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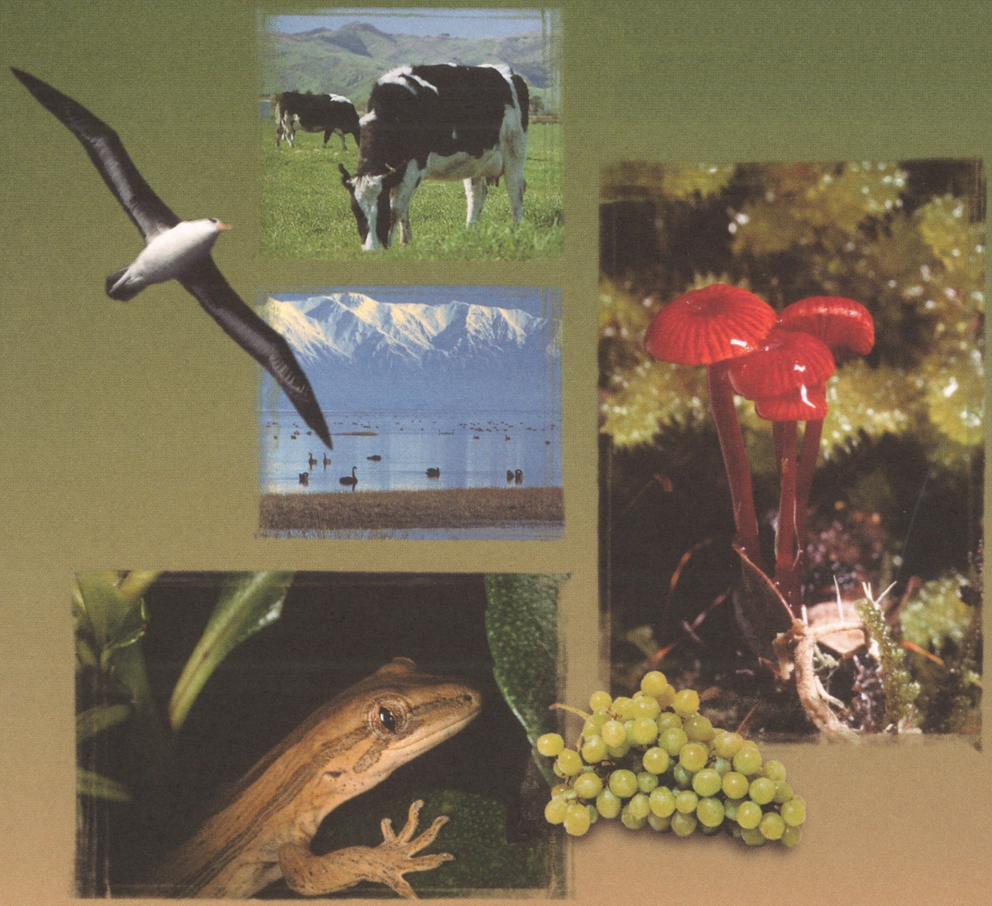

THE ERADICATION OF MAMMALIAN PREDATORS FROM QUAIL ISLAND, BANKS PENINSULA, CANTERBURY, NEW ZEALAND.

Matt Kavermann, Mike Bowie and Adrian Paterson

Ecology & Entomology Group,
P.O. Box 84, Lincoln University

Prepared for:

Quail Island Ecological Restoration Trust,
and the Department of Conservation

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Wildlife Management Report No. 29

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Summary

During January 2000 - January 2003 an attempt was made to eradicate mammalian pests (rodents, mustelids and hedgehogs) from Quail Island (Otamahua) to allow re-introductions of native species that were once present. Eradication techniques involved live trapping, kill trapping using Fenn traps and night searches that removed a total of 353 individuals. A ground-based poison operation was also undertaken. During 2 - 9 August 2002, 555 bait stations (yellow and black) were placed at 40 m intervals covering Quail Island. Stations were baited with Pestoff 20R rodent bait pellets (0.002% brodifacoum) and, at later stages of the operation, Talon 50 WB briquette (0.005% brodifacoum). An analysis of predominant vegetation surrounding stations was also undertaken.

Exotic grassland was the dominant habitat where hedgehogs were trapped and found during night searches. Hedgehogs were caught more readily on or near tracks, which they presumably use to feed and travel around the island. Male rats made up 70% of the rat catch. Bait-take by rodents was highest from black bait stations and from scrubland habitats surrounding bait stations on Quail Island.

Eradication could not be confirmed, as a few bait stations were still active but most, if not all damage, appears to be by ground (*Hemiandrus* sp.) and cave weta (*Pleioplectron simplex* Hutton). Furthermore, a few hedgehog scats have been found since the poison operation began and no hedgehogs have been observed or trapped for 18 months indicating they have become vary scarce or have been eradicated.

This information will be important for future management of Quail Island due to the proximity of the mainland, via mudflats, will need ongoing vigilance to protect against pest reinvasion.

Introduction

Quail Island (Otamahua) is an 81 ha Recreational Reserve located in Lyttleton Harbour, in the Herbert Ecological District, Banks Peninsula (43° 38′ S, 172° 42′ E), Canterbury. The island has great significance to local Maori who used it as a place for food collection and human burials (Norton *et al.*, 2001). European history on the island in the last 150 years includes farming, a quarantine station, a base for Antarctic expeditions and the only leper colony established in New Zealand (Brown, 2001). More recently it has been used as a recreational area and an educational facility for all people.

In 1997, the Department of Conservation, representatives of Te Runanga o Ngati Wheke and dedicated volunteers began the provisional planning for the ecological restoration of Quail Island (Norton *et al.*, 2001). A major impediment to this restoration process were the animal pest species present (rats, mice, hedgehogs, rabbits) on the island. As a result in January 2000 an eradication campaign was undertaken to remove mammalian pests from Quail Island.

The campaign involved a trapping operation followed by an intensive ground-based poison operation using bait stations, which, although more costly in respect to time and money, reduced the amount of poison needed decreasing the risk of secondary poisoning of non-target species, and was perceived to have higher public acceptance (D. Brown pers. comm.). Hunting and live capture were also used to remove pests (Brown, 2001; Thomsen *et al.*, 2000).
Due to a land bridge at low tide providing access to Moepuku Point and the mainland via King Billy Island, Quail Island is considered a secure 'mainland island' rather than a true island (D. Brown

pers. comm.). Given the island is susceptible to re-invasion, ongoing preventative control is needed to intercept and minimise the impacts of future invaders.

This report outlines methods used to eradicate mammalian pest species from Quail and the consequences of the trapping and poisoning operation carried out between January 2000 and January 2003.

Methods

Cage trapping operation

Live-capture wire cage traps and wooden treadle traps were set at 150 m spacing and baited with 'Tasti Dinner' dog roll (Thomsen *et al.*, 2000) targeting hedgehogs. Live trapping began on 18 January 2000 and continued for 11 nights. Captured hedgehogs were translocated back to the mainland where they were liberated.

Kill trapping operation

Between 7 and 27 September 2001, 68 trap boxes were set up in a regular fashion targeting hedgehogs and mustelids over Quail (n = 62) and King Billy (n = 6) Islands (Figure 1). Locked trap boxes (made from H4 treated pine) were 20 cm x 25 cm x 100 cm and contained two Mk 6 Fenn traps baited with 'Kitekat chunky fish' tinned cat food placed between them. Ten grams peanut butter was used as bait in warmer summer weather (from 20 November 2001 and replenished on 30 January 2002), as the meat deteriorated quickly.

Figure 1: Trap boxes set on Quail Island between 7 and 27 September 2001

penguin, korora (*Eudyptula minor albosignata*) nest and were a small risk of being captured. Traps remained baited and were monitored every three to four days during the initial 11-week trapping period with all catches and sprung traps recorded. Where possible trapped animals were collected, with their capture date and location recorded, and frozen for further analysis.

On 29 October and 28 November 2001, a total of 28 non-productive trap boxes were closed while repeatedly active traps were continually checked weekly until 23 May 2002. On 1 June 2002 most of the trap boxes were closed with the exception of those on King Billy Island and the five at the Southwest corner of Quail Island near Walker's Beach as it was hoped these would intercept pests emigrating from the mainland via Moepuku Point.

Night walking around Quail Island took place on 12 occasions between 27 April 2000 and 7 February 2003. Searchers wearing halogen headlamps walked tracks between 5:30 pm and 12:00 pm and collected hedgehogs, recording location and time. Hedgehogs were humanely euthanised and frozen for further analysis.

The Fenn trap data were corrected for unavailable traps due to capture and/or sprung traps using methods adapted from Nelson & Clarke (1973) and Taylor & Thomas (1993). Each trap box was counted as one trapping unit with sprung traps only recorded if both traps were unsuccessful. Results of trapping expressed as captures per 100 trap nights (C/100 TN). Because the trapping intervals between collections from trap boxes during the trapping operation varied between three and 14 days and as trapping intervals were not constant, an average catch for the days between intervals was taken as an estimate of trap success for the duration of the operation.

As the paired traps were not independent of one another, the use of each Fenn trap as an individual trapping unit was not ideal. Twenty percent of captured animals sprung both traps thus rendering them inoperable for the remainder of the trapping interval. Furthermore, as traps were not always checked daily, a daily catch rate could not be used for analysis. Consequently catch effort, represented by corrected daily catches, was calculated using captures/100TN for the trapping interval averaged over the number of days during the trapping interval to give assumed catches per day.

Poisoning operation

During 2 – 9 August 2002, 555 bait stations were placed in a regular fashion at 40 m intervals running North-South over the island. The stations comprised of yellow Pestoff bait stations (n = 351) (Animal Control Products Ltd, Wanganui, New Zealand) and 450 mm lengths of 110 mm diameter black non-perforated plastic 'Novacoil' drain pipe (n = 204) (Humes Pipe & Precast, Christchurch, New Zealand) with a covered 5 x 7 cm viewing window cut into the top. Each station was numbered and its position marked with a Global Positioning System (GPS) unit. Pestoff stations were secured with two 12.5 cm galvanised flathead nails through their base into the ground and 'Novacoil' stations were secured with two hoops of fencing wire at either end.

Stations were left un-baited for one week prior to the poison operation to minimise neophobic avoidance by vertebrate pests. On the 16 August 2002, ten Pestoff 20R rodent pellet baits (0.002% brodifacoum) (Animal Control Products Ltd, Wanganui, New Zealand) were placed in each bait station. Cereal Pestoff baits were chosen as they have been effective in previous island eradication programmes (Taylor and Thomas, 1989; 1993) and have low impact on non-target wildlife if used in bait stations (D. Brown pers. comm.). Furthermore, brodifacoum allows animals to consume a lethal dose before experiencing toxic effects and any animals ingesting sub-lethal doses should not become bait shy (Redfern *et al.*, 1976). In the initial week, stations were checked daily with bait replenished or increased where bait-take regularly exceeded the number of baits offered. For the following five weeks all stations were checked every two days and bait was replaced as needed.

On 27 September 2002, a single 20 g Talon 50 WB wax impregnated cereal briquette (0.005% brodifacoum) (ICI Crop Care, Richmond, New Zealand), was placed with five Pestoff baits in each station. It was envisaged that any animals developing an aversion to the Pestoff baits would consume this new bait. The higher concentration of poison also meant that a smaller amount of bait was required to consume a lethal dose. During 29 September – 5 October 2002, a single Talon 50 WB bait wrapped in tinfoil to minimise the effects of slugs (*Deroceras* spp.), insects and decomposition due to moisture, was left in each bait station to poison the remaining pests and allow activity to be monitored. In December 2002, a visual analysis of dominant and secondary (significant other) vegetation was recorded in the 20 m surrounding each bait station. Significant geographic features such as coastlines, cliffs and rocky outcrops were also noted.

A total island census from all bait stations was used to calculate the percentage bait-take. The island census took one day for the first five samples and then required two days for the remaining samples. Data collected over a two-day period were combined to give a whole-island census, from which a percentage bait-take was calculated. 'Bait-take' was expressed as the number of baits taken from bait stations, whilst 'activity' was removal of at least one bait from a station.

As there were more yellow than black bait stations (351:204) a subset of 423 stations (223:200) was used to avoid bias caused by some areas only being represented by yellow bait stations. Stations of the same type in groups of more than three in a designated line were eliminated from the analysis. Minitab was used to generate ANOVA to test for significance between bait station types, island vegetation and pest catches.

Pest biology

Of the 304 mammalian pests caught on Quail Island during the campaign, 181 were collected and frozen. The remainder were too decomposed for accurate analysis and were left on the island. Frozen specimens included 145 ship rats (*Rattus rattus*), 27 hedgehogs (*Erinaceus europaeus*), six mice (*Mus musculus*), a weasel (*Mustela nivalis*), a stoat (*Mustela erminea*) and a ferret (*Mustela furo*). All animals were weighed, measured, sexed and had reproductive status determined by key features or by dissection. Following descriptions from Cunningham & Moors (1983), female rats with perforated vaginas and male rats with scrotal testes were classed as mature. Hedgehogs weighing in excess of 500 g were also classed as mature (Brockie, unpublished 1958; Morris, 1983). Body weight of trapped mustelids was used to determine maturity (King, 1990). Rat species were identified from characteristics in Cunningham & Moors (1983) and Atkinson & Moller (1990). All mature females were dissected and inspected for foetuses. Similarly, previous pregnancies, identified by the placental scars on the uterus in female rats (King, 1990), were also noted. Fleas were removed from rats for identification under a binocular microscope.

An analysis of stomach contents was also performed on nine animals (five rats, three hedgehogs and one ferret) that were caught during mid to late September 2001 to determine prey species. Samples were sieved though a fine gauze ('Sunset' fabric, Manakau Knitting Mills Ltd.), rinsed in water and preserved in 70% ethanol. Each sample was examined under a binocular microscope and fauna remains were kept in 70% ethanol for identification.

Results

Trapping operation

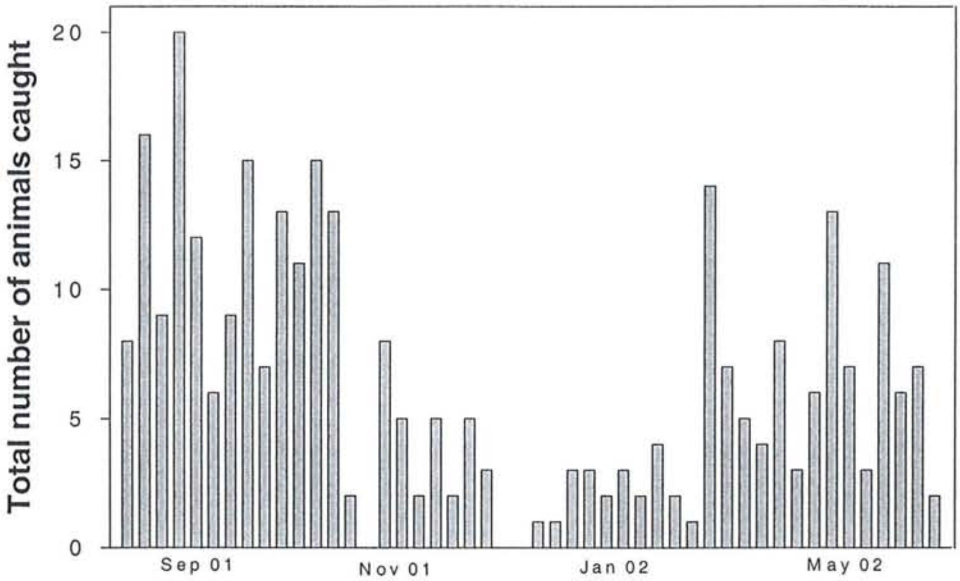
Although hedgehogs and mustelids were targeted, rats made up the majority of animals caught with the highest capture rate of 6.97/100 TN. Mice had the second highest capture rate (0.66/100 TN) followed by hedgehogs (0.26/100TN) and mustelids (0.08/100TN) (Table 1). Sprung traps were common and accounted for 1.04/100TN.

Table 1: Capture data for trap boxes following 3803 trapping nights (258 days).

	Rats	Mice	Hedgehogs	Mustelids	Sprung (79)	Total
Number caught	265	25	10	3	39.5	342.5
Capture/100 TN	6.97	0.66	0.26	0.08	1.04	9.01

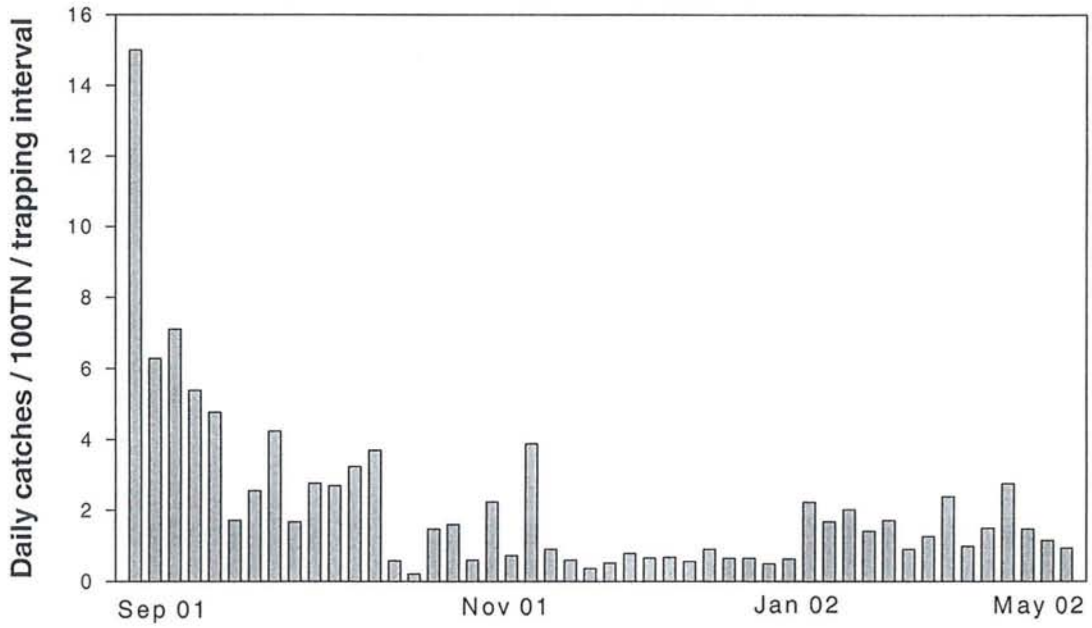
A large number of animals were caught through the first two months peaking on 17 September 2001 with 20 animals being caught in four days. Catches showed a decline through November until early February when catch rates increased to a maximum of 14 animals caught on 9 February 2002 after a 10-day trapping interval (Figure 2). Whilst catches increased, they did not exceed earlier trapping success rates.

Figure 2: Total numbers of animals caught per trapping interval during the initial trapping operation.



Catch effort during the trapping period was corrected as daily catches/100 TN (Figure 3). After initial trapping peaks, catch rates quickly fell and remained below 3/100TN throughout December until the end of the trapping operation. Similarly, relative catch rates rose slightly towards the end of the operation.

Figure 3: Corrected daily catches for the initial trapping operation (per 100/TN)



<u>Hedgehogs</u>

In addition to the 304 animals removed during the initial trapping operation, a further 23 hedgehogs were removed during night walks (Figure 4) and 26 hedgehogs were removed in live traps and showed a large reduction in numbers over time (Figure 5).

Figure 4: Number of hedgehogs collected during night walking on Quail Island tracks

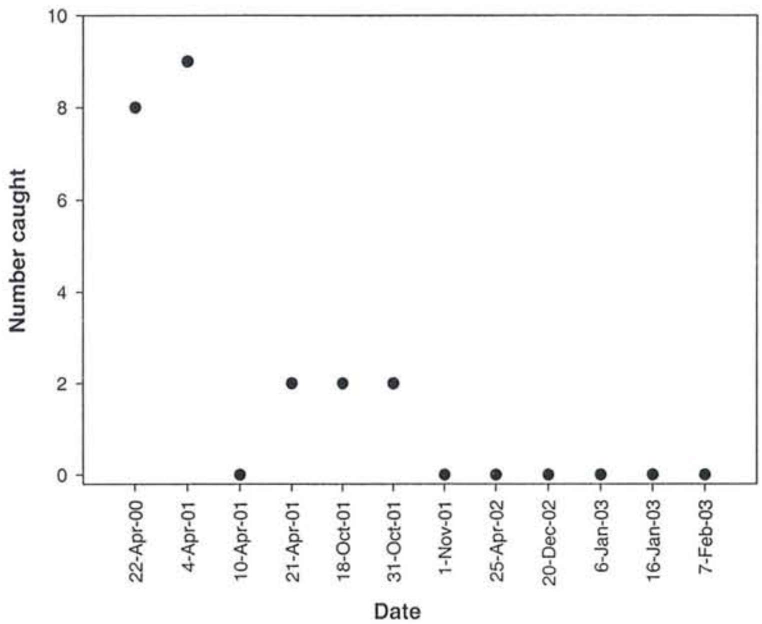
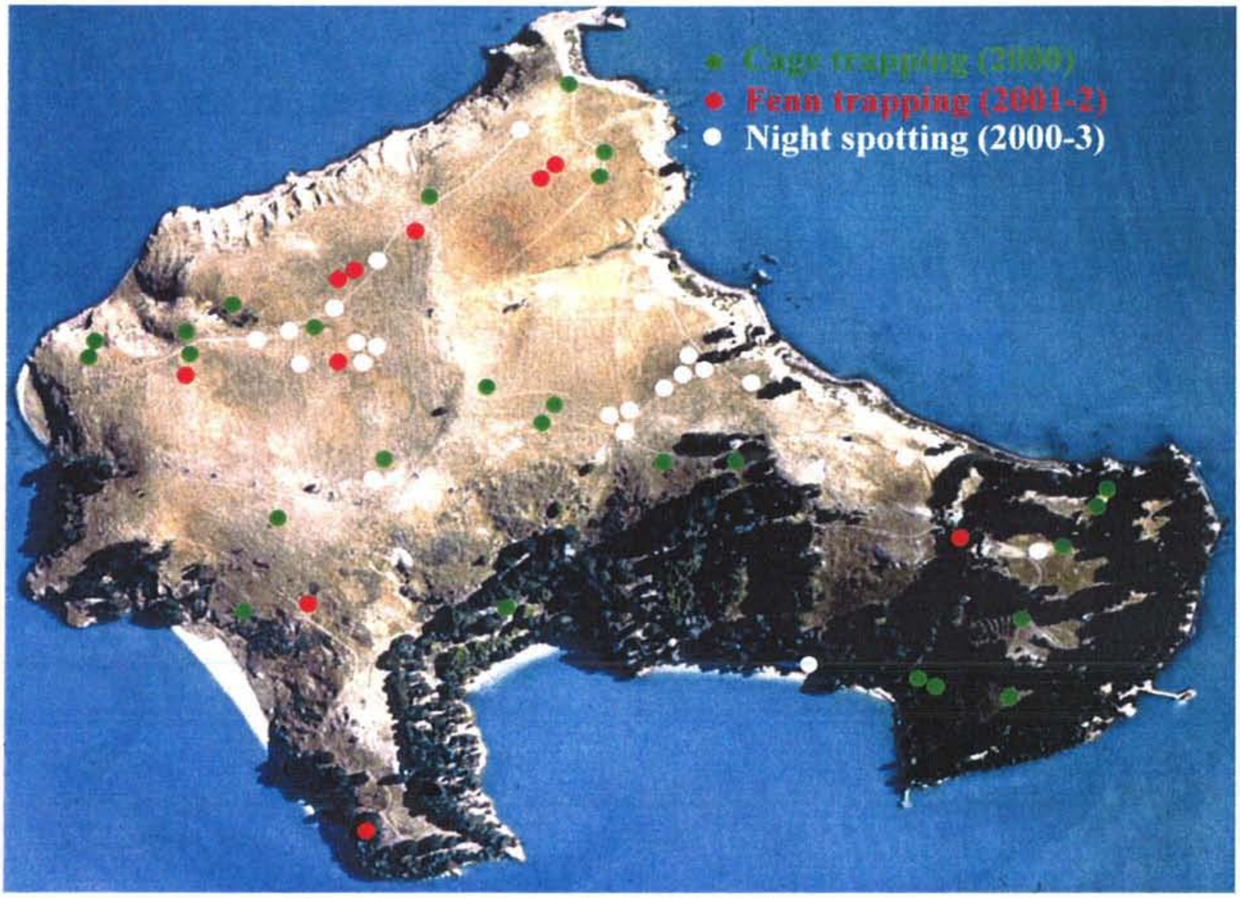


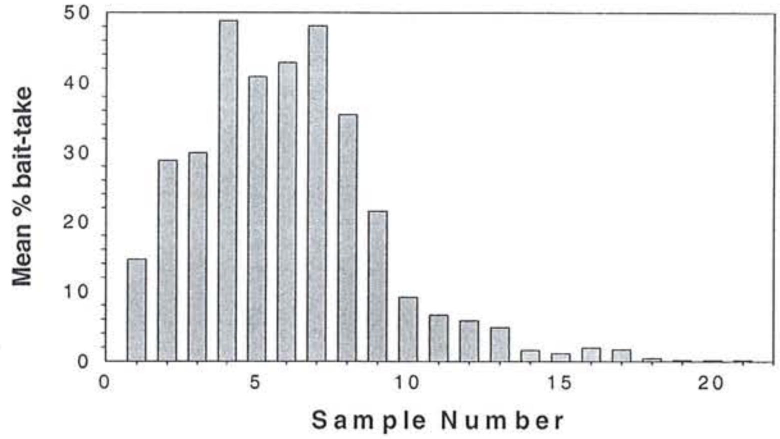
Figure 5: Aerial map of Quail Island showing locations where hedgehogs were caught during live capture (cage trapping), Fenn trapping, and night searches.



Rodent poison operation

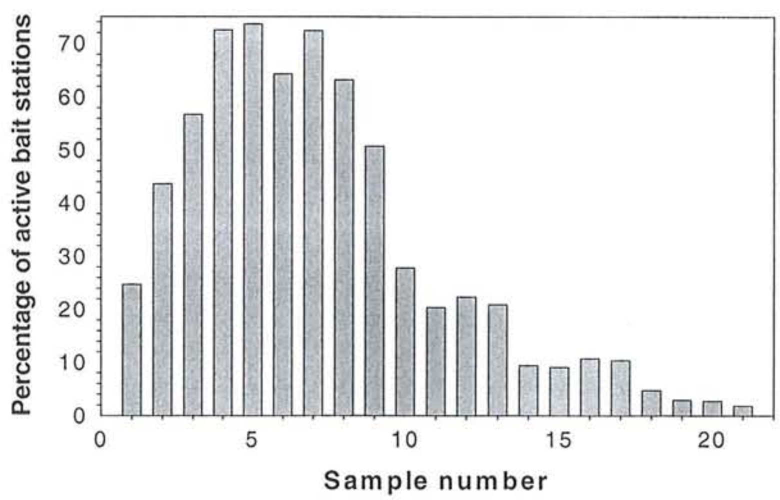
Overall, percentage bait-take and activity was significantly higher ($F_{1,418} = 16.83$, $P<0.001$) from black bait stations for the entire poisoning operation. Mean percentage bait-take was significantly higher from black Novacoil bait stations than yellow Pestoff bait stations during samples 2-7 (days 2-9) although bait station activity was only significantly higher from black stations during samples 2,3 and 5 (days 2,3 and 5) (see appendix 1,2 for statistical analysis). A steady increase in bait-take occurred in the first 4 days of the operation, which peaked at 49% at sample 4 (day 4) and then again at 48% at sample 7 (days 8-9), was followed by a steady decrease in bait-take with minimal interference after sample 18 (day 30-31) (Figure 6).

Figure 6: Percentage bait-take for all bait stations during the initial 21 samples (37 days)



The bait station activity results indicated a similar trend with over 70 % of bait stations active during samples 4, 5 (days 4 and 5) and sample 7 (days 8-9) followed by a decrease in activity (Figure 7).

Figure 7: Percentage of active bait stations during the initial 21 samples (37 days)



Bait-take on Quail Island was highest in the scrubland with 21.6% of baits being taken; grassland habitat had the second highest bait-take (17.1%) followed by the pine (*Pinus* spp.)/macrocarpa (*Cupressus macrocarpa*) habitat (Figure 8). The dominant vegetation cover is grassland representing 77% of Quail Island (Figure 9).

Figure 8: Significant influence of dominant vegetation type surrounding bait stations on bait-take on Quail Island ($F_{2,534} = 16.72$, $P < 0.001$).

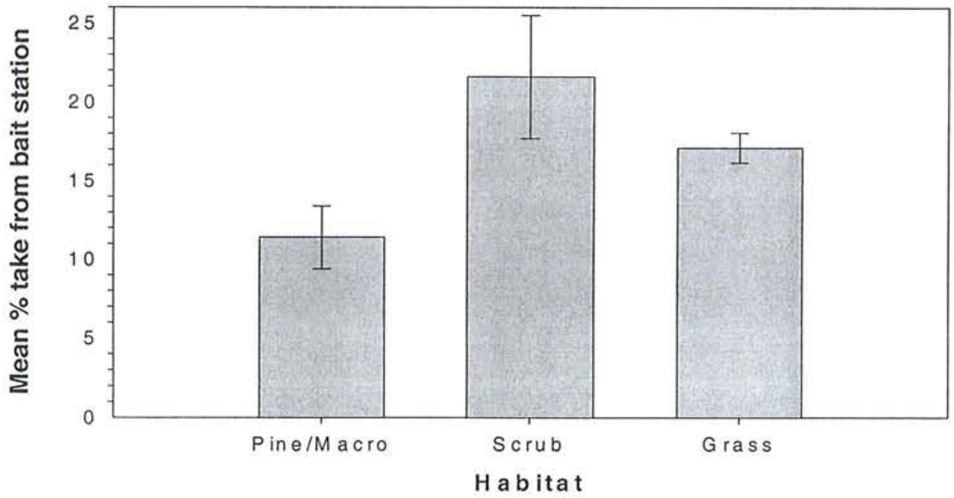
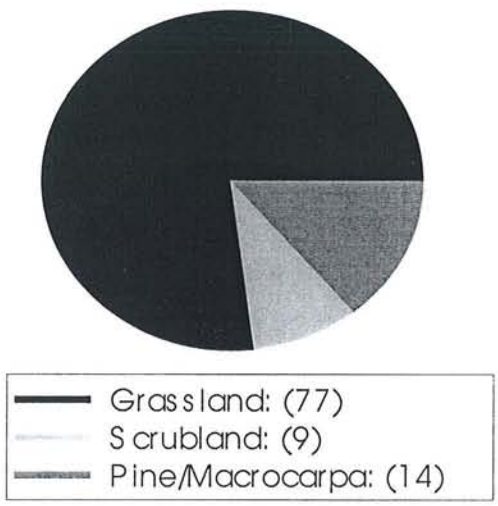


Figure 9: Percentage of dominant vegetation covering Quail Island in December 2002.



Pest biology analysis

Rats

The mean weight of trapped rats was 163 g (range 95-247 g) with male rats significantly heavier than females ($F_{1,122} = 28.33$, $P < 0.001$). Male rats comprised 71% of rat captures during the operation. Whilst 98% of female rats were mature, only 17% were pregnant during the period October 2001 until 8 November 2001. No pregnant female rats in this sample showed a scarred uterus although scarred rats were caught from 1 September 2001 (Table 1).

Mice
Male mice were heavier (range 13.2-20.0 g) than the single immature female caught. Average weight of the mature hedgehogs (n = 17) was 617.5 g whilst immature hedgehogs (n = 10) averaged 268 g.

Hedgehogs
Unlike rats, neither mature male (range 531-711 g) and female (range 493–798 g) hedgehogs or immature male (range 207-392 g) and female (range 156-390 g) hedgehogs were significantly different in weight ($F_{1,25} = 0.49$, $P = 0.492$).

Mustelids
All mustelids captured were mature and the only female (a ferret) was not pregnant.

Table 1: Pest Biological data for pest animals removed from Quail Island during the initial trapping operation (* = significant difference $F_{1,122} = 28.33$, $P < 0.001$).

Species	Sex	Age	Number	Mean Weight (g)	% Mature	% Pregnant	% Previously pregnant
Rats[s]	♀	mature	40	149 *	98	17	24
	♀	immature	2	149	-	-	-
	♂	mature	92	178*	89	-	-
	♂	immature	11	162	-	-	-
Mice	♀	mature	1	12.6	0	0	0
	♂	mature	7	16.3	86	-	-
Hedgehogs	♀	mature	10	605	59	20	-
	♀	immature	3	269	-	-	-
	♂	mature	7	630	70	-	-
	♂	immature	3	267	-	-	-
Mustelids							
Ferret	♀	mature	1	621	100	0	0
Stoat	♂	mature	1	341	100	-	-
Weasel	♂	mature	1	141	100	-	-

[s]rat species is *Rattus rattus*

Discussion

Initial trapping operation

Based on the large number of rats caught during the control campaign, they are likely to be the most abundant vertebrate pests on Quail Island. As mice were not specifically targeted and were only caught as by-catch, comparison with other species caught is not valid, given Fenn traps are too large for mice and are unlikely to catch many.

Overall rat catch rates on Quail Island (6.97/100 TN) were similar to those found by Moors (1985) of Norway rats (*Rattus norvegicus*) on Motuhoropapa Island (9.5 ha) during August - September 1977. However, the Quail Island operation produced a lower catch rate than trapping during April (Autumn) on Breaksea (170 ha) and Hawea (9 ha) Islands (Taylor and Thomas, 1989; 1993). This may be explained by the fact that rat abundance increased throughout Autumn on the islands as young animals were recruited from nests into the population resulting in a large, potentially trappable population (Innes, 1990). Furthermore, trapping by Taylor & Thomas (1989; 1993) was performed over a short duration and may not have affected rat abundance as greatly as the longer campaign on Quail Island where the sustained reduction in rat abundance may have contributed to the low catch. It is likely that there was only a small population of rats on the island before trapping began. Finally, longer trapping periods may increase the chance of catching animals but may also induce 'trap shyness' (Cowan, 1977; Moors, 1985).

Another possible reason for low catch could be an aversion to a new bait food (Barnett, 1975). This may have occurred with the change of bait from 'Kitekat chunky fish cat food' lure to peanut butter in traps although peanut butter may not be as attractive to rats as cat food. Results in the week leading up to 21 November 2001 show that ten rats were caught using cat food as a lure, whereas the week following the change to peanut butter only one animal was trapped, and in the subsequent month 10 rats or hedgehogs were trapped. However, in the nine days following the replenishment of the peanut butter lure on 30 January 2002, 14 animals were captured. Peanut butter tends to dry out over time and this may have effected its attraction. A further possibility is that the abundance of natural foods (invertebrates, lizards, berries, seeds, etc) during the summer months may reduce the attractiveness of baits thereby affecting their trapability (Moss, 1999).

The greater number of animals caught during September – October 2001 may be a result of animals moving greater distances in search of mates. This is particularly true for female hedgehogs that increase their home range sizes during spring and summer months (Moss, 1999) and would increase chances of encountering a trap. Similarly, male ship rats (*R. rattus*) increase their home range during the breeding season to encounter more females (Dowding and Murphy, 1994). Once mates were found, movements became reduced and animals encountered traps less often, reducing catch rates. Hedgehog activity is high pre and post hibernation and this is a productive period for trapping.

Daily catches

The significant decrease in corrected daily catches overtime may be the result of reduced animal abundance, other food sources such as invertebrates being available, or animals becoming trap shy. Initial trapping gave an index of population abundance prior to pest eradication from which we infer that, if animals did not become trap shy, the population of vertebrate pests was significantly reduced over time.

Twenty percent of sprung traps did not contain an animal. These sprung traps may be more likely to be set off by animals too big or too small for the Mk 6 Fenn traps used. Several mice were caught in Fenn traps despite not being suitable for their capture, demonstrating that they can spring traps.

Sixty hedgehogs were removed from the island, mostly from the northern grassland areas. Initial trapping, using live capture cages captured hedgehogs in all habitat types (Thomsen *et al.*, 2000). Higher densities of hedgehogs were captured in grassland indicating it may be a preferred habitat. Brockie (1990) proposed that this is a result of more invertebrate food availability, which is supported by Bowie (unpublished) who found invertebrates to be the more abundant in grasslands compared with other habitats on Quail Island.

Night searches were particularly successful at track intersections and the north-western track close to the stock dam, the only open body of water. Although no hedgehogs were observed drinking from the dam, it is quite possible that water does attract hedgehogs as open, wetter, or irrigated areas were also 'hotspots' for their capture. The hedgehogs were seen feeding on invertebrates, particularly slugs (*Deroceras* spp.) and slaters (*Porcellio scaber*) on the tracks, and this has been confirmed by analysis of stomach contents (M. Bowie, pers. comm.). Grasslands also provide a greater abundance of lizards (Lukis, 1999), also preyed upon by hedgehogs (Moss and Sanders, 2001). This has been corroborated by remains of two common skinks (*Oligosoma maccanni*) found in stomach contents as well as several *Metaglymma moniliferum* (Coleoptera: Carabidae) from Quail Island hedgehogs.

Night spotlighting on walking tracks was an effective method for locating hedgehogs, as they appear to use tracks for both feeding and for ease of movement. The number found by night searches over the four years has dropped from eight and nine in the first two nights respectively to zero over the last six nights of spot lighting. The scarcity of hedgehog scats and evidence from tracking tunnels suggests that only a few, if any, individuals remain on the island.

Rodent Poisoning

Bait-take by rodents on Quail Island was slower than those found by Taylor & Thomas (1989; 1993) on Breaksea and Hawea Islands. This could be due to a number of factors on Quail Island including initial bait and/or bait station avoidance, a smaller rat population due to bi-catch from hedgehog trapping before poisoning and the inability of rodents to find bait stations in dense grasses.

Rat eradication campaigns on Hawea and Breaksea Islands used stations sited three weeks and two months respectively prior to poison being laid to reduce any neophobia by rats. This may have led to more activity during the initial stages of these campaigns as rats had become accustomed to stations, which resulted in a quicker eradication than on Quail Island. In contrast, Prakash (1988) suggested that an acclimatization period of four to five days to minimise aversion to stations was adequate to limit aversion by rodents, suggesting that aversion should not have been a limiting factor for initial bait-take on Quail Island.

Prakash (1988) also suggested pre-baiting of non-toxic bait for two to three days would further minimise aversion as food in new environment is only sampled in small quantities resulting in sub-lethal doses and aversion. Similarly, Moors (1985) recommended that extensive pre-baiting would have made eradication more successful on Motuhoropapa Island as rats would have become familiar to the bait matrix and not avoided it. As a result, the lack of pre-baiting on Quail Island may have caused the initial slow response in bait-take.

The Pestoff bait used contained 0.002 % of the second-generation anticoagulant brodifacoum, and a single feed by ship rats and mice is considered to deliver an acute lethal dose (LD_{50}) ranging between 0.40 – 0.73 mg kg^{-1} (Buckle, 1994). Because of the time between consumption and onset of poisoning symptoms in rats they should not associate these baits with symptoms, resulting in lower bait-shyness and aversion than with other faster-acting baits (Prakash, 1988). Talon 50WB containing 0.005% Brodifacoum can cause 100% mortality for both ship rats and mice in 48 hours, and death from accumulated sub-lethal doses within 4-10 days (Buckle, 1994). As this new bait was introduced part way through the operation in conjunction with the Pestoff baits, the effectiveness of these baits may have decreased with rats avoiding all bait at that time.

It is likely that animals found bait stations as the home ranges of ship rats male average 55.4 m^2 and females 38.7 m^2 (King, 1990) with previous studies suggesting ranges up to 0.81 ha (Hickson *et al*, 1986). This would indicate that rats should encounter at least one bait station during the course of the operation. Furthermore, studies suggest that rat home ranges increase as population densities decrease (Innes and Skipworth, 1983; Hickson *et al.*, 1986), therefore, as rat numbers on Quail Island decreased, rats should have had the opportunity to encounter more bait stations. As a result Taylor & Thomas (1989) suggested a bait station spacing of 50m in their poisoning campaign on Breaksea Island (Taylor and Thomas, 1993) was sufficient to achieve complete eradication of Norway rats.

During their study on Hawea Island, Taylor & Thomas (1989) also noticed that large male rats defended bait stations from smaller rats. It has been suggested that rats may exclude mice from taking bait and this may be a reason for the prolonged bait-take (D. Brown pers. comm.). However, Taylor & Thomas (1989) went further to suggest that dominant individuals would initially consume a lethal dose of bait and die within 3-4 days allowing the less dominant rats and mice to gain access to baits to receive lethal doses. This appears to be the case with Quail Island as bait-take continued for 37 days.

One issue that did arise at the beginning of the operation was that animals often removed all baits from stations sometimes storing them in caches nearby. Behavioural studies by Barnett (1975) and observations by Taylor & Thomas (1989) showed that rats either ate or cached the baits in burrows.

Rat fur found in the stoat stomach indicates that rodents had been consumed and mustelids as well as other mammalian scavengers, including hedgehogs, would have been at risk of secondary poisoning. Taylor & Thomas (1993) also suggested that rats scavenging carcases would also be vulnerable to poisoning, as would hedgehogs that tend to eat the gut of animals scavenged (K. Moss, unpublished). Reductions in magpie numbers on Quail Island post-poisoning (Nick Allen pers. comm.) indicate that they may be susceptible to secondary poisoning through scavenging poisoned carcases.

<u>Habitat preferences</u>

Innes (1990) commented that ship rats are able to climb and will ascend trees to access food. Similarly, hedgehogs scavenge poroporo (*Solanum aviculare*) berries when available (Mike Bowie, pers. obs.). An apparent preference for scrubland habitats allows access to a greater food source from native plant species. As a consequence of the limited scrubland on the island (9 %), animals may be found at higher densities thereby increasing bait-take. This habitat type may offer better protection from avian predators than grasslands or the pine/macrocarpa habitats. Finally, the scrubland on the island may offer a more stable habitat for animals to nest leading to increased densities although further study is needed to confirm this.

In contrast to Brooks & Rowe (1987), rats and other pests favoured the black Novacoil bait stations as compared to yellow Pestoff bait stations. The wider entrance of the Novacoil bait stations may have been easier to locate, access and also allowed hedgehogs to the bait. Novacoil stations entrances were positioned at ground levels and did not require animals to step up into them as with the Pestoff stations. Novacoil bait stations may have had greater bait-take due to their more natural colour compared to the yellow pestoff bait stations.

Biological analysis

The larger number of male rats caught on Quail Island (103♂: 42♀) may be explained by males having larger home ranges and may encounter traps more often (Hooker and Innes, 1995). In contrast Best (1973) and Innes *et al.* (2001) found 50% and 47% of rats collected were males respectively. Female ship rats show similar levels of pregnancies to Norway rats collected during October 1985 by Taylor & Thomas (1993) although lactating females from Quail Island could not be identified as they had been frozen for up to 15 months. Flea species removed from rats included the mouse flea (*Leptopsylla segnis*), and the rat flea (*Nosopsyllus fasciatus*). These were more commonly found on male mice and rats.

Several rats caught during January 2000 (not included in the analysis) were identified as Norway rats (*Rattus norvegicus*), which may indicate a change in species composition over time as all rats trapped subsequently have been identified as ship rats (*Rattus rattus*).

Recommendations

Future recommendations for pest eradication on any island would include getting baseline data on animal abundance before and after poisoning to establish the effect poisoning has had on pest populations. This should follow standard protocols as described in many studies (Taylor and Thomas, 1989; 1993; Hickson *et al.*, 1986; Moors, 1985).

Increasing the duration that bait stations are in position before baits are inserted may help reduce neophobia and increase bait-take in the initial stages of poison operation. Similarly, the use of a non-toxic pre-feed may also increase bait-take although eradication from islands has been accomplished without pre-feeding (Taylor and Thomas, 1989; 1993) and reduces costs.

Providing adequate bait in stations so that poison is constantly available to pests is another factor that could increase the success of future poison operations, unfortunately managers can not predict bait-take. Regular monitoring of bait stations would enable changes in the amount of bait loaded into stations to track bait usage.

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Appendix

1997

- Provisional planning for the ecological restoration of Quail Island (Otamahua)

18 – 29 January 2000

- Live capture and removal of hedgehogs.

27 April 2000 – present

- 2 night walking searches to catch and remove hedgehogs.

7 September 2001 – present

- Trap boxes set up with 'Kitekat chunky fish' tinned cat food'
    - 20 November 2001 - Replaced with peanut butter
    - 30 January 2002 - Replenished with peanut butter

2-9 August 2002

- Bait stations placed on Quail Island
    - 16 August 2002 - ten Pestoff 20R rodent pellet baits (0.002% brodifacoum) placed in each station.
    - 27 September 2002 - a single 20 g Talon 50 WB wax impregnated cereal briquette (0.005% brodifacoum) placed in each station.
    - 29 September 2002 – 5 October 2002 - a single Talon 50 WB bait wrapped in tinfoil placed in each station.

December 2002

- Visual analysis of dominant and secondary vegetations in 20m surrounding stations.

1. Mean percentage bait-take analyses

Sample 2	$F_{1,416} = 14.72$, $P<0.001$
Sample 3	$F_{1,415} = 15.52$, $P<0.001$
Sample 4	$F_{1,416} = 12.42$, $P<0.001$
Sample 5	$F_{1,418} = 16.99$, $P<0.001$
Sample 6	$F_{1,416} = 4.89$, $P<0.05$
Sample 7	$F_{1,418} = 4.12$, $P<0.05$

2. Bait station activity analyses

Sample 2	$F_{1,418} = 12.63$, $P<0.001$
Sample 3	$F_{1,418} = 28.95$, $P<0.001$
Sample 5	$F_{1,418} = 20.50$, $P<0.001$