removed before symptoms may have developed. Observations in February/March 1993, five months after the poison drop, showed that there had been no significant change in the total population, and among the radio-tagged study birds, one bird survived at least 10 weeks and three survived 5 months after the poison drop. We could not determine whether the fecundity of birds was affected by low levels of poisoning, except that we know that at least one egg was laid 5 weeks after the poison drop, but this failed to hatch for reasons unrelated to the poisoning.

The Little Spotted Kiwi population on Red Mercury Island seems to have done very well since birds were released there in July 1983. Early counts of the number of birds on the island (Jolly & Colbourne 1991) could have been slight overestimates because the territories of the birds are very large and span several catchments, and without information on territory boundaries it is easy to double-count from calls alone. We do not know how many of the original 12 birds transferred to the island survived to breed, but at least

two males and two females (including a banded female seen but not caught during our study) from the original transfer survived to at least late February 1993, and we know that one female was accidentally killed by a dog in April 1986 (NMNZ specimen No. 23717), and another banded male (O-13985) was caught and released on 29 March 1991 (Graeme Taylor, pers. comm.). From the ratio of three original birds out of 11 birds caught, we would expect that about six of the 22 birds alive in September 1992 were from the 12 birds released in July 1983. Even though the birds have obviously bred well in the past, we found no young birds during many hours of night-time work or when using a dog to search for birds in September. With long-lived birds like kiwi, annual productivity does not have to be high to produce the sort of increase found on Red Mercury Island.

The territories of birds have spread to cover the whole island, and many birds have no access to surface water within their territory; in March 1993, some birds were over 1 km from the nearest standing water, and so we suggest that when assessing islands for future translocations, the presence of surface water (as an indicator of invertebrate availability: see Jolly & Colbourne 1991) is not necessary for the survival of Little Spotted Kiwi, especially where the absence of rodents results in an abundance of ground invertebrates. We do, however, suspect that there is strong competition for burrows with seabirds, especially Grey-faced Petrels (*Pterodroma macroptera*), and that this could lead to eggs being broken or nests being abandoned. In September, when many Grey-faced Petrels were present, most daytime locations of birds were above the surface, especially under astelias, *Doodia* or bracken, but the two radio-tagged birds caught in late February (when the Grey-faced petrels had left) were in burrows. The potential impact of large burrowing seabirds on Little Spotted Kiwi should be included in the assessment of suitable sites for the establishment of new kiwi populations on islands.

We found no evidence that the populations of any other forest bird had been adversely affected by the rat poisoning. The decline in the numbers of Bellbirds recorded after the poisoning, and the absence of Tui in February/March 1993, could be attributed to their shifting away from the Te Roroi valley once the prolific flowering of kowhai had finished; by February/March 1993 Bellbird numbers were higher than before the poisoning. Other changes in the numbers of birds recorded were probably due to seasonal movements of these species (especially Shining Cuckoo), rapid changes in their seasonal conspicuousness, or some observer variability (for example, FN recorded a slight increase in the number of Grey Warblers after rat poisoning, whereas the averages of all observers had indicated a significant decline). In February/March 1993, we found significantly more of all three ground-feeding forest birds, indicating that even if a few did die from poisoning, the survivors had bred well and more than made up the losses in the absence of kiore, which are likely predators of eggs and chicks and also competitors for invertebrates and fruit.

We expect that the population of Little Spotted Kiwi on Red Mercury Island will continue to grow because, with the absence of rats, ground-dwelling invertebrates are expected to increase. However, the benefit to Little Spotted Kiwi could be offset to some extent by the increase in populations of other birds which feed from the leaf litter; of some concern was the

presence of Starlings (*Sturnus vulgaris*) in the forest in February/March 1993, when flocks of 20-30 birds were seen feeding on the forest floor under a dense canopy.

The apparently successful eradication of kiore from a 220 ha island is an important conservation event. It provides experience for eradicating rats from even larger islands, such as Kapiti Island. The survival of Little Spotted Kiwi, and the other forest birds on Red Mercury Island, through the poisoning operation gives some confidence that use of similar baits on Kapiti Island will do little or no permanent damage to these particular bird species.

ACKNOWLEDGEMENTS

The work on Little Spotted Kiwi was supported by the Bank of New Zealand as part of the Kiwi Recovery Programme. We thank Eric Fox and the Otorohanga Kiwi House for allowing us to trial baits on captive birds. Doug Taucher, DoC Te Kuiti, carried out one night of observations at Otorohanga. The kiore on Red Mercury Island were eradicated by the Waikato Conservancy and Science & Research Division of the Department of Conservation with financial or technical support from ICI Crop Care Division, the Zoological Society of San Diego, Fay Richwhite Ltd and the Waikato District Council. Roche Products (NZ) Ltd and the Hillcrest Veterinary Clinic, Hamilton, supplied the materials needed to administer the antidote to brodifacoum poisoning if it was needed.

Tracey Kimber helped to count forest birds, and she, Ed Murphy, Clinton Waghorn, Phil Bradfield, Rob Chappell, Ian McFadden, Annie and Shirley Nieuwland provided invaluable assistance in the field tracking kiwi, doing nightly call counts and/or helping to recapture kiwi between September and December. Alan Saunders and Wendy Hare helped in the field during the February/March visit. Phil Thomson, Dave Towns and Rob Chappell helped with logistics throughout. Our dog Lucy helped to locate kiwi. Barrie Heather, Alan Saunders, Theo Stephens and Dave Towns improved the manuscript.

LITERATURE CITED

DAWSON, D.G.; BULL, P.C. 1975. Counting birds in New Zealand forests. Notornis 22: 101-109.

GODFREY, M.E.R. 1985. Non-target and secondary poisoning hazards of "second generation" anticoagulants. Acta Zool. Fennica 173: 209-212.

JOLLY, J.N; COLBOURNE, R.M. 1991. Translocations of little spotted kiwi (*Apteryx owenii*) between offshore islands of New Zealand. J. Roy. Soc. NZ 21: 143-149.

McFADDEN, I.; TOWNS, D. 1991. Eradication campaigns against kiore (*Rattus exulans*) on Rurima Rocks and Korapuki, northern New Zealand. Science & Research Internal Report No. 97. Wellington, Department of Conservation.

MILLENER, P.R. 1972. Auckland University Field Club Scientific Camp. Red Mercury (Whakau) Island, August, 1971. Introduction and Acknowledgements. Tane 18: 5-7.

MOORS, P.J.; ATKINSON, I.A.E.; SHERLEY. G.H. 1992. Reducing the rat threat to island birds. Bird Conservation International 2: 93-114.

RAMMELL, C.G.; HOOGENBOOM, J.J.L.; COTTER, M.; WILLIAMS, J.M.; BELL, J. 1984. Brodifacoum residues in target and non-target animals following rabbit poisoning trials. NZ J. Experimental Agric. 12: 107-111.

TOWNS, D.R.; ATKINSON, I.A.E.; DAUGHERTY, C.H. 1990. The potential for ecological restoration in the Mercury Islands. Pages 91-108 in Towns, D.R., Daugherty, C.H.; Atkinson, I.A.E. (eds). Ecological restoration of New Zealand islands. Conservation Sciences Publication No. 2. Wellington, Department of Conservation.

TOWNS, D.R.; McFADDEN, I.; LOVEGROVE, T.G. 1993. Offshore islands co-operative conservation project with ICI Crop Care Division: Phase One (Stanley Island). Science & Research Internal Report No. 138. Wellington, Department of Conservation.

HUGH A. ROBERTSON & ROGAN M. COLBOURNE, *Science & Research Division, Department of Conservation, P.O. Box 10 420, Wellington*

FOLKERT NIEUWLAND, *38 Berkley Avenue, Hamilton*