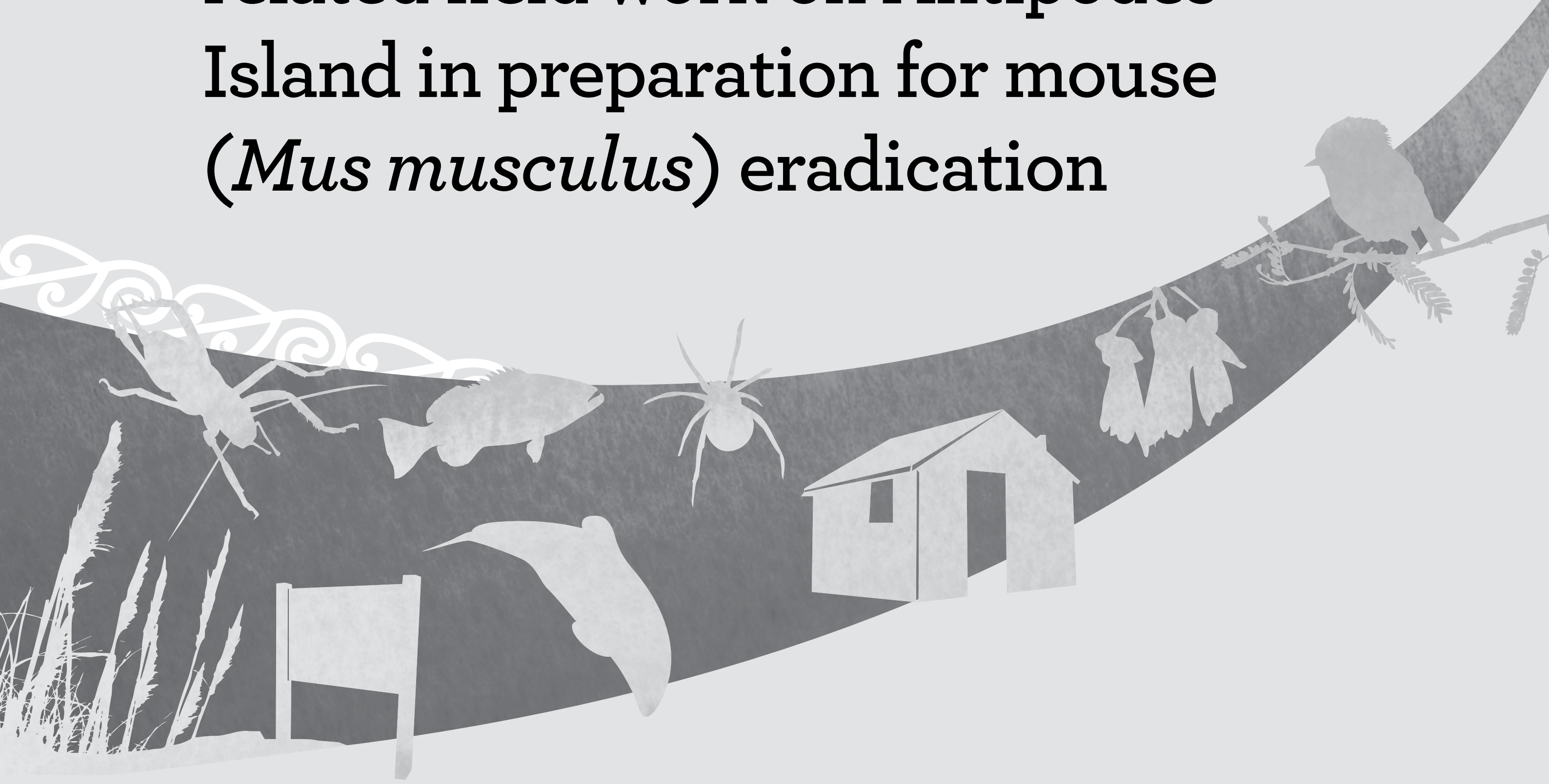
Winter bait uptake trials and related field work on Antipodes Island in preparation for mouse (*Mus musculus*) eradication



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Abstract

The eradication of house mice (*Mus musculus*) from subantarctic Antipodes Island is likely to present many challenges, but of particular concern is the potential impact on resident non-target terrestrial and marine bird species. Therefore, the likely impacts of the proposed eradication operation were examined in July 2013. Non-toxic baits containing the biotracer pyranine were distributed over 6 ha of the island at a density of 16 kg/ha. The density of mice and levels of bait uptake were then measured on three trapping grids, two within and one external to the bait distribution area. All mice that were captured in the two trapping grids in the baited area at Reef Point returned positive results for pyranine. In contrast, 1 snipe (*Coenocorypha aucklandica meinertzhagenae*), 9 pipits (*Anthus novaeseelandiae steindachneri*), 17 Reischek's parakeets (*Cyanoramphus hochstetteri*) and 16 Antipodes Island parakeets (*Cyanoramphus unicolor*) that were captured within the Reef Point study area showed no signs of having eaten the baits. Pyranine was, however, found in bird faeces collected within the bait distribution area, which predominantly originated from blackbirds (*Turdus merula*) and song thrushes (*Turdus philomelos*), along with small numbers of pipits. Pipits were also observed eating small quantities of bait and producing faeces containing the biotracer. Scavenging species such as brown skua (*Catharacta antarctica lonnbergi*), kelp gulls (*Larus dominicanus*) and northern giant petrels (*Macronectes halli*) appeared to show no interest in the baits or, in the case of northern giant petrels, dead mice. Bait persistence trials were also conducted, and population monitoring of mice, parakeet species, pipits, snipe and invertebrates are reported on, along with captive husbandry techniques and observations of the diet of parakeets. Finally, a list of recommendations for minimising non-target impacts and carrying out monitoring prior to and following mouse eradication is provided.

Keywords: Antipodes Island, eradication, biotracer, non-target, mouse, *Mus musculus*, parakeet, *Cyanoramphus*, pipit, *Anthus novaeseelandiae steindachneri*, snipe, *Coenocorypha aucklandica meinertzhagenae*

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1. Introduction

1.1 Background

The Antipodes Islands (49°41′S, 178°48′E) comprise seven islands located 733 km southeast of New Zealand. This sub-temperate group comprises the large main Antipodes Island (2025 ha) and five smaller offshore islands (Fig. 1), and is less than 0.5 million years old (Scott et al. 2013). It is considered part of the New Zealand subantarctic, with World Heritage Listing, and is managed by the New Zealand Department of Conservation.

Antipodes Island consists of a low-lying coastal area that is dominated by dense stands of tussock grass species (*Poa* and *Carex* spp.), and an elevated interior plateau at approximately 100 m altitude that is dominated by cushion herbs, ferns and shrubs, rising to 366 m at its highest point on Mt Galloway. The native breeding avifauna comprises 21 seabird species and four land bird species (Tennyson et al. 2002). Of the land birds, two species of parakeet are found only on Antipodes Island: the ancient lineage Antipodes Island parakeet (*Cyanoramphus unicolor*) and the more recent lineage Reischek's parakeet (*Cyanoramphus hochstetteri*). Antipodes Island snipe (*Coenocorypha aucklandica meinertzhagenae*) and Antipodes Island pipits (*Anthus novaeseelandiae steindachneri*) are also present, and are endemic subspecies. All four species are distributed across the entire island (Tennyson et al. 2002).

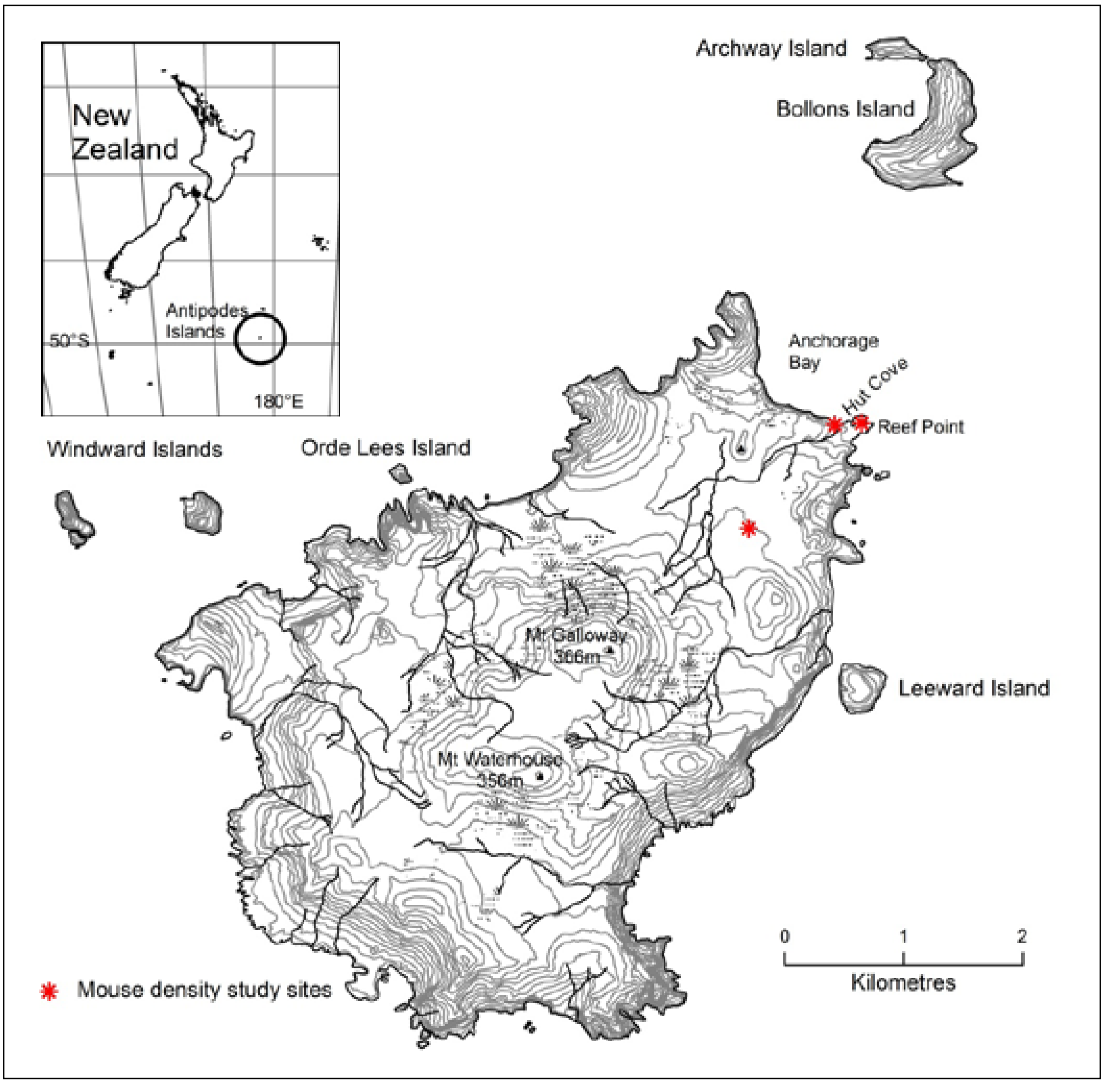

Figure 1. Map of Antipodes Island showing the principal geographic features mentioned in the text and the location of the mouse (*Mus musculus*) trapping sites.

Two historical shipwrecks are known from the island—*Spirit of the Dawn* in 1893 and *President Felix Faure* in 1908—and a castaway depot was maintained on the island from 1886 to 1927, which was serviced annually by New Zealand government lighthouse steamers (Taylor 2006). It was around this time that house mice (*Mus musculus*) were introduced to the main Antipodes Island, probably from one of the shipwrecks (Russell 2012), and they have remained the only introduced mammal on the island since that time. Although house mice have had significant impacts on the invertebrate community (Marris 2000), there have been no reports of major impacts on the avian community (Russell 2012), and thus many bird species that are locally extinct on other subantarctic islands that have been invaded by rats (*Rattus* spp.) and cats (*Felis catus*) persist on Antipodes Island. Ecosystem modification of the island by introduced mice is likely to be having flow-on effects to bird populations, however (Miskelly et al. 2006). Mice have not been recorded on the offshore islands of the group, which presumably remain as they always have.

The eradication of mice from Antipodes Island is one of the last remaining mammal eradication projects in the New Zealand subantarctic region, and in March 2012 a philanthropic campaign 'Million Dollar Mouse' was launched by Gareth Morgan to raise the funds required for the Department of Conservation to eradicate mice from the island as soon as possible (possibly starting in 2016).

1.2 Island mouse eradications

Mouse eradications generally have a lower success rate than rat eradications (MacKay et al. 2007). The reason for this remains unclear, but may be related to differences in the ecology and poison susceptibility of mice, or poor operational implementation (MacKay et al. 2007). Importantly, mice are different from rats, with different foraging ecologies, poison susceptibilities and bait preferences, and greater densities, among other traits (Clapperton 2006).

Globally, 89 eradications which had the potential to remove mice have been attempted on 75 islands where mice were present (J. Parkes, Landcare, unpubl. data). Mice were only a specified target in about half of these eradication operations, however, and about half were also undertaken in the presence of at least one species of introduced rat. Of eradications where the outcome for mice is known, mice have only been successfully eradicated in 60%, although this increases to about two-thirds when only those operations that specifically targeted mice are considered, and is also two-thirds for aerially distributed bait operations.

In the subantarctic, nine eradication operations have been undertaken on islands with mice, although mice were sometimes not the target species. Mice have been successfully eradicated from Enderby Island (710 ha) in the Auckland Islands as a side-effect of rabbit (*Oryctolagus cuniculus*) eradication; however, since this was an unanticipated outcome, few data are available on the mouse population prior to eradication and therefore the factors that contributed to their successful eradication. Mice have also been successfully eradicated from nearby Macquarie Island (13 182 ha), where they co-existed with introduced rats (*Rattus rattus*), cats, rabbits and weka (*Gallirallus australis*); again, no data are available on mouse biology prior to eradication, but it is likely that they were suppressed to a low density by rats on the island prior to their eradication (Caut et al. 2007). Eradication operations were unsuccessful on St Paul Island and five smaller islands in the Kerguelen archipelago (Guillou—1994, Cochon—1997, Stoll—2003, Australia—2004 and Moules—2005). The reasons for failure on the latter islands are complex, but include a combination of mice not being targeted in the operation, summer implementation, co-existence with introduced rats and rabbits (which were the targets), and the use of operational methods that would not be expected to successfully eradicate mice (toxin and bait formulation).

The eradication of mice from an area in which they exist alone at much elevated densities, such as occurs on Antipodes Island, remains an important challenge for island conservation, particularly on subantarctic islands where mice have been recorded preying on large seabird species (Wanless et al. 2007). The eradication of mice from Antipodes Island can be considered to be at the current limit of mouse eradication globally, even for temperate regions, where rat eradication is now considered straightforward when operations are implemented correctly. Thus, the successful eradication of mice from Antipodes Island would pave the way for larger mouse eradications on Southern Ocean islands.

1.3 Objectives

Access to Antipodes Island is strictly regulated, and is limited to scientists and conservation rangers, usually with no more than one trip allowed each year. These trips usually occur in summer (November to February), to coincide with a long-term monitoring project on the Antipodean wandering albatross (*Diomedea antipodensis*). Consequently, very few trips to the island have occurred outside the summer months, although it was visited in autumn 2001 (April–June) and 2010 (March–April) to study grey petrels (*Procellaria cinerea*).

The eradication of mice from Antipodes Island would follow recommended Department of Conservation (DOC) best practice, with a winter timing to coincide with a presumed lower density of mice, the cessation of breeding over winter and lower natural food supplies (McFadden & Greene 1994). Ad hoc bait trials have occasionally been carried out during summer field trips and a thorough assessment of mouse biology was made in the summer of 2010/11 (Russell 2012), but no data from winter have previously been collected. Therefore, a winter field trip was required to understand the specific island conditions at this time of year in preparation for mouse eradication.

In this report, we describe a winter visit to Antipodes Island in July 2013, during which we addressed the following questions:

1. How effective will the proposed operation be in targeting mice on the island and what impact is it likely to have on non-target species?
2. How long do baits persist in the environment on Antipodes Island during winter?
3. What is the status of winter populations of mice and resident non-target bird species on the island?
4. Would populations of the two endemic island landbird species—Antipodes Island and Reischek's parakeets—need to be taken into captivity during the operation? If so, what husbandry techniques would be suitable?

2. Methods

2.1 Field trip

A joint DOC and University of Auckland field trip was undertaken from 9 to 29 July 2013, partly funded by the National Geographic Society Committee for Research and Exploration. A team of four scientists spent 20 days on the Antipodes Island researching its winter terrestrial ecology, partly in preparation for mouse eradication. Transport to and from the island was provided by Henk Haazen on *Tiama*.

2.2 Bait uptake trials

2.2.1 Bait distribution

Pestoff 20R non-toxic cereal rodent baits (100 kg, provided by Animal Control Products Ltd) were used to assess target and non-target impacts of the rodent baits. Each bait weighs approximately

2.4 g, is 10 mm in diameter and closely replicates the bait to be used for the eradication. These baits contained the biomarker pyranine (0.4% w/w), which fluoresces under ultraviolet light. No lure, wax coating or Bitrex® was used.

It is currently proposed that mice will be eradicated from Antipodes Island using an aerial application of 32 kg/ha of toxic baits. Baits will be distributed in two independent applications (each at 16 kg/ha) that will be at least 2 weeks apart. However, it is likely that the period between drops will be significantly longer given the poor weather conditions during the winter months.

To replicate this likely operational scenario, a 25-m grid of points was established over an area encompassing the hut and Reef Point (Fig. 2). Using GPS, each point on the grid was visited and 1 kg of baits distributed by hand as evenly as possible over a radius of 12.5 m. Every effort was made to include cliffs and beaches (above MHW) where they occurred. Baits were distributed on 11 July 2013 at a rate of 16 kg/ha over a total area of 6 ha. The application of baits took four people approximately 6 hours. A smaller area (0.6 ha) was sown again at the same rate on 23 July 2013 for intensive bait uptake monitoring.

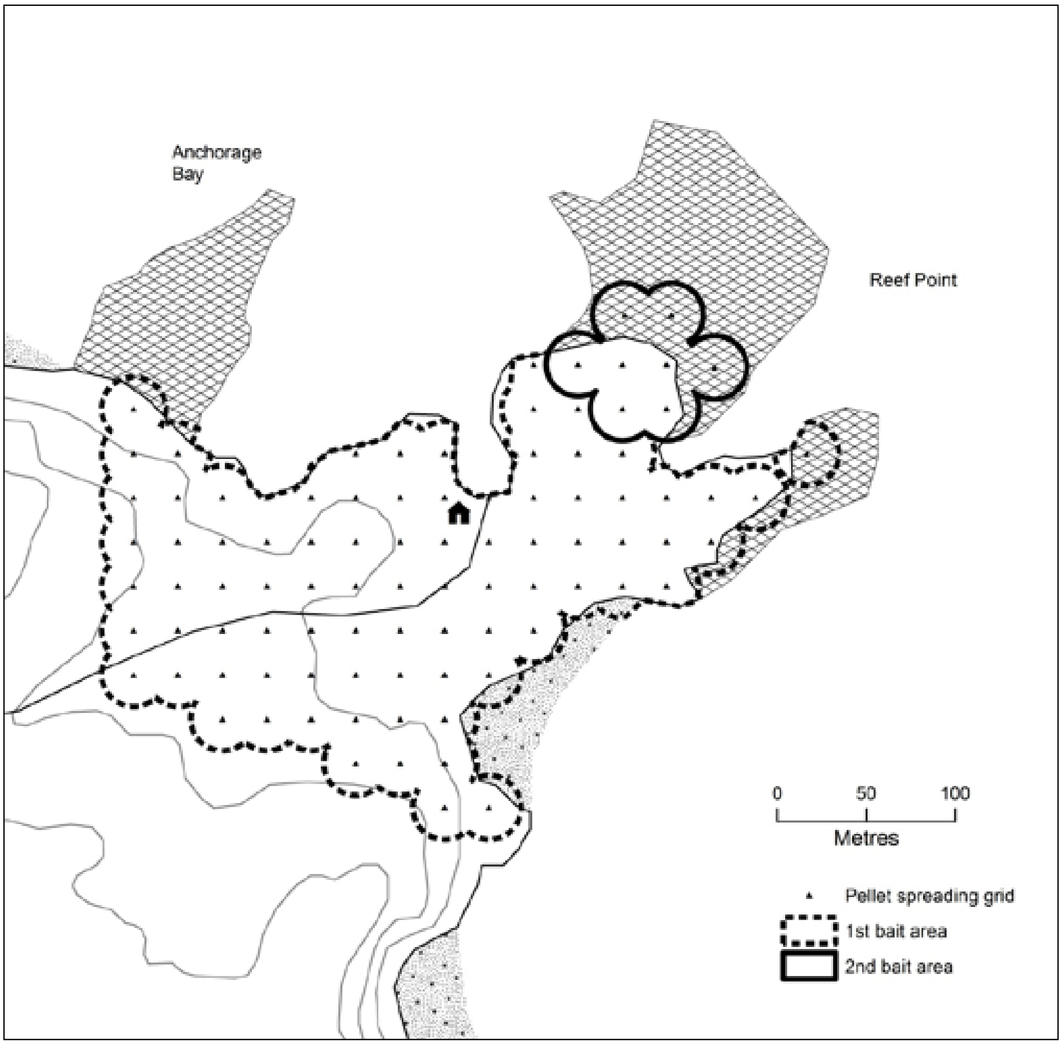

Figure 2. Reef Point showing the 25-m grid where non-toxic baits with a pyranine biomarker were spread on 11 and 23 July 2013.

2.2.2 Uptake by mice

At Reef Point, mice were captured using 49 Longworth live-traps on a 7 × 7 grid at a spacing of 10 m. Traps were set for 7 nights commencing 5 days after bait distribution. Traps were checked every morning and all mice captured were euthanised.

At Anchorage Bay, mice were captured using 14 traps on an underlying 7 × 7 grid at a spacing of 10 m. Traps were set for 3 nights commencing 10 days after bait distribution. These traps were placed at the only vegetated locations that fell on the grid intersection points and were within Anchorage Bay.

Following a capture, each trap was washed in warm water to remove all signs of pyranine. All mice captured at Reef Point and Anchorage Bay were inspected under UV light for signs of pyranine bait consumption, first externally around the mouth, anus, paws and body, and then internally in the gut cavity. Pyranine presence was recorded as high, low or none.

2.2.3 Uptake by birds

The capture and assessment of non-target bird species for bait take commenced on 13 July 2013. We attempted to detect the consumption of baits by non-target birds within the baited area in four ways:

1. Capturing birds and inspecting them under UV light for bait consumption

Between 13 and 21 July 2013, we captured 1 snipe, 9 pipits, 17 Reischek's parakeets and 16 Antipodes Island parakeets in hand nets and examined their bills, cloacas and any faeces they produced under UV light.

2. Opportunistically collecting faeces containing dye

Between 17 and 23 July, we repeatedly walked through the baited area examining bird faeces on the ground and collected 106 samples that glowed under UV light or showed green dye. We subsequently identified the species that produced a random sample of 50 of these droppings using DNA analysis, as follows.

Four blood samples from known species (pipit, Antipodes Island parakeet, Reischeck's parakeet and snipe) were sent to EcoGene® for genetic sequencing and use as reference samples for the identification of bird faecal samples. High-quality sequences for the four blood reference samples were obtained and included in the EcoGene® reference database.

A total of 100 faecal samples were provided for analysis. Initial genetic identification was conducted on a random selection of 20 samples to determine the most appropriate protocol for further DNA extraction. A further 30 randomly selected samples were subsequently analysed using the improved protocol.

Initial DNA extraction from bird faecal samples was completed using readymade reagents from Qiagen® in an automated bench-top DNA extractor for ten of the samples and the QIAamp® DNA Stool kit (Qiagen®) following the Stool Human DNA protocol for the second group of ten samples (A. Ramon-Laca, Ecogene, pers. comm.). Subsequent (and improved) extraction was similar to the former method but used greater volumes of reagents. General species identification was undertaken by amplification of both the cytochrome b gene (Cytb) (primers L15330AV and H16074AV from Lee et al. (2008)) and the cytochrome *c* oxidase subunit I (COI) (primers AWCF1 and AWCR6 from Patel et al. (2010)) (A. Ramon-Laca, pers. comm.). Edited DNA sequences were then compared against sequences from GenBank, which is administered by the National Center for Biotechnology Information (NCBI), and against the database administered by EcoGene®. The BLAST (Basic Local Alignment Search Tool) algorithm was used to search for the most closely matching sequences within the NCBI and EcoGene® databases (A. Ramon-Laca, pers. comm.).

3. Systematically collecting all faeces along a line transect

On 26 July, we systematically collected every bird dropping (a total of 92) within 1 m of five 50-m-long transects.

4. Observing bird interactions with baits

Between 17 and 23 July, we followed pipits (c. 12 hours) and both species of parakeets (c. 12 hours) and watched them through binoculars to observe any sign of bait consumption. Whenever a bird was seen defecating, we examined the faeces under UV light. No snipe were seen defecating and we were unable to identify any snipe faeces.

Northern giant petrels

On Macquarie Island, large numbers of northern giant petrels were killed during a mouse and rabbit eradication operation in 2010 as a result of the birds eating rabbits that had been poisoned with brodifacoum (Tasmania Parks and Wildlife Service 2010). It is considered unlikely that northern giant petrels would eat poisoned baits during the Antipodes Island mouse eradication, but they might eat poisoned mice. Therefore, we attempted to determine whether northern giant petrels on Antipodes Island would eat baits and/or dead mice.

On 23 July 2013, we placed two piles of six dead mice in the middle of a northern giant petrel colony (c. 20 birds) about 400 m from the hut at the northern end of North Plains. We also placed a total of 23 dead mice at 10 m intervals to the northeast and southwest of the colony (Fig. 3). In addition, we placed 30–40 non-toxic baits alongside each of the piles of mice. Motion-triggered automatic cameras were set up at each pile of mice and baits to record any activity by northern giant petrels or mice. The mice, cameras and baits were checked after 2 and 4 days.

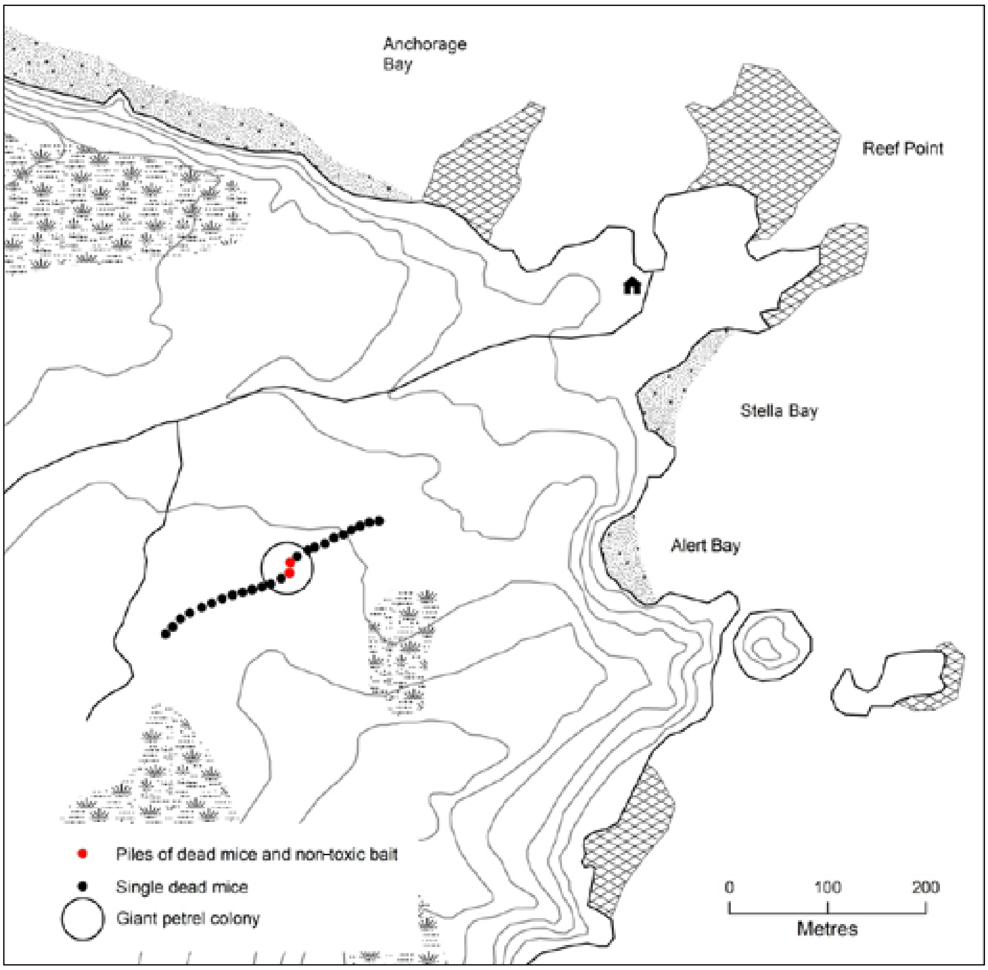

Figure 3. Locations where dead mice (*Mus musculus*) and non-toxic baits were laid to assess their consumption by northern giant petrels (*Macronectes halli*).

2.3 Bait decay trials

To assess the effective life of baits, we set out 50 wire mesh (12 mm) tetrahedrons, each of which contained two baits, at 60-m intervals between the hut and the summit of Mt Galloway (Fig. 4) on 12 July 2013. The intention was to score the condition of baits at regular intervals during our stay on the island (Greene & Dilks 2004). Unfortunately, however, the majority of the baits were quickly consumed by mice—particularly at lower altitudes. Although there was little evidence that mice were entering the mesh cages, mice were able to access baits from the outside—often by burrowing under the base. Therefore, we were only able to assess the condition of baits in seven cages, which we collected on 25 July.

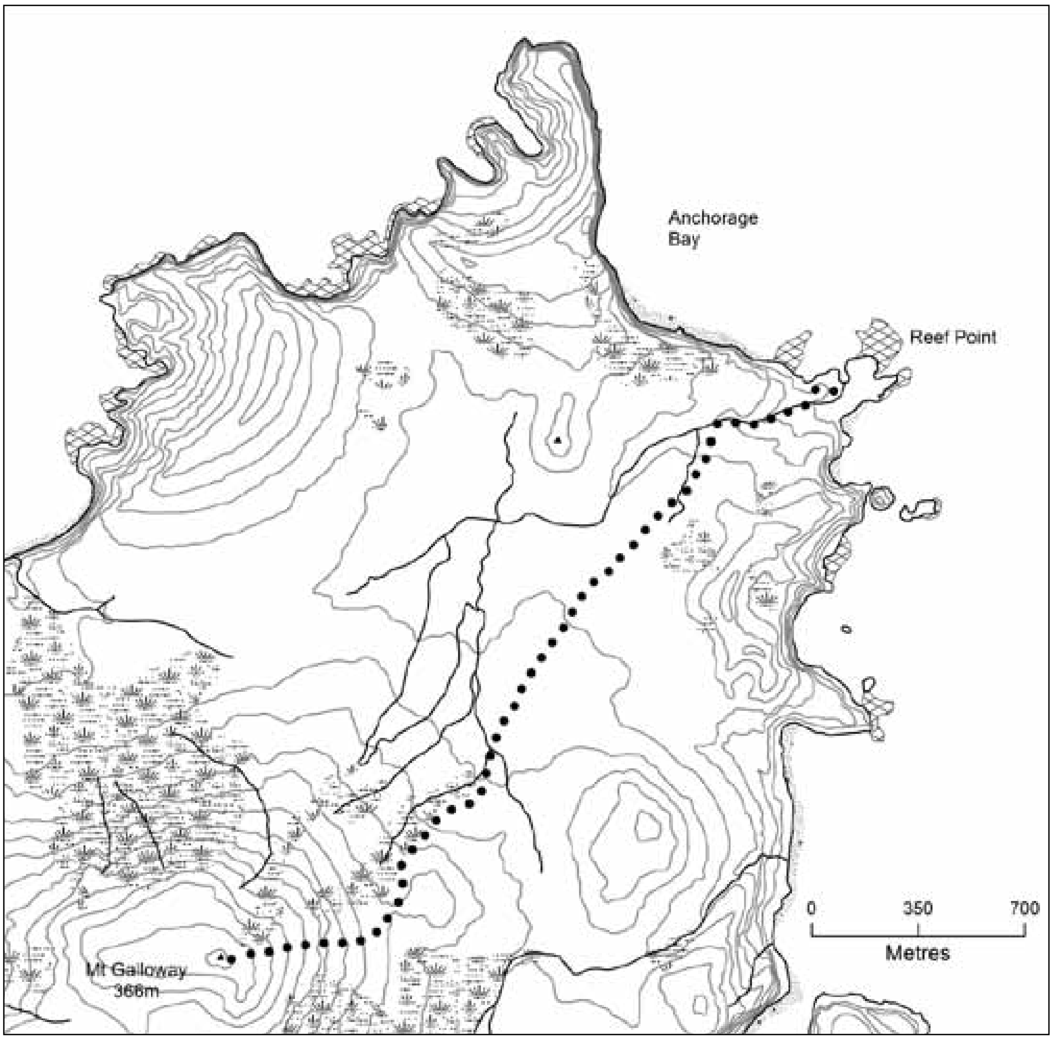

Figure 4. Transect of 50 bait decay tetrahedrons on Antipodes Island.

2.4 Population monitoring

2.4.1 Mice

Three contrasting sites of differing vegetation and altitude that had previously been trapped by Russell (2012) and others were resurveyed for the density of mice in July 2013 (Fig. 1). Sites were relocated to within 5 m using GPS. At each of these sites, the vegetation is most dense (2 m height) around low-lying coastal areas, such as Reef Point and Anchorage Bay, whereas smaller, more widely-spaced cushion plants (0.5 m height) occur on the inland elevated plateau areas, such as North Plains.

At Reef Point and North Plains, the mouse population density was estimated over 7 nights using capture-recapture methods with a 7 × 7 grid of 49 Longworth live-traps spaced at 10-m intervals. Traps were checked every morning. At North Plains, all mice that were caught were ear-tagged to allow short-term individual identification and were approximately weighed in a 5-g zip-lock bag prior to release; and all mice captured on the final night of trapping were euthanised for autopsy. At Reef Point, all mice captured on the grid were euthanised on first capture, as part of the simultaneous pyranine bait-marker study. Mice were trapped over 3 nights at Anchorage Bay using 14 traps on an underlying 7 × 7 grid spaced at 10-m intervals. These traps were placed at the only vegetated locations falling on grid intersection points and within Anchorage Bay, and mice were again euthanised on first capture.

The density of mice, D, was estimated using maximum-likelihood spatially explicit capture recapture (ML SECR) implemented in program R and package SECR (Borchers & Efford 2008). A Poisson (i.e. random) distribution of range centres was assumed, with a half-normal curve detection function parameterised by g_0 (the probability of detection when the trap and range centre coincide) and σ (the spatial scale of the detection function). Removals from the population (i.e. as a result of accidental deaths during trapping or euthanasia on the bait-marker grid) were assigned known capture histories of 0 with probability equals 1 following death. A conditional likelihood was used to derive the density, which incorporated individual covariates of age and sex, and models were compared using an AIC framework. The 'capture function', which in many ways is related to an animal's actual home range (Borchers & Efford 2008), was approximated by the 95% circular probability density area of capture:

$$A = \pi(2.45\sigma)^2$$

Both full grids (Reef Point and North Plains) were analysed simultaneously, whereby density (D) and the probability of capture (g_0) could vary between grids as a function of site, but it was necessary to assume that mice have a constant range size (i.e. σ was estimated from only the North Plains grid). This seemed a fair assumption, as other rodent studies using spatially explicit capture-recapture methods have shown that although D and g_0 differ between sites, σ remains remarkably constant (e.g. Russell et al. 2011), and this was also assumed to be the case for previous live-trapping studies on Antipodes Island (Russell 2012). It was also assumed that a 40-m trapping buffer extended around the grid.

All dead mice were inspected for reproductive activity (scrotal testes or lactating nipples), weighed to the nearest 0.5 g (50-g Pesola Scale), and measured for body and total length to the nearest 1 mm (30-cm ruler). Summaries of adult body-size metrics (weight, head-body length and total length) are provided for comparison with previous studies, and differences in these metrics were individually tested using analyses of variance, which included site (Reef Point, North Plains, Anchorage Bay) and sex as fixed effects. Tissue samples (tail tips) were taken from all individuals and stable isotope samples (muscle, bone and liver) were taken from a subset.

2.4.2 Parakeets and pipits

During our visit, we attempted to estimate the density of Antipodes Island parakeets, Reischek's parakeets and pipits using distance sampling. Distance sampling involves measuring the distance to an object of interest (in this case, a bird or cluster of birds) from a transect line, modelling the observed decline in detectability and deriving an estimate of density using the software program DISTANCE 6.2 (Thomas et al. 2009).

In total, 19 transects of variable length (224–795 m) were traversed up to three times during our visit (Fig. 5), resulting in 12 994 m being surveyed. Distances to individuals and clusters of parakeets and pipits were recorded to the nearest metre using a laser range-finder (Nikon Forestry 550). All distances were measured perpendicular to the line. Birds flying into or over the count area were excluded from the analysis. If birds were flushed on or near the line, every effort was made to record the distance to the point from which the birds were disturbed; and if

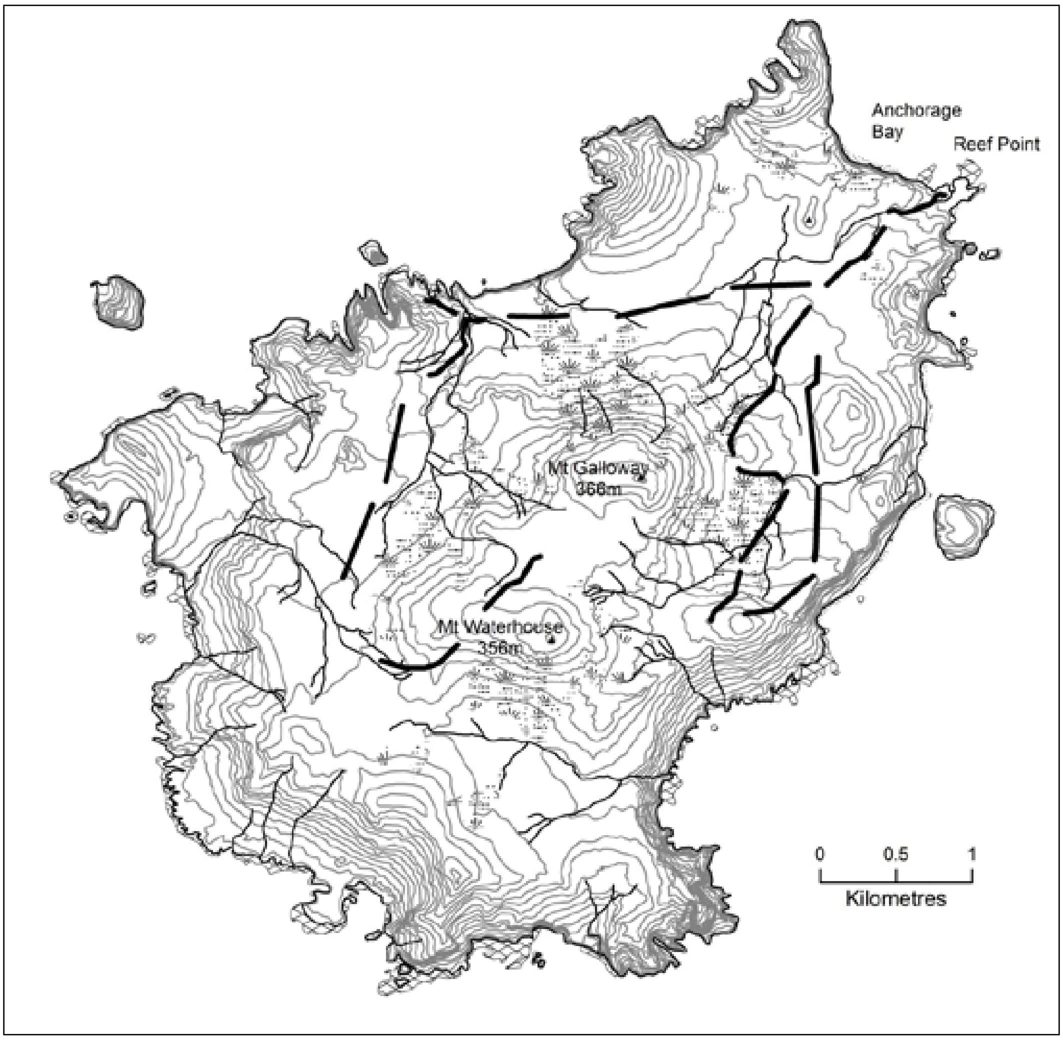

Figure 5. Distance sampling transects (dark lines) for Antipodes Island parakeets (*Cyanoramphus unicolor*), Reischek's parakeets (*C. hochstetteri*) and Antipodes Island pipits (*Anthus novaeseelandiae steindachneri*).

this could not be achieved, these records were excluded from the analysis. Although sampling coverage was not ideal, we attempted to sample the most important and extensive habitats in the northernmost part of the island.

2.4.3 Snipe

It is possible—perhaps even likely—that snipe might increase in abundance on Antipodes Island following the eradication of mice, as snipe and mice are likely to compete for invertebrates (Miskelly et al. 2006). Robust snipe monitoring was initiated by Kath Walker and Graeme Elliott in summer 2012, and we continued this monitoring on this trip.

All snipe that were seen were recorded, as was the amount of time spent in the field. Snipe monitoring was undertaken on most days in all but the foulest weather. Snipe that were heard but not seen were not recorded, as Graeme Elliott and Kath Walker have noted considerable seasonal variation in snipe calling rates, and because many more snipe can be heard in calm weather than in windy weather.

2.4.4 Invertebrates

Surface invertebrates, which are most at risk from mice, were sampled at five previously established sites (Reef Point, Anchorage Bay, Hut Creek, North Crater and Mt Galloway) using ten pitfall traps (80-mm diameter, 90-mm depth) that were spaced more than 10 m apart. Traps were buried with their rim flush with the surface of the ground, were covered with a green plastic lid, and filled to approximately 2-cm depth with a 50/50 mix of glycol and water plus a drop of detergent. After 10 days, the contents were removed and subsequently identified to taxonomic unit (species for Coleoptera, and class or order for all other taxonomic groups). Multivariate (using Pillai's trace) and univariate analyses of variance were used to determine whether there were any differences in the invertebrate communities and taxonomic units between sites on Antipodes Island, and between winter (July) 2013 and summer (January) 2011. All differences reported are significant at the 0.05 level. Count data for the number of individuals were $\log_{10}+1$ transformed to remove right skew, and for multivariate analysis, data were then standardised by subtracting means and dividing by standard deviations. Only taxonomic units with sufficient data were used for univariate comparisons.

2.5 Capture and husbandry of parakeets

2.5.1 Capture

If it is considered necessary to hold parakeets in captivity during the mouse eradication, we will need to know how much person-power is required to capture a suitable sample of both Antipodes and Reischek's parakeets. To this end, we attempted to catch parakeets, recorded how quickly we could catch them as well as collecting blood samples for genetic analysis and examining each bird and any faeces produced for the pyranine biotracer.

We devoted 3 person days to catching parakeets near the hut and Reef Point penguin colony, and opportunistically captured parakeets throughout the rest of the trip. We also observed the activity of parakeets at the penguin colony opposite Orde Lees Island on 27 July.

2.5.2 Diet

Feeding observations for both species of parakeet were recorded opportunistically in a similar format to that used by Taylor (1975, 1985) and Greene (1999), whereby the first food that was seen to be consumed by a parakeet was noted. Foods were classified as one of seven food types or as unknown (Greene 1999). Observations were mostly collected around the northern end of the island and were made within as many habitats as possible.

2.5.3 Husbandry

We held 15 parakeets (ten Reischek's and five Antipodes Island) in captivity for 11–13 days to determine:

1. Whether unrelated parakeets could be held together in a cage without hurting each other.
2. Whether parakeets could be quickly trained to eat artificial food.
3. How the birds fared in captivity.
4. Whether they would eat non-toxic baits.

Groups of five parakeets were held in three separate cages. The Antipodes Island parakeets were held in a cage measuring 100 × 100 × 50 cm, and the Reischek's parakeets were held in two cages that measured 60 × 60 × 40 cm. Birds were provided with water, and heat-treated commercial parrot seed mix (Tui Products Cockatiel Mix) in bowls, and chopped apples and kumara scattered along the front of the cages. Five non-toxic baits were placed in each cage on 15 July 2013 for 24 hrs to assess palatability. No natural food, other than *Poa littorosa* tussocks placed in the cages to give them places to roost and hide, was provided. Birds were weighed and measured on capture, and were weighed again at the time of release.

3. Results and Discussion

Annotated lists of the birds and mammals that were seen on and near Antipodes Island during this trip are provided in Appendices 1 & 2, and all specimens that were collected are listed in Appendix 3.

3.1 Bait uptake

3.1.1 Mice

All of the 100 autopsied mice that were trapped within the baited area at Reef Point and Anchorage Bay showed signs of having consumed pyranine, 95% at high levels and 5% at low levels. Thus, the results of this pyranine bait marker study suggest a 100% exposure of mice to baits distributed at a sowing rate of 16 kg/ha. The level of pyranine consumption was not related to gender. However, four of the five mice that had low levels of consumption were trapped in the last 2 days of trapping, corresponding to days 12 and 13 post-baiting. Thus, there was evidence that at this sowing rate mice were no longer feeding on baits approximately 10 days after bait distribution, probably because they had exhausted the supply of palatable baits within their home range. Since we only started to monitor bait consumption 5 days after bait distribution (to prevent the use of traps from interfering with bait consumption), it is unknown how rapidly mice began to consume the baits. Two aerial applications of bait about two weeks apart, totalling at least 16 kg/ha, appears sufficient for 100% exposure of mice to bait.

3.1.2 Birds

None of the birds that were captured using hand nets (1 snipe, 9 pipits, 17 Reischek's parakeets and 18 Antipodes Island parakeets) showed signs of having eaten baits, based on an inspection of their bills, cloacas and faeces (See Appendix 4 for details of all parakeets that were captured by hand net).

The species that produced 50 of the droppings that glowed under UV light or contained green dye (of the 106 droppings collected) were identified, using DNA analysis (Table 1). The majority of these faeces were produced by non-native bird species with only 3 of the 50 samples (6%) able to be attributed to any native species (i.e. pipits). Interestingly, no snipe faeces were detected in the dyed faeces we collected, despite us repeatedly seeing snipe within the area in which the non-toxic baits had been laid. Therefore, if snipe eat baits, they do so only rarely. It was also surprising that 78% of the faeces genetically identified to species came from blackbirds (*Turdus merula merula*) and song thrushes (*T. philomelos clarkei*), and that we observed these birds on at least three occasions during this trip, as these species are quite rare on Antipodes Island—indeed, prior to this trip, one of us (GE) has made six summer trips to the island, each of about 6–8 weeks'

Table 1. Species identification of 50 faeces containing traces of pyranine.

SPECIES	*n*	%
Mallard *Anas platyrhynchos*	2	4
Blackbird *Turdus merula merula*	22	44
Song thrush *Turdus philomelos clarkei*	17	34
Antipodes Island pipit *Anthus novaeseelandiae steindachneri*	3	6
Dunnock *Prunella modularis*	2	4
Mammals	4	8
Total	50	100

duration, but has never seen a live blackbird or thrush. It seems unlikely that there is a resident population of either of these species on the island. Rather, it is likely that birds arrive on the island from time to time.

Thirty-two (35%) of the 92 faeces that were collected along the line transect contained pyranine dye. Twelve of these samples contained low amounts, while 20 contained large amounts. These samples have not yet been identified using genetic techniques, but we tentatively identified 52 of the 92 droppings as having come from pipits—being amongst the smallest faeces we collected. Twelve (23%) of these possible pipit faeces contained dye.

During our behavioural observations, we did not see any parakeets eating baits, despite observing them walking over baits. However, on 19 July we observed a pipit eating a few fragments of bait. We also saw four Reischek's parakeets, two Antipodes Island parakeets and three pipits defecating; however, only the faeces of one of the pipits contained dye.

The observation that neither species of parakeet ate baits is consistent with the findings of ad hoc trials in previous summer trips to Antipodes Island. Therefore, if they do consume baits, it is likely to be a rare event. Although red-crowned parakeets (*Cyanoramphus novaezelandiae*) were killed during the rabbit and mouse eradication on Enderby Island, these deaths had no apparent impact on the population (GE, pers. obs.); and on Burgess Island (Mokohinau Group) and Macauley Island (Kermadec Islands), red-crowned parakeets were commonly observed feeding on the ground in the presence of baits, but no deaths were recorded and no detectable impact on the parakeet populations was observed (McFadden & Greene 1994; Greene & Dilks 2004; TG, pers. obs.).

It is evident from our findings that pipits do eat the baits. However, the fact that only 23% of the faeces we tentatively identified as coming from pipits contained dye suggests either that most pipits do not eat baits or that pipits only occasionally eat baits. The LD_{50} of brodifacoum for pipits is unknown, but for other passerines it is between 3 and 6 mg/kg (Eason & Wickstrom 2001). This means that a 35 g pipit would have to eat two to four 2 g baits to have a 50% chance of dying. Few observations exist of pipit populations during rodent eradication operations, as rats and pipits do not commonly co-exist. However, baiting in the Stromness Bay area on South Georgia Island locally eradicated a population of pipits at Tonsberg Point, which had been recolonised from Grass Island following rat eradication in 2000 (Poncet 2012). It is most likely that the mouse eradication on Antipodes Island would cause only a minor mortality amongst pipits, but there is a large amount of uncertainty around this. Therefore, there are three options for pipit management during the mouse eradication:

1. Carry out a small-scale toxic operation on part of Antipodes Island before the mouse eradication to obtain a better estimate of pipit mortality rates.
2. Conclude that even if pipit mortality is high, pipits will recolonise from the adjacent offshore islands.
3. Take an insurance population into captivity for a number of weeks around the eradication. This will require development of pipit husbandry techniques.

Northern Giant petrels

None of the mice that were placed in the northern giant petrel colony at North Plains were removed. However, about half of the baits had disappeared after 2 days and all had gone after 4 days. The motion-detecting cameras showed that live mice took the baits away, and that northern giant petrels walked over both the baits and dead mice without showing any apparent interest. We carried out this experiment at the very start of the northern giant petrel breeding season, when individuals were courting and building nests. Over-wintering brown skua (*Catharacta antarctica lonnbergi*) and kelp gulls (*Larus dominicanus*) also showed little interest in baits, but in previous summer trials have shown interest in dead mice.

The northern giant petrels' apparent lack of interest in mice on Antipodes Island contrasts with the high mortality of birds that was recorded on Macquarie Island, presumably as a result of eating poisoned rabbits (Tasmania Parks and Wildlife Service 2010). Since our trial took place at about the same time of year as the poison drop on Macquarie Island, this difference is unlikely to be due to behavioural differences associated with the time of year and stage in the breeding cycle. Rather, it is more likely that small dead mice are less attractive to northern giant petrels than are large dead rabbits, particularly because rabbits were a more conspicuous food source on the more sparsely vegetated Macquarie Island, and birds had learned to look for them, particularly after rabbit control operations.

3.2 Bait decay

Six of the seven cages that still contained baits on 25 July were located on the exposed eastern slopes of Mt Galloway. All baits were wet, soft and slightly swollen (between 1 and 2 on the Craddock scale; Greene & Dilks 2004), but they had maintained their shape and colour well. There were no other signs of decomposition, such as mould or fungus.

3.3 Population monitoring

3.3.1 Mice

A total of 60 mice were live-captured at North Plains, 42 of which were autopsied; and 71 mice were live-captured at Reef Point and 29 at Anchorage Bay, all of which were autopsied. Tissue samples (tail tips) were taken from all dead mice (n = 142), and stable isotope samples (muscle, bone and liver) were obtained from a subset of Reef Point and North Plains (n = 22 each), and Anchorage Bay (n = 21) mice.

There was no significant difference in the sex ratio of captured mice (binomial test, $n = 142$, $P > 0.05$). There was also no significant difference in the lengths of males and females ($F_{1,138} = 0.96$, $P > 0.05$), but males were significantly (albeit only slightly) heavier ($F_{1,138} = 9.58$, $P < 0.05$). Coastal mice were in better physical condition (estimated as the ratio of body-weight to head-body length). Adult mice were of a body size and weight that was typical for Antipodes Island (Table 2), although mice at North Plains were significantly smaller in both weight ($F_{2,138} = 83.29$, $P < 0.05$) and head-body length ($F_{2,138} = 22.39$, $P < 0.05$)—mice that were recaptured at North Plains lost an average of 0.67 g body weight per day of the study from first capture, but even after accounting for this they were significantly smaller. Six of the 15 largest mice (weight > 24 g) had evidence of being reproductively able (four males and two females), although no embryos were found on dissection of the females. No juveniles were captured using the 72-mm head-body length summer threshold of Russell (2012), and this was supported by a clear unimodal distribution of body size (c.f. a bimodal distribution corresponding to different cohorts in summer).

Mouse breeding appears to almost, if not completely, cease at midwinter on Antipodes Island, except perhaps for a few of the largest and healthiest individuals, who may retain reproductive condition (5% of the population). Similarly, on Steeple Jack Island in the Falklands, mice recommence breeding in late August (Rexer-Huber et al. 2013). The density of adult mice on the island in winter 2013 (104 mice/ha at Reef Point and 74 mice/ha at North Plains) was not significantly different from the adult density that was previously recorded in January 2011 by Russell (2012) (83 mice/ha at Reef Point and 55 mice/ha at North Plains). This may be due to winter 2013 having been incredibly mild on the island—also being the warmest winter on record for New Zealand (at the time of writing). However, this may also be the norm, as the incumbent adult population of a species with no more than a 2-year life-span should remain constant, with population fluctuations instead being driven by the onset of breeding and juvenile recruitment—the latter of which appears to be focused mainly in the dense coastal tussock on Antipodes Island

Table 2. Mean morphological parameters (range in parentheses) of adult mice (*Mus musculus*) captured at three sites on Antipodes Island in July 2013. HBL = head-body length; TL = total length.

SITE	SEX	*n*	WEIGHT (g)	HBL (mm)	TL (mm)
Reef Point	♂	42	19.6 (15.5–26.0)	86.5 (77–98)	82.5 (73–94)
	♀	29	19.4 (15.0–25.0)	86.2 (76–99)	81.9 (73–95)
Anchorage Bay	♂	16	23.2 (18.5–29.0)	90.2 (83–100)	86.4 (76–93)
	♀	13	19.3 (17.5–21.0)	85.8 (80–90)	78.8 (73–86)
North Plains	♂	25	14.8 (11.0–19.0)	80.2 (71–90)	79.5 (70–97)
	♀	17	13.5 (11.0–17.5)	80.9 (69–92)	77.9 (67–92)
Total	♂	83	18.9 (11.0–29.0)	85.3 (71–100)	82.4 (70–97)
	♀	59	17.7 (11.0–25.0)	84.6 (69–99)	80.1 (67–95)
	♂ + ♀	142	18.4 (11.0–29.0)	85.0 (69–100)	81.4 (67–97)

over summer (Russell 2012). It also seems likely that the abundance of carex seeds driving mouse abundance near the coast during summer months may also persist into the winter. These seeds can remain viable for more than a year (S. Courtney pers. comm.) and may represent a reliable winter food source for mice until at least spring.

In the model with best fit (97% model weight) for the winter capture-recapture data (for which all mice were adults), sex had a significant effect on capture probability and range size, and site also had a significant effect on capture probability (remembering that range size was assumed to be the same between sites as only one grid yielded recapture data). Winter estimates of mouse density, probability of capture and range size on Antipodes Island (Table 3) were generally similar to summer estimates for adult mice. Capture probability at Reef Point may have been depressed by baits providing an alternative resource. Adult females had a smaller range than males, but this was still large at c. 20 m radius (c.f. 30 m for males). It would be useful to carry out further analysis that includes summer capture-recapture data from January 2011. However, this would be difficult, since the juvenile age class only exists in summer, and although density estimates are reasonable, simultaneous analysis generates non-identifiability between g_0 and

Table 3. Density (number/ha, 95% CI in brackets, sexes combined), g_0 and σ for mice (*Mus musculus*) captured at two sites on Antipodes Island in July 2013.

SITE	SEX	g_0	σ (m)	DENSITY (number/ha) (95% CI)
Reef Point	♂	0.04	15.7	104 (73–148)
	♀	0.06	9.5	
North Plains	♂	0.12	15.7	74 (56–98)
	♀	0.16	9.5	

σ for juveniles, and thus unreliable estimates of these parameters. The inclusion of capture data from Anchorage Bay suggests that this area has the highest mouse density, i.e. around the penguin colonies; however, these estimates were unreliable as they were based on removal data over only 3 nights.

3.3.2 Parakeets and pipits

Relatively few birds were encountered along the transects. In total, only 21 Antipodes Island parakeets and 36 Reischek's parakeets were counted, for all of which distance measurements were obtained; and pipits were even rarer, with distance data recorded for only five individuals. Since 60–80 measurements are generally required to make robust estimates of detection probability, the data for parakeets were pooled (assuming equal or very similar detectability) and a global detection function computed and used to estimate the density for both species (Buckland et al. 2001). Density could not be computed for pipits due to the very low encounter rate. To improve model fit, distance data were truncated to only include distances to parakeets of less than 55 m (Buckland et al. 2001).

Analysis suggested that a hazard rate model described the data reasonably well and encounter rate variance was best estimated assuming a Poisson distribution of observations (Table 4). However, although model fit was reasonable, variance estimates were very high (CV > 35%). This was probably due to the small sample sizes and the need to pool data to compute a global detection function for both parakeet species, as the detection probabilities for each are likely to be dissimilar. Winter counts may also have been biased by the apparent movement of parakeets towards coastal areas—particularly those associated with abandoned penguin colonies. Despite these concerns, however, the encounter rates and density estimates for Antipodes Island parakeets and Reischek's parakeets (Table 4) seemed to be reasonable and appeared to reflect both parakeet species' abundances relative to each other.

Table 4. Encounter rate (per km) and density estimates (*n*umber/ha; 95% CI in brackets) for Antipodes Island parakeets (*Cyanoramphus unicolor*), Reischek's parakeets (*C. hochstetteri*) and Antipodes Island pipits (*Anthus novaeseelandiae steindachneri*) on Antipodes Island in July 2013.

	n	ENCOUNTER RATE (/km) (95% CI)	MODEL	GOF K-S p*	DENSITY (number/ha) (95% CI)
Antipodes Island parakeet	21	1.6 (1.1–2.5)	Haz rate/cos	0.69	1.02 (0.47–2.22)
Reischek's parakeet	36	2.8 (2.0–3.8)	Haz rate/cos	0.69	1.66 (0.81–3.39)
Pipit	5	0.4 (0.2–0.9)	–	–	–

* Goodness of fit statistic estimating model fit.

3.3.3 Snipe

In total, we saw 26 snipe over 325.5 person-hours across 16 days of observation—equivalent to a rate of 0.0799 snipe per hour. In the previous summer (2012), Graeme Elliott and Kath Walker saw 38 snipe over 341.0 person-hours across 31 days of observation—a rate of 0.1114 snipe per hour. These summer and winter detection rates are not significantly different (Poisson GLM with observation hours as an offset, $P = 0.1872$), and yield a combined rate of 0.0960 snipe per hour, as a pre-eradication baseline.

3.3.4 Invertebrates

Pitfall trapping in July 2013 yielded a total of 803 individuals from 12 orders (Araneae, Chilopoda, Coleoptera, Diptera, Gastropoda, Hemiptera, Hymenoptera, Isopoda, Neuroptera, Oligochaeta, Pseudoscorpionida and Siphonaptera; Fig. 6), although only five of these were found more than rarely (overall > 10 individuals: Araneae, Coleoptera, Diptera, Isopoda, Neuroptera), with the sample being dominated by Isopoda (> 100 individuals) and Coleoptera (> 500 individuals). Most Coleoptera (90% of 539 individuals) comprised a *Stenomalium* species, which was also the most

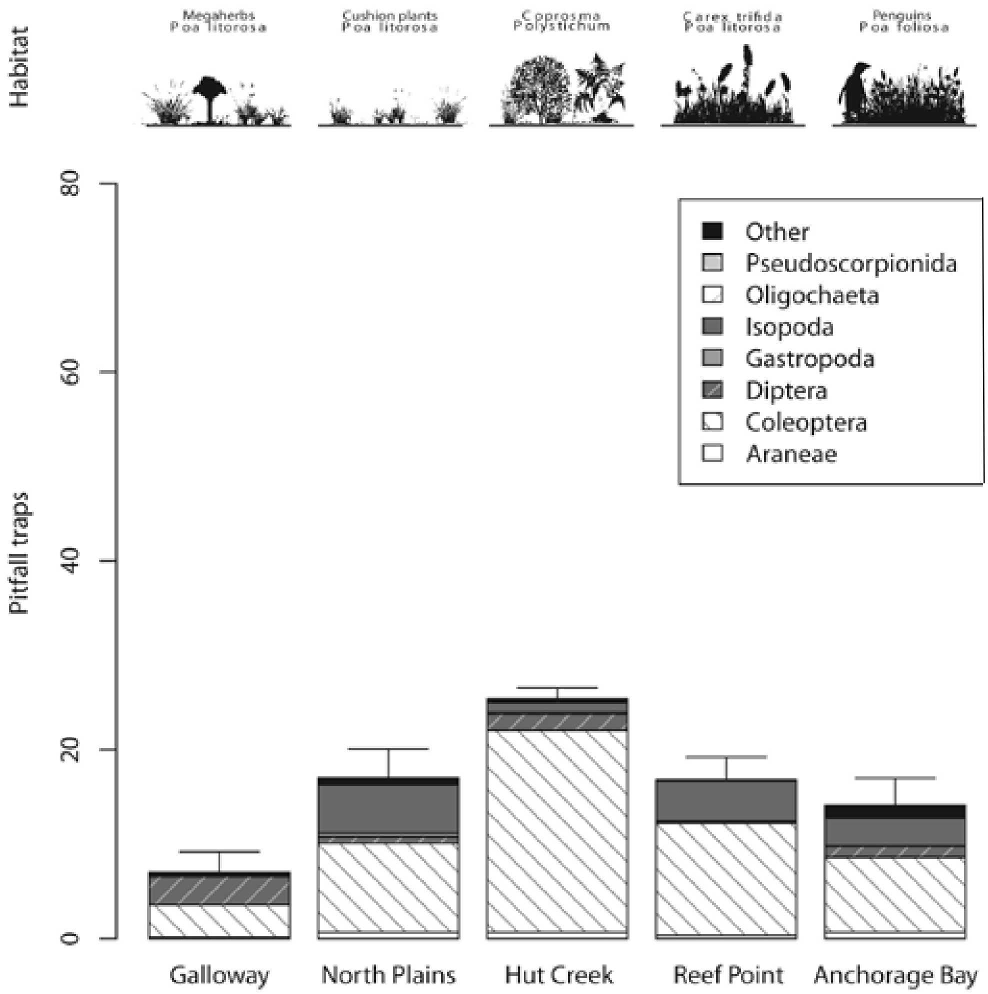

Figure 6. Relative abundances of macroinvertebrates at five locations on Antipodes Island in July 2013 (following Russell 2012). The error bars indicate 1 SE for the mean number of total macroinvertebrates per sample.

abundant in summer (January) 2011 (85% of 606 individuals), when Coleoptera numbers were similar. Although the abundance of this *Stenomalium* species decreased in winter at Mt Galloway, North Plains and Anchorage Bay, it increased at Reef Point and Hut Creek, and drove the overall patterns in macroinvertebrate community composition, which overall differed significantly between sites.

A comparison of winter (July 2013) with summer (January 2011) showed that the total number of macroinvertebrates in pitfall traps (all orders combined) decreased markedly at North Plains and Mt Galloway, and somewhat at Reef Point and Anchorage Bay, but increased at Hut Creek (mainly driven by the one species of Coleoptera). Orders that were only found occasionally (Pseudoscorpionida and Siphonaptera) or uncommonly (Amphipoda, Chilopoda, Hymenoptera and Lepidoptera) in summer 2011 were either at reduced numbers or completely absent from pitfall traps in winter 2013. However, Neuroptera (net-winged insects) and Oligochaeta (earthworms) appeared for the first time in Anchorage Bay, and Hemiptera (true bugs) shifted to higher altitudes (North Plains and Mt Galloway) in winter 2013. Orders that were found commonly in summer 2011 (Araneae, Coleoptera, Diptera, Gastropoda and Isopoda) were overall found in reduced numbers in winter 2013, although increases were observed at some sites (Coleoptera at Reef Point and Hut Creek, and Isopoda at the coastal sites Reef Point and Anchorage Bay).

Overall, the abundance of macroinvertebrates had halved over winter, although with some notable diversity changes, such as the appearance of net-winged insects and earthworms at Anchorage Bay over winter, and a shift of true bugs to higher altitudes. Sites that were associated with high-quality resources, such as coastal habitat (Reef Point), seabird nutrients (Anchorage Bay) or flowing water (Hut Creek), appeared to provide valuable over-wintering habitat to mitigate seasonal declines in some orders (Neuroptera with seabird nutrients, Isopoda at coastal sites and Coleoptera with flowing water). Winter declines in macroinvertebrate abundance were greatest at the high-altitude sites (North Plains and Mt Galloway).

Pitfall trapping following this protocol provides a simple tool for ongoing monitoring of the macroinvertebrate community and should be continued as regularly as possible to monitor community recovery following mouse eradication, especially at coastal sites, which have less seasonal variation.

3.4 Parakeet capture and husbandry

3.4.1 Capture

Graeme Elliott and Kath Walker had previously caught parakeets during January and February 2013, and concluded that Reischek's parakeets were relatively easy to catch in the open country away from the coast, but adult Antipodes Island parakeets were quite hard to catch in the thick vegetation they favoured. However, recently fledged Antipodes Island parakeet chicks were easier to catch from around the beginning of February, when they started to wander independently of their parents and could easily be attracted using recorded calls.

It was immediately apparent that in winter parakeets were much more common in and around the (now empty) penguin colonies than they had been in the summer. Reischek's parakeets were less common and more difficult to catch in the open country away from the coast than they had been in summer and Antipodes Island parakeets were still difficult to catch in the thick coastal vegetation they favoured. However, both species were relatively easy to catch in hand nets in the empty penguin colonies and on the boardwalks around the hut. Over 3 person days that were devoted to parakeet catching near the hut and Reef Point penguin colony, we caught 19 parakeets—5 Antipodes Island and 14 Reischek's. We also caught a further 15 parakeets (12 Antipodes Island and 3 Reischek's) more or less opportunistically during the rest of the trip.

On 27 July, we visited the penguin colony opposite Orde Lees Island. We found 30–40 Reischek's parakeets and about 20 Antipodes Island parakeets foraging amongst the penguin faeces and feathers that covered most of the ground in the colony. The Antipodes Island parakeets were also eating old penguin carcases. This confirmed our observation that parakeets were particularly numerous around the penguin colonies during the winter, and that penguin colonies would be the best places to catch them. However, only the Reef Point and Anchorage Bay colonies are easily accessible, and bringing birds back to the hut from either the south coast or Orde Lees penguin colonies would require a 1-hour walk through very difficult vegetation followed by 2–3 hours easy walking back to the hut.

Plots of weight versus bill length suggest that we probably caught about three times as many females as males of both species (Fig. 7). Therefore, we estimate that it would take up to 60 person days to catch 50 parakeets of both species with approximately equal sex ratios. Catching would most productively be confined to the penguin colonies around the hut, the Orde Lees penguin colony and on the South Coast. A helicopter would be required to bring birds back to the hut from Orde Lees Island and the south coast.

3.4.2 Diet

The winter diet of both species of parakeet was restricted to a small number of plant and animal species.

Of the 75 feeding observations recorded for Reischek's parakeets, 36% comprised leaves (mainly those of *Crassula moschata* and *Coprosma rugosa*) and over 40% were of unidentified items that were being actively sought in the wet ooze of faeces covering abandoned penguin colonies

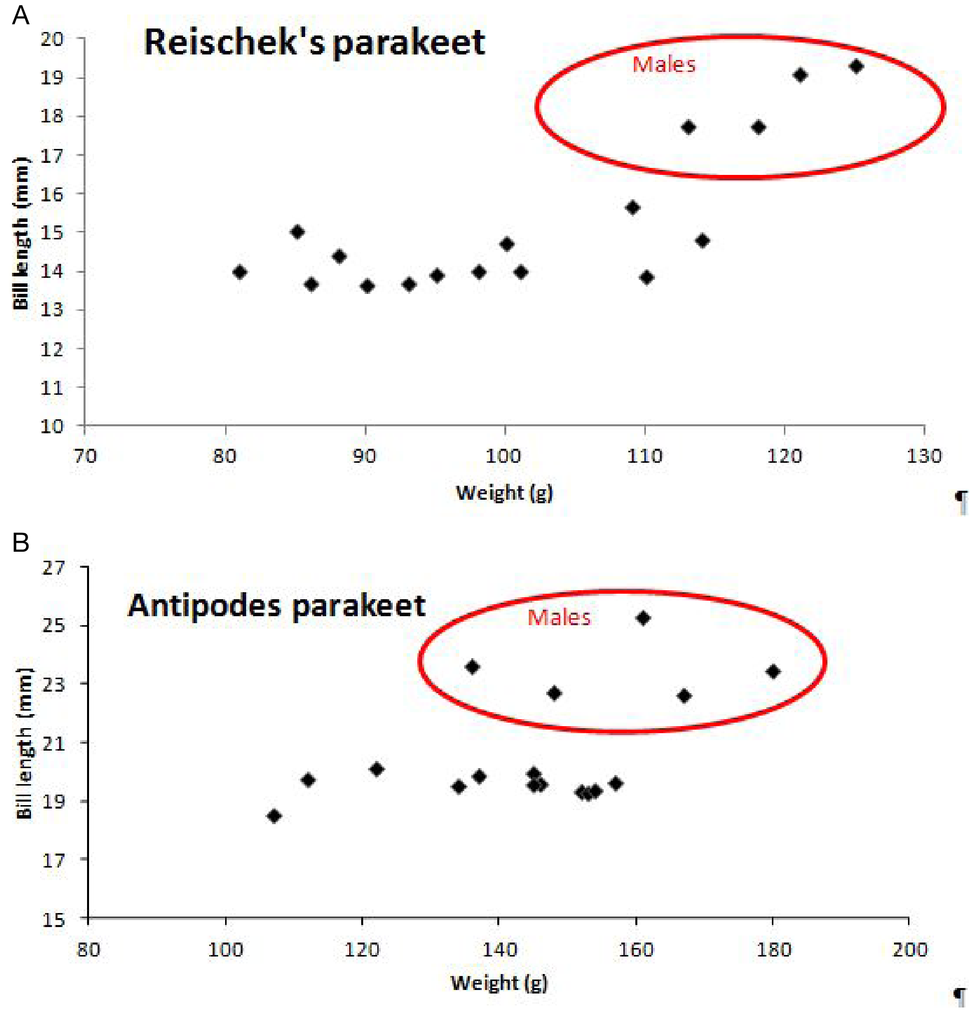

Figure 7. Plot of weight versus bill length for A. Reischek's parakeets (*C. hochstetteri*) and B. Antipodes Island parakeets (*Cyanoramphus unicolor*), with probable males circled in red.

(Tables 5 & 6). Reischek's parakeets were observed scratching through this wet and very smelly material with their feet and picking out very small items (invertebrates, seeds?) that we were unable to identify. This food source appeared to be a very important one for a significant number of parakeets during the period when erect-crested (*Eudyptes sclateri*) and rockhopper (*E. chrysocome*) penguins were absent from their colonies. In total, 30–40 Reischek's parakeets were observed foraging in this manner at the Orde Lees penguin colony on the North Coast of Antipodes Island (Fig. 1), while smaller numbers of parakeets were seen foraging at lesser penguin colonies in Anchorage and Stella Bays. Less-important components of this parakeet species diet included fruits (*Coprosma perpusilla*), roots and stems.

The diet of Antipodes Island parakeets was even less diverse (six plant species consumed compared with nine for Reischek's parakeet), with the bulk of the diet consisting of the chewed leaves of *Poa litorosa* (48.1%), *Carex appressa* (20.2%) and *Poa foliosa* (5.1%). Piles of chewed leaves were commonly seen wherever this species of parakeet was found, particularly in areas close to the coast. Also significant were observations of this parakeet species scavenging the corpses of penguins (10.1%) and petrels (1.3%). At Reef Point, the corpse of a New Zealand fur seal (*Arctocephalus forsteri*) pup provided a significant foraging opportunity for at least five Antipodes Island parakeets throughout the period we were on the island.

Table 5. Observations of foods consumed by Reischek's (*Cyanoramphus hochstetteri*) and Antipodes Island (*C. unicolor*) parakeets on Antipodes Island in July 2013.

FOOD TYPE	REISCHEK'S PARAKEET (*n* = 75)	ANTIPODES ISLAND PARAKEET (*n* = 79)
Leaves	36.0%	76.0%
Flowers	0.0%	0.0%
Berries & fruits	5.3%	0.0%
Seeds	0.0%	0.0%
Other vegetation	12.0%	2.5%
Invertebrates	0.0%	0.0%
Corpses	0.0%	19.0%
Unknown	46.7%	2.5%

Table 6. Frequency of food species consumed by Reischek's (*Cyanoramphus hochstetteri*) and Antipodes Island (*C. unicolor*) parakeets in July 2013 (percentage contribution in parentheses).

FOOD SPECIES	REISCHEK'S PARAKEET (*n* = 75)	ANTIPODES ISLAND PARAKEET (*n* = 79)
Acena minor—leaf buds	1 (1.3%)	–
Anisotome antipoda—stem base	1 (1.3%)	–
Carex appressa—leaves	–	16 (20.2%)
Carex ternaria—leaves	–	1 (1.3%)
Coprosma ciliata—leaves/buds	4 (5.3%)	–
Coprosma perpusilla—fruit	4 (5.3%)	–
Coprosma rugosa—leaves/buds	9 (12.0%)	1 (1.3%)
Crassula moschata—leaves/buds	12 (16.0%)	–
—stems	2 (2.7%)	–
Epilobium pedunculare—stems	–	2 (2.5%)
Leptinella plumosa—leaves	3 (4.0%)	–
—roots	1 (1.3%)	–
Montia fontana—leaves	2 (2.7%)	–
Poa foliosa—leaves	–	4 (5.1%)
Poa litorosa—leaves	1 (1.3%)	38 (48.1%)
Penguin carcass	–	8 (10.1%)
Other bird carcass	–	1 (1.3%)
Fur seal carcass	–	6 (7.6%)
Penguin colony ooze—unknown	30 (40.0%)	2 (2.5%)
Earth/roots	5 (6.7%)	–

3.4.3 Husbandry

Both species adapted quickly to captivity and there was very little panic reaction or flying into the wire. A little seed, apple and kumara were eaten on day one, after which consumption of all three foods increased quickly. Antipodes Island parakeets eventually ate lots of apple, some seed and no kumara, while Reischek's parakeets ate mostly seed, some kumara and very little apple. The Antipodes Island parakeets also ate quite a lot of the provided *Poa littorosa* foliage, so we did not test a completely 'cold turkey' transition to artificial food for this species. By contrast, Reischek's parakeets did not eat the *P. litterosa*. We found the food requirements of Reischek's parakeets to be slightly more than 1 cup of seed, 1 apple and 100 g of kumara per five birds per day; while Antipodes Island parakeets required 1 cup of seed and 2 apples per five birds per day. Neither species ate the non-toxic baits presented on 15 July 2013.

Whilst there was occasional squabbling amongst the captive birds, we did not observe any problematic social interactions. Therefore, it seems likely that unrelated birds could be held in groups in small cages. However, it should be noted that all three of our groups of five birds comprised one male and four females, so it is possible that there would be more aggressive interactions if there was more than one male per cage. Three of the five Antipodes Island parakeets had gained weight by the time they were released (mean weight change = + 16.8 g), while eight of the ten Reischek's parakeets had lost weight (mean weight change = −11.8 g) (Table 7). This difference is probably attributable to the Reischek's parakeets being accidentally left without food for an 8-hour period which corresponded to the day before five birds were released and 3 days before the other five were released.

Table 7. Weight changes in ten Reischek's (*Cyanoramphus hochstetteri*) and five Antipodes Island (*C. unicolor*) parakeets after 9–12 days in captivity.

PARAKEET SPECIES	SEX	BAND	CAGE	DAYS IN CAPTIVITY	WEIGHT (g)		
					CAPTURE	RELEASE	CHANGE (%)
Antipodes	Female	E130734	1	11	146	158	+12 (8.2)
Antipodes	Female	E130735	1	11	152	150	−2 (1.3)
Antipodes	Female	D134504	1	11	107	134	+27 (25.2)
Antipodes	Female	E130732	1	11	145	130	−15 (10.3)
Antipodes	Male	E130733	1	11	136	198	+62 (45.6)
Reischek's	Male	D134508	2	11	121	100	−21 (17.4)
Reischek's	Female	D134507	2	11	110	88	−22 (20.0)
Reischek's	Female	D134510	2	11	81	84	+3 (3.7)
Reischek's	Female	D134509	2	11	109	91	−18 (16.5)
Reischek's	Female	D134511	2	11	90	78	−12 (13.3)
Reischek's	Female	D134505	3	13	85	93	+8 (8.6)
Reischek's	Male	D134501	3	13	113	92	−21 (18.6)
Reischek's	Female	D134502	3	13	86	77	−9 (10.5)
Reischek's	Female	D134503	3	13	98	83	−15 (15.3)
Reischek's	Female	D134506	3	13	88	77	−11 (12.5)

4. Recommendations

Based on the findings of this study, we make the following recommendations for target and non-target populations on Antipodes Island prior to and following the planned mouse eradication operation.

4.1 Pyranine biotracer

Although pyranine was successfully detected in the faeces of birds, there is still considerable uncertainty around whether this dye can be directly detected on the beaks and/or anuses of birds that may have consumed dyed baits—particularly if quantities consumed are small. Therefore, we recommend further research into our ability to detect this biotracer on live birds and the optimum sites for doing so using a variety of captive species.

4.2 Mice

Throughout the year mice are having strong impacts on Antipodes Island, predominantly through direct impacts on invertebrates (Russell 2012), which are likely to have indirect flow-on effects on vegetation and land birds (although these are currently less well understood). Therefore, the eradication of mice should be considered a priority given that these impacts are likely to increase as winters get warmer.

The eradication of mice on Antipodes Island will provide an important case-study for scaling up mouse eradication operations to other larger islands.

Statistical tools are now available that allow eradication success to be confirmed more rapidly than the usual 2-year period. However, given the remoteness of Antipodes Island, a 'wait and see' approach will probably be the only viable option.

Following the successful eradication of mice from the island, there should be ongoing biosecurity to detect rodent invasion, at least at the current level (i.e. following the DOC standard operating procedure for subantarctic islands).

4.3 Birds

4.3.1 Parakeets

- Both the results of this study and findings from previous rodent eradications on islands where *Cyanoramphus* parakeets have been present (e.g. Macauley Island, Enderby Island and the Mokohinau Group) suggest that the mouse eradication operation on Antipodes Island is unlikely to have significant deleterious population-scale impacts on either of the parakeet species. However, should temporary captive holding be implemented, we recommend the following:
  - A minimum of twenty-five males and twenty-five females of each parakeet species should be captured and housed in captivity on the island for the duration of the operation. We recommend that these birds be held in large aviaries (rather than small cages) to reduce the captive management work load, to provide more natural food and better shelter, and to reduce the level of weight loss from that which was observed for Reischek's parakeets held in captivity during this study.
  - Careful consideration should be given to the size of enclosures to be used, the number of birds to be housed within them and the ratio of males to females to limit the potential for aggressive interactions.

  - Irrespective of the type of enclosure that is used, careful consideration should be given to ensuring that no toxic baits enter the cages and that any mice living in or around the enclosures are killed.
  - Given the perceived risk profile, the removal of birds to other islands (e.g. Campbell Island/Motu Ihupuku) solely for the purpose of protecting the species is considered unwarranted and likely to be problematic logistically.
  - Priority should be given to landing observers on Bollons Island to confirm the continued presence of both parakeet species. The presence of parakeets on the smaller outlying islands (i.e. Bollons, Archway, Leeward and the two Windward Islands) will provide useful natural source populations for future recolonisation of Antipodes Island, if required.
- We strongly recommend that the density of both parakeet species and pipits should be assessed using distance sampling prior to and following mouse eradication whenever field teams visit the island. Counts should incorporate distance data measurements and use the established transect lines outlined in this report. However, the accuracy and precision of density estimates could be significantly improved by establishing a more robust sampling design and ensuring that sufficient numbers (60–80 observations) of distance measurements for each species are collected.

4.3.2 Pipits

- Direct observations and genetic screening of faecal samples clearly demonstrated that pipits are likely to eat toxic baits and consequently there is a significant risk that a substantial number of birds will be killed during the proposed eradication operation. Unfortunately, our ability to manage this risk seems somewhat limited, but we recommend the following measures to address some of our uncertainty:
  - Priority should be given to landing observers on Bollons Island to confirm the continued presence of pipits. The presence of pipits on the smaller outlying islands (i.e. Bollons, Archway, Leeward and the Windward Islands) will provide useful natural source populations for future recolonisation, if required. Pipits are known to have rapidly recolonised Campbell Island/Motu Ihupuku from small offshore islands following the removal of rodents (Thompson et al. 2005).
  - Consideration should be given to holding pipits in captivity on Antipodes Island. However, before doing so, we need to be certain that pipits can be successfully held in captivity for significant periods of time by using one or more of the following methods:
    - Establishing whether pipits have been successfully kept in captivity elsewhere in New Zealand.
    - Holding a number of pipits in captivity on Antipodes Island during summer 2014/15 in the cages that were previously used for parakeets. However, it should be noted that any birds captured during the summer months are likely to be nesting and nest failures would be inevitable.
    - Organising a second winter trip to Antipodes Island to catch pipits and hold them in captivity.
    - Initiating a mainland analogue capture and holding programme over the winter months.
- If pipits can be held successfully in captivity, we recommend holding similar numbers as proposed for parakeets in small aviaries.
- The density of pipits (and parakeets) should be assessed prior to and following mouse eradication whenever field teams visit the island. Counts should incorporate distance data measurements and use the established transect lines outlined in this report.
- If rodent eradications are planned for islands with resident populations of pipits prior to the Antipodes mouse eradication, every effort should be made to monitor the impact on these birds.

4.3.3 Snipe

- As far as we are aware, this is the first rodent eradication to date in which large numbers of snipe will be exposed to toxic baits. Although a remnant snipe population was possibly still present on Enderby Island prior to rabbit eradication, it is not known how they fared or whether there was subsequent recolonisation from surrounding islands (A. Cox, DOC, pers. comm.). We have no evidence (direct or indirect) that snipe are likely to eat baits in the winter, but their diet and mode of foraging suggests that the risk to them is very small. However, we acknowledge that the non-toxic trial was small in scale and the number of birds exposed to these baits was also likely to be very small.
- Catching and holding birds in captivity as an insurance population does not appear to be a practical option for snipe.
- Priority should be given to landing observers on Bollons Island to confirm the continued presence of snipe. The presence of snipe on the smaller outlying islands (i.e. Bollons, Archway, Leeward and the Windward Islands) will provide useful natural source populations for future recolonisation, if required. Snipe are known to have rapidly recolonised Campbell Island/Motu Ihupuku from small offshore islands following the removal of rodents (Miskelly et al. 2006).
- The index of snipe encounter rates should continue to be recorded both prior to and following mouse eradication whenever field teams visit the island.

4.3.4 Northern giant petrels

- There was no evidence that northern giant petrels were tempted to eat baits or dead mice and so the risk to this species appears to be low.
- The continued persistence of the four known colonies of northern giant petrels (location and approximate size) should be monitored both prior to and following mouse eradication.

4.3.5 Other bird species

- We have no evidence (direct or indirect) that skua (*Catharacta antarctica lonnbergi*) eat baits or dead mice in the winter, but given their dietary habits, the risk of secondary poisoning appears high. Fortunately, however, few skua remain on the island over winter, so any population impact is likely to be minimal.
- An attempt to assess the size of the skua population that is present on Antipodes Island should be made. If a meaningful monitoring method can be established, it should be repeated annually prior to and following mouse eradication.
- We have no evidence (direct or indirect) that kelp gulls (*Larus dominicanus*) eat baits or dead mice in the winter, but given their dietary habits, the risk of primary or secondary poisoning appears high. Fortunately, however, few kelp gulls remain on the island over winter, so any long-term population impact is likely to be minimal.
- If possible, seasonal counts of gulls should be conducted and their persistence over time, particularly between Anchorage and Stella Bay, should be monitored.
- Non-toxic baits were known to have been consumed by all the recent bird colonisers listed in Table 1. Therefore, it seems likely that their numbers will be significantly reduced and they may be eliminated from Antipodes Island as a result of the mouse eradication operation. However, no impact mitigation plan is required because of their introduced and abundant status on mainland New Zealand and the likelihood they will recolonise relatively quickly.
- No impact mitigation plan is required for redpolls (*Carduelis flammea*), which are recent colonisers and common on mainland New Zealand.
- It is unlikely that silvereyes (*Zosterops lateralis*) will eat baits (K. Broome, DOC, pers. comm.) and even if they do, no impact mitigation plan is required because of their recently introduced and abundant status on mainland New Zealand, and the likelihood they will recolonise relatively quickly.

4.4 Invertebrates

- The programme of standardised invertebrate monitoring using pitfall trapping should be continued in all subsequent visits to the island, where practical, regardless of the outcome of mouse eradication. Increases in the invertebrate populations are likely to be a key outcome of mouse eradication and it is essential that this response is monitored using robust methodologies to demonstrate island restoration.

4.5 Vegetation monitoring

- It is possible that the removal of mice will have an impact on the structure and composition of the vegetation on Antipodes Island. Therefore, thought should be given to how long-term vegetation monitoring might be conducted and how any changes could be quantified. Given the remote location of the island, high-definition satellite imagery may be worth considering in conjunction with a limited plot-based sampling regime.

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Appendix 1

Annotated list of the birds seen during the voyage, on and near Antipodes Island, July 2013

Mallard (*Anas platyrhynchos*)

Two birds seen at both Reef Point and Alert Bay (presumably the same individuals) on 11 July. Two mallards also seen flying along the coast from the Orde Lees penguin colony on 22 July.

Erect-crested penguin (*Eudyptes sclateri*)

One bird (adult) seen swimming about Anchorage Bay (9 July). Fresh tracks seen in the Orde Lees penguin colony on 27 July. One bird (adult) observed at Anchorage Bay colony on 28 July.

Southern royal albatross (*Diomedea epomophora*)

Most commonly seen well offshore at sea between Antipodes Island and mainland New Zealand.

Antipodean albatross (*Diomedea antipodensis antipodensis*)

Common offshore near Antipodes Island. Large downy chicks present on the island and some adults seen ashore feeding chicks. Two adult pairs seen displaying.

Northern giant petrel (*Macronectes halli*)

Marked increase in numbers and breeding activity from 9 July to 27 July. The number of birds in Anchorage Bay increased from a low of 4 to over 100 by 19 July. One of the more common species of bird seen flying over the island. Increasing aerial displays apparently associated with colony occupation and nest mound construction at several sites.

Cape petrel (*Daption capense capense*)

The most commonly seen seabird during the voyage to and from the island. Often seen around coastal cliffs, with small numbers of birds observed rafting up just offshore. A fur seal (*Arctocephalus forsteri*) was seen attacking and killing a bird sitting on the sea. Several birds were seen landing on coastal cliffs between Alert Bay and Perpendicular Head, which appeared to be prospecting for nest sites and/or mates. Apparent courtship calling heard on several occasions.

White-headed petrel (*Pterodroma lessonii*)

Several recently dead birds found at scattered locations.

Soft-plumaged petrel (*Pterodroma mollis*)

From 26 July, birds could be heard calling from the ground at night in the vicinity of the hut.

Fairy prion (Pachyptila turtur)

Several seen at sea approximately one day from Antipodes Island.

White-chinned petrel (*Procellaria aequinoctialis*)

A few recently dead corpses found. One live but very weak bird was located on North Plains on 12 July, which was found dead the following day, apparently from starvation. Stomach contained only plant foliage.

Grey petrel (*Procellaria cinerea*)

Commonly seen flying over the island by day, particularly in more coastal areas. Birds in burrows would often call softly when disturbed. Commonly heard calling from land (inside and outside burrows) from just on dark to dawn. One of the most commonly seen birds at sea between the mainland and Antipodes Island.

Subantarctic little shearwater (*Puffinis elegans*)

None seen or heard either at sea or on land.

Grey-backed storm petrel (*Garrodia nereis*)

One bird found on the ground outside the hut on 9 July.

Back-bellied storm petrel (*Fregetta tropica*)

Frequently seen at sea during the voyage to and from the island. None seen or heard on land.

Common diving petrel (*Pelecanoides urinatrix*)

Only seen close to Antipodes Island. Very common in Anchorage Bay between Reef Point and Perpendicular Head, with between 50 and 100 birds seen sitting on the sea surface. Rarely heard on land. Two or three birds seen departing from near possible burrows above Hut Cove just after dawn.

Antipodes Island snipe (*Coenocorypha aucklandica meinertzhagenae*)

Regularly seen throughout the island from the coast to higher parts of the interior, but not common anywhere. Occasionally heard calling during the day, but only rarely during hours of darkness. See index of encounter rates in section 3.3.3.

Brown skua (*Catharacta antarctica lonnbergi*)

Very few birds seen on Antipodes Island. One bird commonly seen on land at Reef Point. We estimate that no more than 5–6 are birds present in the northern half of the island.

Kelp gull (*Larus dominicanus dominicanus*)

Approximately 30 birds seen around Anchorage Bay, Reef Point and Stella Bay. Adults and juveniles present.

Antarctic tern (*Sterna vittata*)

Less than ten adult birds seen in the vicinity of Anchorage Bay and Reef Point.

Antipodes Island parakeet (*Cyanoramphus unicolor*)

Encountered in all habitats throughout the island, but more common in areas of dense vegetation in stream gullies and near the coast. Female birds seem far more common than males.

Reischek's parakeet (*Cyanoramphus hochstetteri*)

Also common throughout the island, and appear to be present in higher numbers than Antipodes Island parakeets. More common in shrubby areas (e.g. *Coprosma rugosa*), and in coastal areas associated with penguin and fur seal colonies.

Silvereye (*Zosterops lateralis lateralis*)

A small number of birds were heard above the waterfall on Dougal Stream.

Eurasian blackbird (*Turdus merula merula*)

One or two female birds seen at Reef Point on 11 July 2013.

Song thrush (*Turdus philomelos clarkei*)

At least one bird seen and heard at Reef Point on 19 July 2013, and another in 'Sectoides Stream' north of Mt Galloway on 22 July 2013.

Antipodes Island pipit (*Anthus novaeseelandiae steindachneri*)

Common about the coast and beaches, particularly in areas associated with penguin and fur seal colonies. Much less common in areas associated with dense, tall vegetation and inland.

Dunnock (*Prunella modularis*)

Scattered throughout the island. Seen and/or heard at Reef Point, on North Plains, Dougal Stream, Alert Bay and Orde Lees Island.

Common redpoll (*Carduelis flammea*)

Three individuals seen at Castaway Depot on 16 July 2013.

Appendix 2

Marine mammal notes

New Zealand fur seal (*Arctocephalus forsteri*)

Adult females and numerous pups present at Reef Point, with lesser numbers at Stella Bay (c. 15 females). Some pups very small, with no evidence that any had been weaned.

Elephant seal (*Mirounga leonina*)

Up to four individuals seen in Hut Cove on 21 July 2013 (one adult male, one adult female and two juveniles). Animals also seen in adjacent bays (Anchorage Bay and Stella Bay) on other days, but assumed to be the same individuals.

Appendix 3

Specimens collected

As part of an ongoing stable isotope study of the Antipodes Island terrestrial food web, samples were taken from birds and plants to complement the samples obtained from mice and invertebrates using the methods described in sections 2.5.1 and 2.5.4. The target sample size was a total of five for each bird species, and five of each plant species at each of the three main study sites (Reef Point, Anchorage Bay and North Plains). Blood and feather samples were taken from birds, and foliage samples were taken from plants and seaweeds. Additional tissue samples were opportunistically taken from dead animals. All samples were stored in 95% ethanol and are lodged at the University of Auckland (Table A3.1).

Table A3.1. Stable isotope samples collected. Additional tissue samples were also collected from dead fur seal (*Arctocephalus forsteri*) pups (2), white-chinned petrels (*Procellaria aequinoctialis*) (2) and a white-headed petrel (*Pterodroma lessonii*) (1).

SPECIES		TOTAL	REEF POINT	ANCHORAGE BAY	NORTH PLAINS
LAND MAMMALS					
House mouse *Mus musculus*	Adult ♂		17	12	9
	Adult ♀		5	9	13
LAND BIRDS					
Antipodes Island parakeet *Cyanoramphus unicolor*		8			
Reischek's parakeet *Cyanoramphus hochstetteri*		6			
Antipodes Island snipe *Coenocorypha aucklandica meinertzhagenae*		6			
Antipodes Island Pipit *Anthus novaeseelandiae steindachneri*		5			
SEABIRDS					
White-chinned petrel *Procellaria aequinoctialis*		1			
Grey-backed storm petrel *Garrodia nereis*		1			
Antipodean albatross *Diomedea antipodensis antipodensis* (chicks)		5			
Grey petrel *Procellaria cinerea*		5			
PLANTS					
Poa litorosa			5		5
Carex trifida			5	5	
Leptinella plumosa			5	5	
Crassula moschata				5	
Urtica australis				5	
Poa foliosa				5	
Carex appresa			5		5
Coprosma perpusilla					5
Coprosma ciliata					5
SEAWEEDS					
Durvillaea antarctica				5	
*Xiphophora chondrophy*lla				5	
Porphyra columbina				5	
Adenocystis utricularis				5	

When dead animals were found, any museum-quality specimens were opportunistically collected and presented to Auckland Museum for lodging in their collection (Table A3.2).

Table A3.2. Specimens collected and lodged at Auckland Museum.

SPECIES	BONES	SKINS	ALCOHOL
House mouse *Mus musculus*		LM1572, LM1573	LM1535, LM1536
White-chinned petrel *Procellaria aequinoctialis*	LB14756, LB14767	LB14833	
White-headed petrel *Pterodroma lessonii*	LB14746, LB14753	LB14820	
Erect-crested penguin *Eudyptes sclateri*	LB14802		
Reischek's parakeet *Cyanoramphus hochstetteri*			LB14722

Appendix 4

Details of parakeets captured by hand net on Antipodes Island, July 2013

Table A4.1: Details of parakeets captured by hand net on Antipodes Island, July 2013.
RP = Reischek's parakeet (*Cyanoramphus hochstetteri*); AI = Antipodes Island parakeet (*C. unicolor*); a dash means no measurement taken or sample collected.

DATE (2013)	TIME	SPECIES	LOCATION	EAST	NORTH	SEX	WEIGHT (g)	BILL LENGTH (mm)	BILL WIDTH (mm)	BILL DEPTH (mm)	TARSUS (mm)	WING LENGTH (mm)	WING BAR	BAND no.	BLOOD			FEATH-ERS	HELD CAP-TIVE?	COMM-ENTS
															FILTER	BUFFER	EtOH			
13 July	10:00	RP	Stella Bay	12033	9766	M	113	17.8	11.4	–	23.3	141	Nil	D134501	✓	✓	×	✓	✓	
13 July	10:00	RP	Stella Bay	12023	9752	F	86	13.7	9.7	–	22.7	132	Complete	D134502	✓	✓	×	✓	✓	
13 July	10:00	RP	Stella Bay	12033	9767	F	98	14.0	9.9	–	23.2	135	Complete	D134503	✓	✓	×	✓	✓	
13 July	12:00	AI	Hut			F	107	18.5	–	–	–	141	–	D134504	✓	✓	×	✓	✓	
13 July	12:30	RP	Anchorage Bay	11914	9868	F	85	15.1	10.2	–	22.9	132	Complete	D134505	✓	✓	×	✓	✓	
13 July	12:30	RP	Anchorage Bay	11914	9868	F	88	14.4	8.6	–	22.2	134	1/3	D134506	✓	✓	×	✓	✓	
13 July	13:00	AI	Hut			F	152	19.3	–	–	–	146	1/4 faint	E130735	✓	✓	×	✓	✓	
13 July	13:00	AI	Hut			F	146	19.6	–	–	–	149	–	E130734	✓	✓	×	✓	✓	
13 July	14:00	RP	Hut			F	110	13.9	10.9	–	24.4	135	1/2	D134507	✓	✓	×	✓	✓	
13 July	15:45	RP	Ladder	11949	9856	M	121	19.1	11.7	–	25.0	141	Faint	D134508	✓	✓	×	✓	✓	
13 July	15:55	RP	Anchorage Bay			F	109	18.7	10.3	–	23.4	137	Complete	D134509	✓	✓	×	✓	✓	
14 July	08:50	AI	Castaway			M	136	23.6	–	–	–	145	Nil	E130733	✓	✓	×	✓	✓	
14 July	09:00	AI	Toilet			F	145	20.0	–	–	–	143	Nil	E130732	✓	✓	×	✓	✓	
14 July	11:30	RP	Reef Point	12102	9946	F	81	14.0	10.2	–	22.0	125	Complete	D134510	✓	✓	×	✓	✓	
14 July	11:30	RP	Reef Point	12102	9946	F	90	13.7	10.2	–	23.4	129	1/2	D134511	–	–	×	✓	✓	
14 July	14:00	RP	Reef Point	12127	9836	M	118	17.7	11.5	9.2	25.5	142	Nil	D134512	✓	✓	✓	✓	×	
14 July	14:40	RP	Reef Point	12181	9894	F	101	14.0	9.4	7.6	21.0	129	1/2	D134513	✓	✓	✓	✓	×	
14 July	15:00	RP	Reef Point	12185	9886	F	114	14.8	10.1	8.7	22.2	129	1/4	D134514	✓	✓	✓	✓	×	
14 July	15:30	RP	Reef Point			F	95	14.0	9.4	8.0	21.4	125	1/2	D134515	✓	✓	✓	✓	×	
15 July	09:00	AI	Hut			F	153	19.3	13.9	12.0	25.8	151	Nil	E130731	✓	✓	✓	✓	×	
16 July	07:45	RP	Hut			F	93	13.7	9.9	7.7	22.8	–	1/4 faint	D134516	✓	✓	✓	✓	×	
17 July	09:30	AI	Hut			M	161	25.3	15.3	13.0	27.6	149	Nil	E130704	✓	✓	✓	✓	×	Smelly
17 July	14:15	AI	Hut			F	137	19.9	13.5	10.4	26.0	150	Nil	E130705	✓	✓	✓	✓	×	V. skinny
17 July	15:30	AI	Toilet			F	145	19.6	13.4	10.5	26.3	150	Nil	E130730	✓	✓	×	×	×	
18 July	07:45	AI	Hut			M	148	22.7	15.2	12.8	26.8	153	Nil	E130729	✓	✓	✓	✓	×	
18 July		AI	Reef Point	12111	9938	F	106	20.3	13.7	10.9	26.8	146	Nil	E130728	✓	✓	×	✓	×	V. skinny
18 July	09:25	RP	Castaway			M	125	19.3	12.2	8.9	25.4	142	Nil	D134517	✓	✓	–	✓	✓	
19 July	12:05	AI	Toilet			F	154	19.4	13.4	11.7	25.0	143	Nil	E130727	✓	✓	×	×	×	Smelly
19 July	12:40	AI	Hut			M	180	23.5	14.6	12.7	27.5	145	Nil	E130726	✓	✓	✓	✓	×	

Continued on next page

Table A4.1 continued

DATE (2013)	TIME	SPECIES	LOCATION	EAST	NORTH	SEX	WEIGHT (g)	BILL LENGTH (mm)	BILL WIDTH (mm)	BILL DEPTH (mm)	TARSUS (mm)	WING LENGTH (mm)	WING BAR	BAND no.	BLOOD			FEATH-ERS	HELD CAP-TIVE?	COMM-ENTS
															FILTER	BUFFER	EtOH			
19 July	13:40	RP	Reef Point	12127	9945	F	100	14.7	10.0	7.1	22.5	134	2/3	D134518	✓	✓	✓	✓	×	
19 July	14:45	AI	Reef Point	12095	9883	F	112	19.7	13.1	11.1	25.9	142	1/2 faint	E130725	✓	✓	✓	✓	×	
20 July	15:00	AI	Hut Creek	11881	9789	F	157	19.6	13.5	10.1	26.0	144	Nil	E130724	✓	✓	✓	✓	×	
21 July	16:30	AI	Castaway			F	134	19.5	13.3	11.5	25.6	150	Nil	E130723	✓	✓	✓	✓	×	
21 July	16:55	AI	Castaway			M	167	22.6	15.2	13.6	27.4	155	Nil	E130722	✓	✓	×	✓	×	
27 July	11:05	AI	Orde Lees Colony	9032	8995	F	122	20.1	13.2	–	26.5	133	Nil	Nil	✓	✓	✓	✓	×	