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Contents

Rat control in Rarotonga: some lessons for Mainland Islands in New Zealand

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ABSTRACT

The Kakerori, or Rarotonga Flycatcher (*Pomarea dimidiata*), is an endangered forest bird endemic to Rarotonga, Cook Islands. We identified that the Kakerori population was in decline, mainly because of predation at nests by ship rats (*Rattus rattus*) and possibly Pacific rats (*Rattus exulans*), and because of some predation of adults by cats (*Felis domesticus*). Since 1987, we have carried out a research-by-management project using intensive rat control in 155 ha of steep forested country in the south-eastern part of Rarotonga. The Kakerori population has recovered from a low of 29 birds in 1989 to 134 birds in 1996. Some of the lessons learned from this programme have relevance to the management of 'mainland islands' in New Zealand, and to other sites where rat eradication is not possible. Poison baits need to be both attractive to rats and durable under local conditions. Cats (and other higher predators) can be controlled effectively by secondary poisoning through eating poisoned rats, and various widely used traps and bait hoppers are not effectual under all conditions.

INTRODUCTION

New Zealand conservation managers and scientists can justly claim to lead the world in the eradication of rodents from islands. Through previous experience and with the development of new methods, they have successful eradicated rodents from large islands such as 220 ha Red Mercury Island in 1992 (Pacific rats *Rattus exulans*), and the 1996 programme on 1960 ha Kapiti Island to eradicate Pacific and Norway rats *Rattus norvegicus*. Following the success of an intensive 'research-by-management' project at Mapara, aimed at restoring the Kokako *Callaeas cinerea* population there, attention has recently begun to move to the long-term management of threatened species and ecosystems on the mainland of New Zealand, in 'mainland islands'. Here we report on another 'research-by-management' project in a simple ecosystem on the 'mainland' of Rarotonga, Cook Islands, aimed at the recovery of the critically endangered forest bird, the Kakerori or Rarotonga Flycatcher *Pomarea dimidiata*. The system is simple in that rats (ship rats and Pacific rats) and feral cats *Felis*

domesticus are the only significant threats to Kakerori, although Long-tailed Cuckoos *Eudynamys taitensis* may take a few eggs or young, and a few Norway rats have been recorded in the area.

Rarotonga (21°14'S, 159°46'W) is the largest and highest island in the Cook Islands. It has an area of about 6700 ha, over three times the size of Kapiti Island, and the mountainous forested interior reaches 653 m above sea level. Almost all of the 8,000 inhabitants live on the narrow (< 1 km wide) fertile, coastal ring-plain.

The Kakerori is a 22 g forest bird endemic to Rarotonga (Robertson et al. 1994). It breeds from about mid October to early January, and the clutch is 1-2 eggs. Pairs lay up to four replacement clutches in a season, but few pairs raise more than one brood per season. The nest is a bulky cup, usually placed in a triple fork of a branch 5-15 m above the ground, often in trees overhanging a small stream. In the mid 1800s the Kakerori was common throughout the island, but it declined dramatically and by 1885 became restricted to the forested interior of the island. We suspect that ship rats arrived in Rarotonga about this time, as they also reached New Zealand about then (Atkinson 1973). By the early 1980s, the Kakerori was restricted to four adjacent valleys in the coastal foothills in the south-eastern part of the island. The 155 ha area currently occupied by Kakerori is on the wettest part of the island, and receives an average yearly rainfall of 3250 mm, compared with 2021 mm at the airport on the opposite side of the island (refer Figure 1 for study area location).

When we started our project in 1987, we aimed to assess the numbers of Kakerori, to determine what their threats were, and to begin a management programme to recover the population. In the 1987-88 season, we found a minimum of 38 birds, but only 2 (17%) of 12 nesting attempts were successful, with rat predation of eggs or chicks being the main apparent cause of nest failure. We set snap-traps in the valleys occupied by Kakerori, and determined that ship rats and Pacific rats were present (but trapping in 1996 revealed that a few Norway rats are also in the study area). We saw feral cats and their droppings in the study area, and a colour-banded adult Kakerori was apparently killed by a cat.

RESEARCH BY MANAGEMENT

We planned our rat control programme so that we could measure the effectiveness of the management, and test the cost-effectiveness of different methods of rat control. The ultimate aim is to devise an ongoing programme which is cheap and easy to apply, minimises the amount of poison that enters the environment, yet is sufficient to protect the Kakerori and to allow their population to recover.

This paper reports briefly on the various techniques used in the rat control programme, and the implications of our experiences for the long-term management of predators in mainland situations where eradication is not possible. A description of the work to 1993 appears in Robertson et al. (1994), and a fuller description of the annual rat control programme will appear elsewhere.

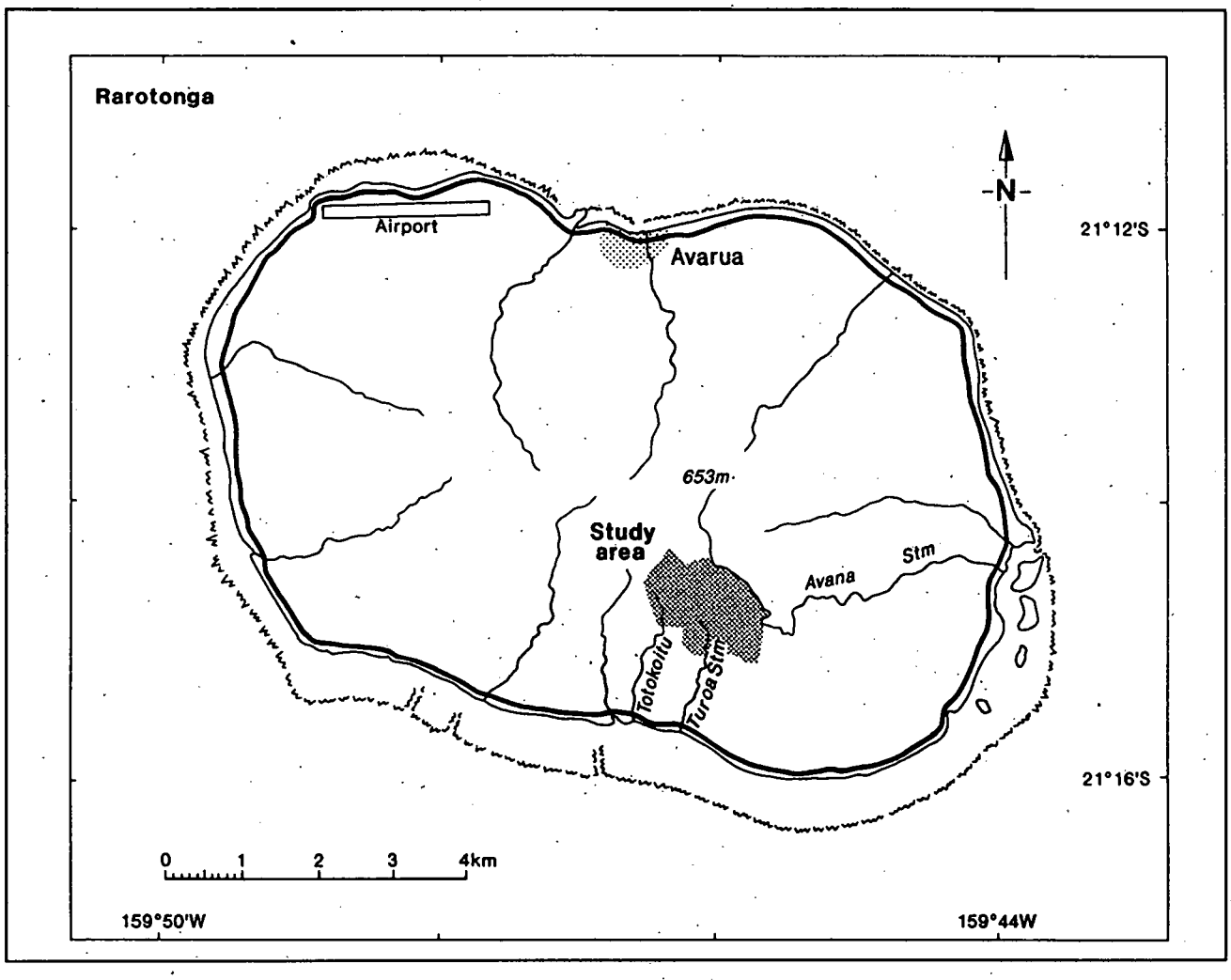

FIGURE 1. MAP OF RAROTONGA SHOWING THE LOCATION OF THE STUDY AREA.

TREE-BANDING

Throughout the Pacific, coconut trees are often banded with a strip of metal to prevent rats from climbing to reach the ripening coconuts - we did the same for trees used as nest sites by Kakerori. We purchased 59 cm wide Possum coil (as used on power poles in New Zealand) and, where possible, we have tried to protect Kakerori nests each year by nailing 29.5 cm wide (i.e. coil cut in half) aluminium bands around the trunk of the tree containing the nest and the trunks of adjacent trees whose branches interlaced with those of the nest-tree. Often, such as when nests were in the fronds of ana'e (king fern) *Angiopteris longifolia*, or where there were too many adjacent trees with branches interlacing, this method of protection was not possible.

RAT POISONING

Since 1988, we have tried a variety of poison baits, frequency and timing of poisoning, and density of bait stations. We gradually increased the density and area of rat poisoning (Table 1) until all nesting territories were protected in 1992. Since then, funding difficulties, low density of nests in some areas, and our desire to reduce the amount of poison used each year, has led to a reduction in the poisoning effort and trials of other control techniques and methods of bait presentation.

TABLE 1. RAT CONTROL IN EACH OF FOUR CATCHMENTS FROM 1988 TO 1997.

	TOTOKOITU	TUROA	LOWER AVANA	UPPER AVANA
AREA COVERED	30 HA	35 HA	25 HA	20 HA
1988-89	Talon 20P 20 kg	nil	nil	nil
1989-90	Storm 44.4 kg	nil	nil	nil
1990-91	Talon 50WB 50.0 kg	Talon 50WB 69.6 kg	nil	nil
1991-92	Talon 50WB 90.1 kg	Talon 50WB 110.8 kg	Talon 50WB 102.6 kg	nil
1992-93	Talon 50WB 50.5 kg	Talon 50WB 55.3 kg	Talon 50WB 56.0 kg	Talon 50WB 51.6 kg
1993-94	Talon 50WB 88.0 kg	Talon 50WB 71.6 kg	Talon 50WB 88.4 kg	nil
1994-95	Talon 50WB 16.1 kg	Snap-trapping	nil	nil
1995-96	Ridrat super 24.4 kg	Ridrat super 25.5 kg	Ridrat super 15.2 kg	nil
1996-97	Ridrat super 32.8 kg	Traps + Ridrat 4.8 kg	Ridrat (tubes/ hoppers) 14.4 kg	nil
TOTAL BAITS	416.3 kg	339.3 kg	276.6 kg	51.6 kg
Kg/ha	13.9	9.7	11.1	2.6

Poison baits are placed in 40 cm long and 10 cm diameter Novacoil flexible drainpipe tubes. These are placed around the perimeter of each valley system, and also within the valley, near where Kakerori nests are usually found. Bait tubes are placed away from streams so that baits could not be washed away in floods. At the peak of management, the total area covered was about 110 ha out of the 155 ha used by Kakerori.

Throughout the study, we have compared the nesting success (Table 2) and survivorship of adult Kakerori (Table 3) in areas protected and not protected by poison. This showed that rat poisoning significantly increased both breeding success and adult survival.

TABLE 2. KAKERORI NESTING SUCCESS IN POISONED AND UNPOISONED AREAS

SEASON	POISONED		UNPOISONED	
	%	NO. NESTS	%	NO. NESTS
1987-88	-	[0]	17	[12]
1988-89	38	[8]	25	[8]
1989-90	88	[8]	43	[14]
1990-91	71	[14]	50	[4]
1991-92	60	[20]	0	[1]
1992-93	86	[14]	-	[0]
1993-94	85	[27]	100	[1]
1994-95	75	[12]	54	[26]
1995-96	53	[40]	67	[3]
TOTAL	68	[143]	42	[69]

Chi-squared = 12.9, P<0.001

Type of Poison Baits

We started in 1988-89 by using a 'handful' (about 10) of Talon 20P pollard pellets (active ingredient: 0.02g/kg brodifacoum) in each bait tube. We had major problems with mould forming on the pollard baits in the very humid conditions, and they had to be replaced every 1-2 weeks. We felt that the mould reduced their attractiveness to rats. Similar problems with mould forming on baits has been reported subsequently in warm sites within New Zealand (Ian McFadden pers. comm.). Overseas, Brian Bell found that some operators had breathing problems after handling mouldy pollard baits (pers. comm.). An additional problem was that, in the field, it was impossible to measure and record the precise amount of bait taken each week, as there were so many small and irregularly sized pellets.

The next year (1989-90), we used Storm waxy block baits (active ingredient: 0.05g/kg flocoumafen), and maintained three 16 g baits in each tube each week. The baits survived moderately well (3-4 weeks) in the humid conditions. The rate of bait removal could be accurately quantified because we were able to record the precise number of baits removed each week.

Through the Department of Conservation, we obtained supplies of Talon WB50 waxy block baits (active ingredient: 0.05g/kg brodifacoum) and from 1990-91 to 1994-95 used this poison. These 18 g baits lasted a similar time to the Storm baits and bait take was again easy to monitor.

To try to reduce the deterioration of baits in humid conditions, in 1995-96, and in 1996-97, we used Ridrat Super waxy block baits (active ingredient: 0.05g/kg bromadiolone). Each bait tube had a single 38 g bait fastened by a wire through the hole provided in the wax block. These baits lasted better (approximately 6 weeks) than did the Storm or Talon 50WB, but a small trial at the start of the 1995-96 season showed that they were much less attractive to rats, and this may have caused an initially very low bait-take compared with the other bait types (see below). Bait take may have been partially reduced because baits were fixed and had to be eaten within the bait tube, but it was more difficult to maintain a constant amount of bait in each tube each week as rats often removed 25%-50% of a bait rather than whole baits as they did with Storm or Talon WB50 baits.

TABLE 3. SURVIVAL OF ADULT KAKERORI IN POISONED AND UNPOISONED AREAS.

SEASON	POISONED		UNPOISONED	
	%	NO. BIRDS	%	NO. BIRDS
1987-88	-	[0]	84	[38]
1988-89	67	[18]	67	[18]
1989-90	93	[15]	100	[14]
1990-91	94	[32]	86	[7]
1991-92	93	[46]	100	[2]
1992-93	95	[57]	-	[0]
1993-94	96	[57]	100	[8]
1994-95	100	[30]	84	[58]
1995-96	92	[97]	100	[9]
Total	93	[352]	86	[154]
Chi squared = 7.2, P< 0.01				

Frequency of baiting

We have found over the years that it was much easier to programme field assistants to spend one or two fixed days each week replenishing bait stations rather than to replenish baits at say fixed 10 day intervals, or even at fortnightly intervals. Likewise it was easier to programme 16 weeks of continuous poisoning through the breeding season than having say three pulses of three weeks of baiting six weeks apart. Analysis of results was also simpler with a regular record of weekly bait take, and minor corrections based on daily removal rate could be applied if bad weather or staff absence meant that the interval was slightly different from weekly.

Timing of baiting, and pattern of bait removal

The pattern of weekly bait-take of Talon and Storm baits was relatively consistent from year to year, and was independent of when the poisoning started - a very high (80%-100% bait-take in the first 2-3 weeks, dropping to less than 50% by about the fourth week, declining steadily to 10-20%, then followed by a rise to 30-40% in November-December (Figure 2). The pattern of bait take of Ridrat baits was different; the initial bait-take was moderately low (14%), rose to peak at 75% in the third week, before dropping to less than 50% by the fifth week.

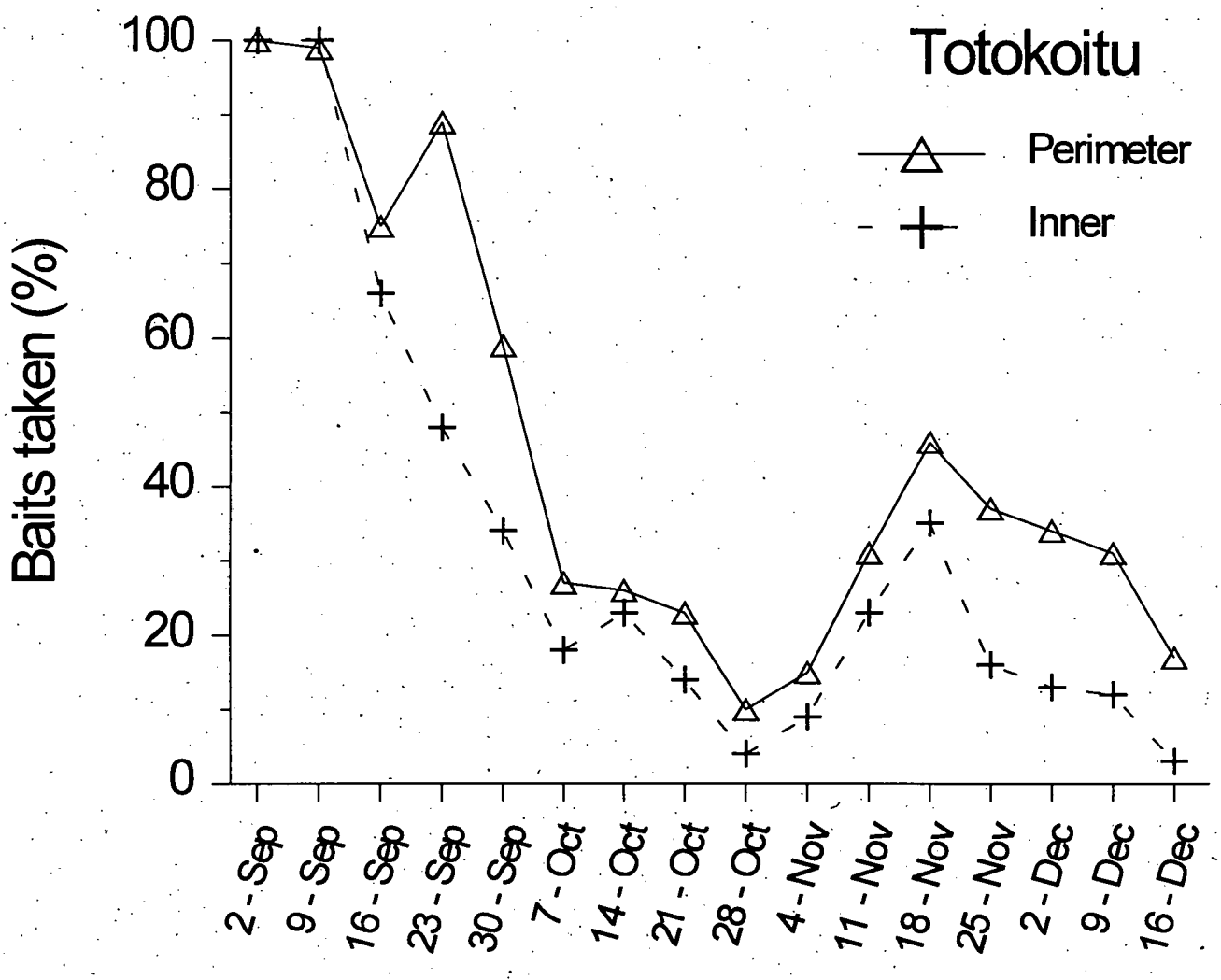

FIGURE 2. TYPICAL SEASONAL PATTERN OF POISON BATE TAKE, TOTOKOITU VALLEY (1991). NOTE THAT THE BAIT TAKE IS HIGHER FROM PERIMETER BAIT STATIONS (TRIANGLES) THAN FROM THOSE WITHIN THE VALLEY (CROSSES).

During the first two weeks bait take was similar from the perimeter and valley bait tubes, however after this, bait take was higher on the perimeter lines (Figure 2). Despite our intensive poisoning efforts (e.g. 7 bait stations per ha in the Totokoitu Valley replenished weekly for up to 16 weeks) there were some rats present all the time. The minimum weekly take from inner lines of bait tubes was usually 5-10%, and on valley perimeter lines was 5-15%, and in the nine years, we had only one weekly round where no baits were taken from a

single line of (75) bait tubes. With assistance from snap-trapping data (see below), we interpret this pattern as an initial knockdown of rats resident in the poisoned area, followed by continuous immigration of rats from non-poisoned areas nearby (causing the higher bait-take on the perimeter where we intercept invading rats) and perhaps bait-take by rats that could not gain access to baits earlier in the season, followed by a major influx of Pacific rats into the system in November-December. If the aim had been to temporarily eradicate all rats from these valleys, rather than to reduce the rat populations to levels which allowed Kakerori to breed successfully, then the area we were covering and/or intensity of poisoning would have been insufficient.

Given that we aimed to reduce bait take to less than 50% by the time Kakerori started nesting in mid-October, and ultimately to lower bait take to less than 10%, we usually started poisoning in early September and achieved these goals, especially on the inner lines which ran near to where most Kakerori nests were placed.

In 1993, we carried out an experiment to see if rat numbers could be lowered at the start of the following season by periodic poisoning ('maintenance poisoning') during the non-breeding season. Baits were put out on 3 February, 18 April and 6 July in the Totokoitu outer and inner stations and the inner stations of the Lower Avana basin. The pattern of bait take was similar throughout: in February about 45% of baits disappeared in a week, but by April, and again in July, 93-99% of baits were removed. A shortage of poison baits meant that we could complete the trial by using only the Totokoitu inner stations. The bait take in the first three weeks at the start of the 1993-94 breeding season (89%, 73% and 20%) was lower than in previous years (95-100% in 1990-1991; 94-100% in 1991-1992; and 64-86% in 1992-93). However, we concluded that this difference was not sufficiently dramatic to be a cost-effective method compared with starting the poisoning a week earlier, given that rats had rapidly replaced those that had died in the 'maintenance poisoning', and some of the poisoned rats would have died naturally before September anyway.

Bait tubes versus bait hoppers

In 1996, we tried an experiment to protect one valley system by using Ridrat baits in Philproof bait hoppers rather than using traditional bait tubes. Ten bait hoppers were filled with 26 Ridrat super waxy baits on 13 September in the Lower Avana valley. No baits were taken from the hoppers until early December, by which time we had shifted two baits to the ground outside the hoppers to try to entice rats to enter the hoppers. Over the next five weeks, rats ate all 26 baits at three of the hoppers and removed at least one bait at six of the seven other hoppers. Given that no baits had been removed from the hoppers in the first two months, we set out nearby bait tubes and discovered that unlike previous years, few baits were eaten, and so the lack of bait-take from the hoppers may have been due to a lack of rats rather than an aversion to enter the bait hoppers. It is important to distinguish between these possibilities, because although we know that in mainland forests in New Zealand rats readily enter bait hoppers, this may be associated with possums feeding from them and attracting rats to small pieces of bait that are dropped on

the ground nearby (pers. obs.). If use of hoppers by rats is related to the presence of possums, then they may not be suitable for use on possum-free islands, or for detecting and dealing with the arrival of rats onto otherwise rodent-free islands. We intend to repeat the experiment in 1997-98, but with nearby tubes baited from the time the bait hoppers are filled.

RAT TRAPPING

Snap-trapping

We quickly discovered that the traditional New Zealand bait of a mixture of peanut butter and rolled oats was not suitable because it was rapidly eaten by ants during the day, and so we have subsequently baited the traps with small chunks of salami, bacon rind or, more recently, with (much preferred) toasted pieces of coconut.

In the first three years (1987-1990) we set Ezeset snap-traps to determine which species of rats were present in the study area, and found that ship rats predominated the samples in early spring (August-September), but in early summer (November-December) Pacific rats dominated the samples. We were also able to demonstrate that poisoning had significantly reduced rat densities within the areas poisoned. Investigation of stomach contents showed that fruits, especially of the pua *Fagraea berteriana* dominated their diet through spring and summer.

In 1994, we had virtually run out of poison, and so we compared the nesting success and survival of Kakerori in a valley intensively snap-trapped (traps set each week at each poison bait station) with that in a neighbouring valley where we used our conventional weekly poisoning regime, and the rest of the area where no special control took place apart from appropriate tree-banding. There were no significant differences in breeding success, but the 100% survival of 30 adult Kakerori in the poisoned area was significantly better ($P = 0.013$) than the 81% survival of the 31 birds in the untreated area, but not significantly better than the 89% survival of the 27 birds in the trapped area ($P = 0.099$). The bait take at the end of the season in the three areas was 37%, 14% and 70% respectively, suggesting that poisoning and snap trapping had a similar effect on the rat population. We believe that the differences in adult survival are most likely related to the differing numbers of cats in these areas; high in the trapped and non-treatment area, but low in the poisoned area because some died from direct poisoning (one was seen eating baits from tubes) and some from secondary poisoning after eating poisoned rats.

Live capture of rats

In 1996, we tried to find out about the movements and numbers of rats in one valley by catching them in Elliott traps and then ear-tagging them. We followed this up with poisoning and simultaneous snap-trapping. We caught and tagged 17 Pacific rats between 25 October and 10 November, and over the next fortnight we snap-trapped 5 of them (up to 75 m away from their capture site) plus 54 untagged Pacific rats (although ants may have removed some eartags

from the rats); however, we also caught 38 ship rats and 2 Norway rats. This indicated that the Elliott traps had failed to catch ship rats, even though the Elliott traps and snap traps had both been baited with toasted coconut. Apart from the captures of Pacific rats, few traps were disturbed and so it was clear that ship rats were not entering the traps rather than escaping from them. We conclude that ship rats have an aversion to entering the enclosed Elliott traps, and so these traps are not an appropriate tool for sampling rat populations.

CAT CONTROL

In 1987-88, Peter Gaze found the remains of a colour-banded adult Kakerori that had apparently been killed by a cat. Since intensive management started in 1989-90, the annual survival of adult Kakerori has increased dramatically from 76% to 93%. We have no direct evidence that rats killed adult Kakerori on nests (rat predation at nests typically left only small eggshell fragments or chick feather quills, and also rat droppings), and so we suspect that much of this improvement in adult survival is from a reduction in cat predation. We have sporadically trapped and killed cats, but suspect that many cats are being killed by secondary poisoning when they eat poisoned rats - the main item of food in the scats we examined - but some probably died from direct poisoning.

CONCLUSIONS

This study, done in a relatively simple ecosystem on Rarotonga, provides some useful insights into predator control on a 'mainland' situation where it is not (yet) feasible to eradicate rats or cats. By identifying the threats to Kakerori, and then using predator-control technologies developed in New Zealand in a structured experimental way, we have achieved our aim of increasing the Kakerori population to a state where its IUCN ranking can be downgraded from "critically endangered" to "endangered". By being able to continuously monitor the success of the various methods through a programme of research-by-management, we have been able to refine our management to try to achieve the most cost-effective management which still achieves our required conservation outcome.

We are conscious of the need to reduce the amount of poison entering the environment, and also the possibility that Kakerori itself may be vulnerable to secondary poisoning. The total amount of baits applied over the last 9 years in the Totokoitu valley (13.9 kg/ha), is similar to the 16 kg/ha of Talon used in the aerial rat poisoning on Red Mercury Island in 1992 (Robertson et al. 1993). The extremely high annual survivorship (93%) in the poisoned areas (Table 3) suggests that Kakerori have not been affected by the poison; we suspect that the low adult survival (67%) in the year we used pollard baits (1988/89) was more likely caused by an inadequate level of poisoning rather than any secondary poisoning effect.

The main lessons which can be applied to 'mainland island' management are:

1. If the goal is to temporarily remove ship rats or Pacific rats from an approximately circular area of less than 110 ha within continuous forest,

then intensive rat control using poison baits in bait stations is unlikely to be successful, because re-invasion appears to be very rapid.

2. Wax baits (Storm, Talon WB50 and Ridrat super) are much more suitable for use in warm humid conditions than are pollard baits.

3. Ridrat baits last much longer in warm humid conditions than do Storm and Talon 50WB baits, but they are much less attractive to rats.

4. Coconut (or coconut-flavoured) baits are extremely effective lures for attracting Cook Island rats into traps. A word of caution is that coconut contains vitamin K_1, the antidote to talon; however, our results suggest that this does not protect rats sufficiently in the field situation. The main lesson is that whatever local product the rats like best is most likely to make the best bait.

5 Ship rats show a clear aversion to entering Elliott live traps, and rats may possibly have an aversion to entering Philproof bait stations if possums are not also feeding from them.

6. Control of higher predators (e.g. cats) which feed on rats, can probably be achieved successfully through secondary poisoning, as long as the control of rats is not so intensive (e.g. an air-drop of poison over a large area) that it eliminates them temporarily as a vector for the poison.

7 Much still needs to be learnt about the social behaviour and movement of rats and higher predators during rat control operations, e.g. the rate and timing of re-invasion of rats, and whether cats move from, or quickly through, an area depleted of rats, or whether they switch their diet to other prey such as lizards or birds.

ACKNOWLEDGMENTS

Rod Hay and Gerald McCormack helped to get this research-by-management programme under way, and Rod bore the brunt of funding problems. Many staff from the Cook Islands Conservation/Environment Service have helped with the predator control programme, especially Vavia Vavia, Teina Rongo and Aitua Kuro. A number of conservation volunteers and/or former Ecology Division, DSIR, staff have helped with this project, especially Mike Fitzgerald, Peter Gaze, Nigel Langham, Ray Pierce and Kerry Sanders. Financial or logistical support has been given over the years by the Pacific Development and Conservation Trust, South Pacific Regional Environment Programme, Ecology Division (DSIR), Department of Conservation and the Ornithological Society of New Zealand. Rod Hay and Ray Pierce improved the manuscript.

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FOOTNOTE

Management of the 155 ha of private land on which Kakerori survive is now in the hands of the three land-owning families as the Takitumu Conservation Area Project. This project is part of the South Pacific Biodiversity Conservation Programme run by the South Pacific Regional Environment Programme. The aim of the Takitumu Conservation Area Project is to develop an ecologically and commercially sustainable ecotourism venture and to use the income generated to continue to manage the Kakerori population (and other wildlife and plants in the area) and to employ members of the local community. This could well provide a good model for the integrated management of ecotourism and biodiversity conservation in the South Pacific. For information about visiting the conservation area, please contact: The Conservation Area Support Officer, PO Box 817, Rarotonga, Cook Islands, email: kakerori@tca.co.ck.

An attempt to establish a new, viable population of blue duck (*Hymenolaimus malacorhynchos*) in Egmont National Park

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ABSTRACT

Twelve blue duck (*Hymenolaimus malacorhynchos*) have been released in Egmont National Park in three separate liberations. Of these, seven were captive-reared juveniles and five were wild adult birds from the Manganui a te ao River. A minimum of five banded birds remain, as well as three unbanded, in 1994. Additional liberations will be required to further enhance the establishment of a population, building on the experiences of previous trials.

INTRODUCTION

The motivation for the establishment of new viable populations of blue duck stems from general objectives and policies in the Conservation Strategy for Blue Duck 1988-1992. Specifically, section four of the "Management Procedures" sets out the policy for "Population Establishment and Enhancement":

Criteria for the selection of suitable sites for population establishment and/or enhancement include the quality and quantity of suitable habitat; the security of the habitat; the potential for birds to colonise adjacent catchments; and whether the site is within the historical range of the species.

The release Sites

According to the criteria for assessing a release site, Egmont National Park rates well. It is within the natural range of the species with the last confirmed record in 1948 (Molloy and Cotton 1986) and some unconfirmed records up until the 1987 release. The Park offers over 300 rivers and streams and has a secure status. Additionally, some rivers have vegetated and protected riparian margins outside the Park boundary. These offer further opportunities for blue duck to establish territories.

The release sites (Figure 1), Manganui River (1987, 1989), and the Waiwhakaiho River (1991) were assessed in terms of the stability of the habitat they offered, food availability, and their accessibility for release and ongoing monitoring.

The Taranaki Catchment Commission's (1984) report on the freshwater biology of the Taranaki ring plain, rated the upper sections of the Manganui and Waiwhakaiho Rivers in the top 17 sites for habitat quality. The dominant invertebrate taxa were in the Ephemeroptera (mayflies), Trichoptera (caddis flies), and Diptera (midges). This diversity compared favourably with an analysis of the diet of blue duck on the Manganui a te ao River (Veltman et al. in prep.). They found that 60% of blue duck diet was made up of chironomid larvae (Diptera) and 24% of caddis fly larvae. It was further calculated that blue duck consistently sought out Hydrobiosidae (Trichoptera), stone flies (Plecoptera), and Aphrophila (Diptera).

The objectives of this study were to 1) establish a new viable population of blue duck in Egmont National Park; 2) test the suitability of captive-reared blue duck for relocation; and 3) test the suitability of wild adult blue duck for relocation.

1987 Release

The initial release of blue duck in Egmont National Park occurred in April 1987. Six captive-reared juvenile blue duck were transferred from the National Wildlife Centre at Mount Bruce to the Manganui River in the Park.

1989 Release

In 1989 a single captive-reared male from the National Wildlife Centre was released on the Manganui River with a resident unbanded juvenile female. The justification for this release will be dealt with later.

1991 Release

Following the trial releases of captive-reared birds in 1987, the Blue Duck Recovery Group further agreed (July 1990) to trial the capture and release of up to four wild pairs of blue duck. The relocation of wild birds had never been attempted before.

The Manganui a te ao River was selected as the source population. The dynamics of this population had been comprehensively monitored over the previous ten years (Williams 1991) providing a sound information base on which to measure the effects the removal of birds would have.

In March 1991 two neighbouring pairs and a single male were captured from the lower gorge section of the river and transported by helicopter to the Waiwhakaiho River in Egmont National Park.

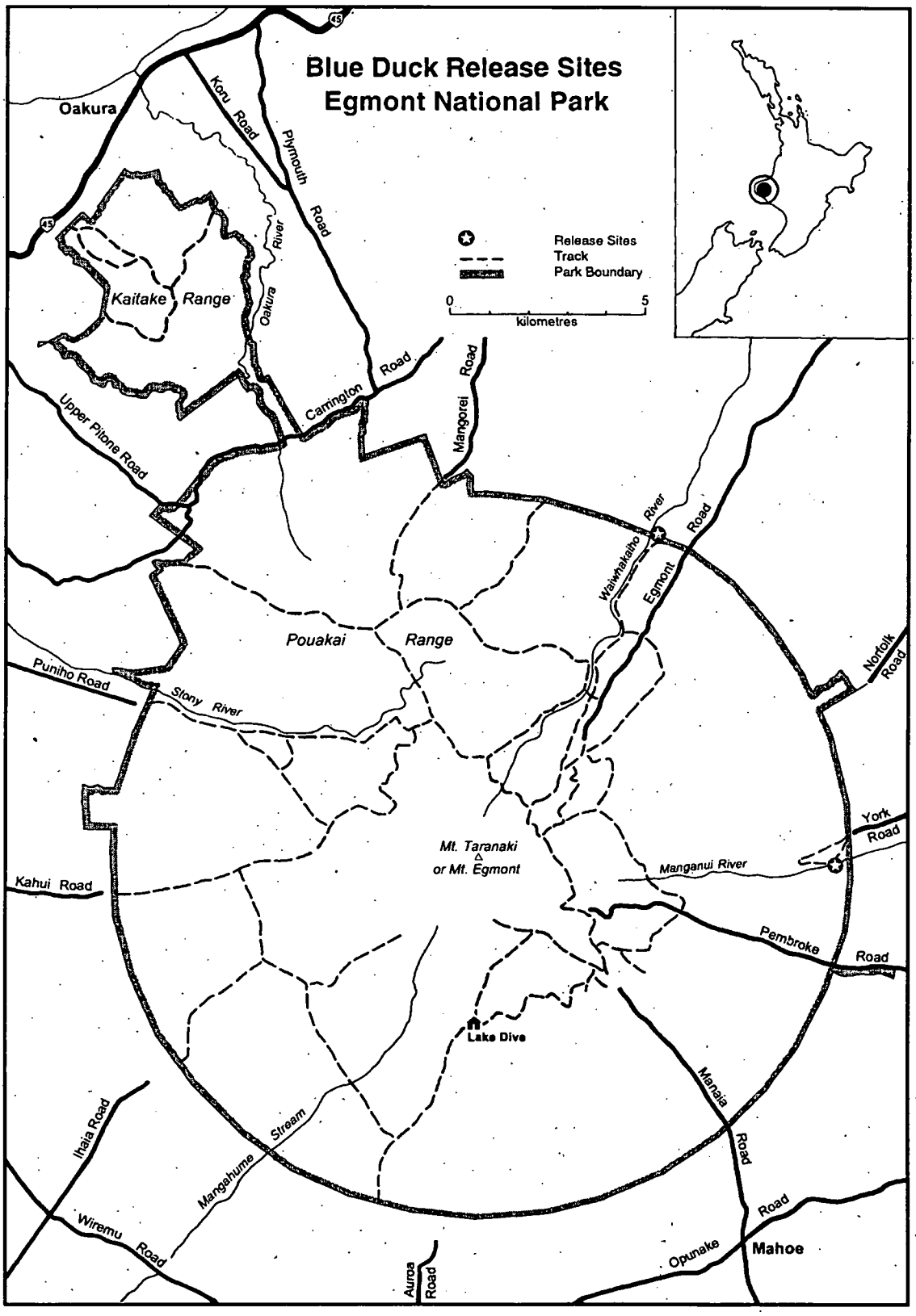

FIGURE 1. LOCATION OF BLUE DUCK RELEASE SITES IN MT TARANAKI/ MT EGMONT NATIONAL PARK.

MONITORING

(i) 1987 Release

All six birds involved in this release (three males and three females) were fitted with tail-mounted radio transmitters at the National Wildlife Centre. Four of these fell off within two days and were not reattached. In three cases, the tail feathers pulled out with the transmitter attached.

For four days prior to release, the birds were held in a pen at the release site. Predator trapping was undertaken in the area but none were caught. During the acclimatisation period, the birds continued to be fed on an artificial diet. On release, all six birds appeared to feed within the first hour. Green droppings found over the following two weeks suggested that they fed extensively on aquatic vegetation.

The birds were monitored closely (visual recordings) for the first two weeks, after which they disappeared following a major storm event. Frequent searches over the following 6-12 months failed to find them.

In December 1988, twenty months after release, three blue ducks were seen together on the Manganui River by a member of the public. In March 1989, three birds were again observed on this river; an unbanded juvenile female approximately 2 km above the release site, and a banded pair a further 2 km upstream.

The finding of the juvenile unbanded female (now separated from the upstream pair and almost certainly a juvenile of the year), prompted the further release of a captive-reared male bird from the National Wildlife Centre in 1989, with the intention of creating a new pair.

In April 1989, two other blue duck were seen on Lake Dive, about 8 km from the Manganui River. One, the male, was banded.

In subsequent years, up to and including 1994, banded birds of this release were regularly recorded on Lake Dive, the Manganui River, and also the Waiaua River which is some 12 km from the original release site.

(ii) 1991 Release

In this relocation trial, each pair was released immediately on arrival on 17 March 1991 at sites approximately 200 m apart. The single male was released with the downstream pair, just inside the Park boundary on the Waiwhakaiho River.

This trial was designed to test the ability of translocated wild birds to settle into new habitat despite many years' familiarity with their former haunts. In this experiment, neighbouring adult pairs were moved (together with a solo male with which both pairs were familiar) on the assumption that the presence of familiar birds would aid in the settlement process.

A programme was set up to record the location of these birds monthly from April to December 1991, by both remote and visual survey methods. To assist in this monitoring, radio transmitters were fitted to all three male birds.

Initial post-release monitoring involved remote tracking from the air, together with ground searches. A flight in April 1991 recorded only the single male. This bird has since been regularly observed on the Waiwhakaiho River in 1991, 1992 and 1994.

Between the release date and September 1991, no observations were made of either pair. In September, the female of one pair was recorded in the company of an unbanded male, back on the Manganui a te ao River, on the territory from which it had been taken from six months earlier and some 140 km from the release site. Its male partner was seen in October 1991 on the adjacent territory. Its transmitter was still operational although the harness had partially detached and the transmitter hung from the bird's breast. The female and her new mate were seen together throughout the 1991 breeding season and 1992. In November 1993, the original pair were reported together again.

In January 1994, after several failed attempts, the male was caught and relieved of its transmitter. Because two birds returned to the Manganui a te ao River prompted an immediate flight over the Whanganui National Park area between there and Egmont to see if any of the other transmitters could be detected. No signals were received.

The whereabouts of the second pair remained a mystery until March/April 1994 when the male was seen twice on the Stony River approximately 6 km west of the release site.

Both males of the 1991 release that remain in Egmont National Park retain their transmitters. The Stony River male's transmitter was partially detached in a manner described earlier while the Waiwhakaiho male's is as fitted. An attempt was made in June 1994 to catch the Stony River male, but it was not found.

RESULTS

Of 12 birds released, at least five remain in 1994 within Egmont National Park and two others returned to the Manganui a te ao River. Of the five remaining birds at Egmont, four are single birds and the fifth is paired to an unbanded bird.

In addition to the six birds above, an unbanded pair was observed regularly over a week in March 1994 on the Mangahume Stream. The origin of this pair is uncertain. An unbanded bird described as a juvenile was observed on Lake Dive in 1989 and may be one of these birds. The other unbanded bird is paired with a female of the 1987 release on the Manganui River.

Although some uncertainty surrounds the origin of the unbanded birds seen in 1994, monitoring has shown that since the first release there was apparently a high survival of the captive-reared birds two years after release, and confirmation that at least one pair (resident on the Manganui River) had bred. It is likely that all unbanded birds are progeny of the 1987 release. It is worth noting that the continued survival of captive-reared blue ducks contrasts favourably with attempts to establish aviary-sourced birds of other species (e.g. brown teal) in the wild.

The trial release of wild adult birds was a partial success since two males remain as single birds in the Park. The fate of one female is unknown while the fate of the other pair has been discussed. This release did not however succeed in the establishment of pairs in the Park.

DISCUSSION

The first objective, the establishment of a new viable population of blue duck in Egmont National Park may not have been fully realised as yet. In retrospect, it is probably unreasonable to have expected this to happen, considering the small number of birds released. However, the trials outlined in Objectives Two and Three have gone some way to assessing the suitability of captive-reared and adult wild birds for release. Further releases should investigate other techniques such as the suitability of wild juveniles for transfer and release, and consolidate the information already gained on the release of captive-reared birds. The release of wild adult birds appears to be unsuitable, although a soft release technique may improve the retention of these birds on the release river. Problems inherent in a soft release include maintaining the birds' ability to feed during the holding period.

Monitoring of the released birds has not been ideal. Problems with transmitters, initially in where they were attached and latterly in how they were attached, need to be looked at. It also appears that released birds did not retain much site loyalty and moved both between streams within a catchment and between catchments. This has made it difficult to predict where birds are likely to be and to implement adequate monitoring programmes. In many cases, observers reported that birds were extremely nervous and difficult to approach closely, making individual identifications difficult.

The suitability of Egmont National Park to sustain a viable blue duck population appears clear as far as it has been tested. Nine years after the initial release, a small but stable number of both banded and unbanded blue duck remains. I (we) believe that the potential for a blue duck population here remains great, with several suitable habitats such as the Stony River available.

ACKNOWLEDGMENTS

I would like to thank Murray Williams, Duncan Cunningham and Colin Ogle for casting a critical eye over this paper, and to Carol Greensmith for her editing skills.

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APPENDIX 1: SUMMARY OF BLUE DUCK OBSERVATIONS 1987-1994

1987

April

- six captive-reared birds from Mt. Bruce released on Manganui River.

1988

December

- three unidentified birds together on Manganui River.

1989

March

- banded pair and an unbanded juvenile on Manganui River.

April

- banded male and unbanded female on Lake Dive.
- single captive-reared male released on Manganui River with unbanded juvenile female.
- unconfirmed sighting of single bird on Maketawa Stream.
- unconfirmed sighting of single bird on Waiwhakaiho River.

1990

January

- a single unbanded bird on Manganui River.

March

- unconfirmed sighting of single bird on Waiwhakaiho River.
- banded pair and a single banded bird on Manganui River.
- banded male and unbanded female on Lake Dive.

August

- three unidentified birds seen on Lake Dive.
- two pairs on the Manganui River (1 banded and 1 banded/unbanded pair).

1991

March

- two wild adult pairs and a single wild male released on the Waiwhakaiho River. Monthly monitoring of these birds both from the air and on the ground. No observations were made of these birds until October 1991.

Date unknown

- transmitter of single male received from the air.

October

- male of one pair seen back on the Manganui a te ao River.

1992

June

- single male from 1991 release on Waiwhakaiho River.
- 2 unidentified birds seen on Maketawa Stream.
- single unidentified male seen on Manganui River.
- 2 banded males (1987 confirmed) seen on Waiaua Stream.

1993

October

- 8 unidentified birds seen on Manganui River (this report followed up immediately. The observation was not confirmed).
- 1 identified bird on Lake Dive.

1994

January

- pair of 1991 release (same male as Oct 1991) seen together on Manganui a te ao River.
- single male of 1991 release seen on Waiwhakaiho River.

February

- single banded female (1987) seen on Lake Dive.
- faecal sign recorded on Manganui River.

March

- one banded male (1991) seen on Stony River (first observation of this bird since release in 1991. Whereabouts of mate unknown).
- pair recorded on Manganui River. One banded (1987) and 1 unbanded.
- two unidentified birds seen over 3 days on Mangahume Stream.

April

- banded male as above seen again on Stony River.
- single banded female (probably 1987 - band worn smooth) seen on Waiwhakaiho River.
- single banded male (1991) seen on Waiwhakaiho River.

Introduction of northern tuatara to Moutohora Island, Bay of Plenty

Keith Owen

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ABSTRACT

Thirty-two Northern tuatara (*Sphenodon punctatus punctatus*) were released on to Moutohora Island, Bay of Plenty Conservancy on 18 October 1996. All tuatara originated from Moutoki Island, Rurima Rocks. After nine months a minimum of 28 tuatara (88%) had survived the release and courting had been observed.

INTRODUCTION

Tuatara, the sole living representative of the Order Sphenodontida (Fraser, 1988) once occurred throughout the two main islands of New Zealand, but over the past 150 years have become extinct there, as well as on at least 10 offshore islands. Habitat destruction and predation by cats, rats, pigs and other mammals introduced by Maori and Europeans are probably the main causes of extinction.

To ensure the survival, and, where appropriate, the enhancement of remaining tuatara populations, the Department commissioned the production of a Tuatara Recovery Plan (Cree and Butler, 1993) and established a Tuatara Recovery Group. The plan was approved in September 1993.

Objective 12 of the plan's recovery strategy proposes "restoration of northern tuatara on an island where controlled public access is permitted." The purpose of this objective is:

> "To establish a self-maintaining stock of northern tuatara on an island capable of supporting at least 1,000 tuatara, preferably on an island from which they have become extinct in historic times, in order to allow the public to view wild tuatara and an island restoration programme without endangering existing tuatara populations, and to increase the population size and number of habitats of northern tuatara towards their former levels."

Moutohora Island in the Bay of Plenty Conservancy (see Figure 1) was selected as an ideal site for this recovery objective.

To my knowledge only one attempt at transferring tuatara (Brothers tuatara to Titi Island) has taken place within the last 50 years although attempts were

apparently made during the 1920s and although details are scant, none seem to have been successful. The development of techniques for establishing and monitoring survivorship of released tuatara populations on new islands was identified by the Recovery Group as an important research need. In response, monitoring of animals released on to Titi Island is being carried out by Nicky Nelson of Victoria University of Wellington.

In May 1995 the Tuatara Recovery Group recommended that:

"Bay of Plenty Conservancy's plans to establish a tuatara population on Moutohora (Whale) Island are supported. It is intended to release animals there during the 1996/97 year from Moutoki Island (8 males and 12 females) and from either Plate (Motunau) or Karewa Islands (8 males and 12 females), i.e. total release should be 40 animals."

Karewa Island Wildlife Sanctuary, a 3.5 hectare island near Tauranga was rejected as a source because it is extensively burrowed by seabirds and prone to major damage by human trampling. The proposal to remove tuatara was also culturally sensitive to the Tauranga Moana people, the local tangata whenua, therefore it was not considered further.

Following this decision, in March 1996 the Tuatara Recovery Group recommended the following:

1 Once agreement has been reached between Ngati Awa and Ngati Whakahemo, Northern tuatara should be transferred from Motunau (8 males and 12 females) and Moutoki (8 males and 12 females) Islands to Moutohora Island during spring (ideally October) 1996.

2 Keith Owen will act as transfer co-ordinator for the Moutohora Island tuatara liberation, and the outcome of the release will be monitored by Graham Ussher, Auckland University, as part of his Ph.D. research.

After consultation with Ngati Whakahemo, Motunau Island Wildlife Sanctuary, a small 2.8 hectare island, lying 13 kilometres north-east of Pukehina Beach in the Bay of Plenty and 42 kilometres north-west of Moutohora Island was rejected as a source for this translocation.

Source Population

A Transfer Proposal application prepared by the Bay of Plenty Conservancy of the Department (Owen and Newman, 1996) sought approval from Head Office to release Northern tuatara on to Moutohora Island during October 1996.

Moutoki Island (0.9 hectare) is one of three small islands comprising the 15.88 hectares Rurima Rocks group (the other islands are Rurima and Tokata Islands). The group lies 8.5 kilometres north from Thornton Beach and is 8 kilometres north-west of Moutohora Island (Figure. 1).

The Island is Maori-owned and Ngati Awa are tangata whenua. The Rurima Rocks group, including Moutoki Island, are a Wildlife Refuge (Section 14 of the Wildlife Act 1953, NZ Gazette 1969, page 359). The refuge is administered by the Department.

An amended proposal was negotiated with Ngati Awa where the number of tuatara removed from Moutoki was increased from 20 to 32 tuatara to fulfill the

release requirement and Graham Ussher's research plan (to monitor the released animals in different habitats on Moutohora Island over a 15 month period). Methods used for the captures and transfers were approved by Auckland University's Animal Ethics Committee.

Moutoki Island supports about 180 animals (Garrick, 1996), and it was believed that the island could sustain the loss of up to 32 adults. Blood-sample analyses had previously revealed no discernible genetic difference between the three Bay of Plenty populations (C. Daugherty, pers. comm.).

The three Bay of Plenty Conservancy islands with tuatara - Motunau, Moutoki and Karewa Islands have small tuatara populations. All are vulnerable to rodents accidentally reaching the islands, fire and poaching. Current populations are limited by the size of the islands. Moutohora Island is a much larger island than Karewa, Motunau and Moutoki Islands so potentially it can support a much larger population than the other three islands combined. The release of tuatara on to another Bay of Plenty Conservancy island will help safeguard these populations. Over time Moutohora will have a large population of tuatara, if the release is successful.

Transfer Population

Thirty-two adults (12 males, 20 females) were planned to be released on to Moutohora Island and their survival monitored. Twenty animals were to have transmitters attached to them, to allow for their easy monitoring on Moutohora. As these animals were adults we were able to sex individuals relatively accurately from external examination.

The sourcing of animals from one small island raises the possibility that the transfer population is made up solely of closely related individuals. It was not possible to take blood samples from the released animals to check their genetic relatedness at the time of transfer.

To alleviate this concern to some degree, the sex ratio of adults to be transferred was biased towards females because they usually breed, on average, just once every four years (Cree *et al.*, 1991). The males have an annual reproductive cycle (Saint Girons and Newman, 1987) and in any one season, a single male can mate with several females (J.C. Gillingham, pers.comm.). Prior to their release, most of the females are likely to have mated with males which may not be transferred to the island (tuatara do not form permanent pair bonds), thus the genetic diversity of the transfer population is likely to be increased by any ensuing young. About one quarter of the females should lay during the spring or early summer following their release. Since tuatara eggs take between 12 and 15 months to hatch (e.g. Newman 1987b), the first young can be expected some time after December 1997.

Tuatara were planned to be liberated during spring (October) just after the cool winter months when they are relatively inactive (Walls, 1983). As a consequence, they were expected to remain at their release sites and feed at a moderately low rate. If they established territories at the four proposed release sites, the females should remain localised, at least in the short term since only males are likely to forage away from their preferred burrows (Newman, 1987a). Therefore the population was expected to remain local (to release sites) and

with functioning transmitters attached, most individuals should be initially easy to relocate. During spring - early summer (October - December) some females are likely to move up to 50 metres to search for suitable nesting areas. They are expected to return to their original territories within two weeks of laying (Cree and Daugherty, 1990).

Release Site

The release site, Moutohora Island, is a 143 ha island, 8.5 kilometres north of Whakatane (see Figure 1). It is a Wildlife Management Reserve (NZ Gazette 1991, page 3674) administered by the Department. Mair (1873) and Buller (1877) recorded tuatara on Moutoki and mention that Maori tradition records them as "plentiful on Whale (Moutohora) Island". Ngati Awa supports this view making reference to mutton birders in the 1930's feeling tuatara in some of the burrows occupied by grey-faced petrel (K. Merito, pers.comm).

It is recognised that Ngati Awa as donor of the 32 tuatara had a special interest in the release of tuatara to the island. They fully supported the release and return of this taonga (treasure) to the island.

The island is large enough so that if tuatara became distributed over only half the island at an average density of 100 tuatara per hectare, the total population supported could be about 7000+ animals. This potentially could become one of the largest populations of northern tuatara.

Tuatara feed on a wide range of small animals, mainly insects. On Stephens Island over 100 different items or types of material have been recognised in tuatara droppings, with the large darkling beetle (*Memopeus opaculus*) occurring most frequently (Walls, 1981). Reptiles (lizards and hatching tuatara) and birds (adults, chicks and eggs of small petrels) each made up only 4% of the diet (Walls, 1981). An invertebrate survey of Moutohora made in 1995, some nine years after Norway rats were eradicated (Jansen, 1993), revealed a large number of widespread New Zealand species together with a substantial number characteristic of northern New Zealand (Patrick, 1996). This survey was specifically undertaken to determine whether any invertebrate species (especially ground dwelling beetles) were placed at risk through such an introduction. Since removal of rats, the island's insect and lizard populations have expanded rapidly (K. Owen, pers. obs.). Three lizard species, common gecko (*Hoplodactylus maculatus),* speckled skink (*Oligosma infrapunctatum*) and copper skink (*Cyclodina aenea*) are found on Moutohora. Visiting Conservation Officers now report seeing lizards on the island far more frequently than when rats were present. These lizards co-exist elsewhere with tuatara on other offshore islands.

As the number of tuatara proposed for release was small (32 adults) and their potential for increase in the short-to-medium term (5 - 15 years) was lower than that for the island's insect and lizard populations, sufficient food was judged to be available to support the transferred tuatara. The large black tenebrionid beetle (*Mimopeus elongatus*), a common species on the island, may form an important part of the tuatara diet. Tuatara are not considered to put at risk any lizards (K. Owen, pers.obs) or invertebrates already occurring on the island (Patrick, 1996).

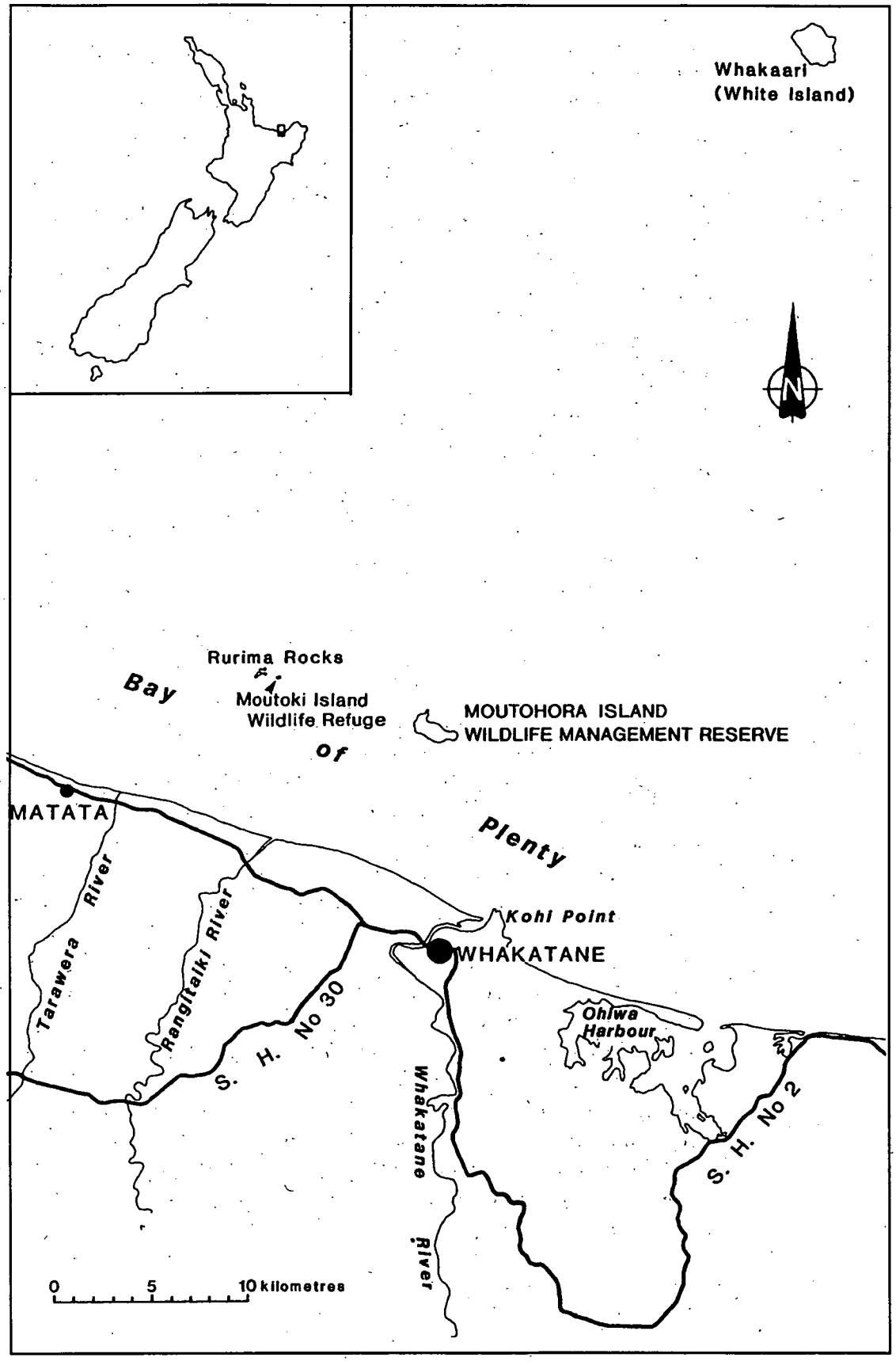

FIGURE 1. LOCALITY OF MOUTOHORA ISLAND

Today all islands where tuatara are definitely maintaining their numbers are not only rodent-free, but also have very large breeding populations of seabirds (e.g. Newman 1987b). Moutohora has a minimum of 40,000 pairs of grey-faced petrel (*Pterodroma macroptera*), one of the largest breeding colonies in New Zealand (Imber, 1969). This number is likely to be considerably greater today with the eradication of rats in 1986. Also present is a small breeding colony of sooty shearwater (*Puffinus griseus*) (Imber, 1969). These birds, by turning over the soil and incorporating their mineral-rich guano, create conditions likely to increase the production of ground-dwelling invertebrates which form the bulk of the diet of tuatara. Seasonally, the birds themselves, their chicks and their eggs, may represent a valuable nutritional resource for female tuatara improving the quality of their eggs (A. Cree, pers. comm.).

Females are likely to gather at sunny, open sites to nest as soil temperatures in the forest are likely to be too low to allow successful incubation (Cree and Daugherty, 1990). A visit to set up experimental research gear (artificial burrows and insect pitfall traps) took place in August 1996 prior to the release of tuatara. Four sites were chosen for tuatara release: two in mid successional kanuka-mahoe forest and two in early successional kanuka forest; one site in each of the two vegetation types had high petrel burrow density, the other had low petrel burrow density.

TRANSFER METHODS

Adult tuatara were hand captured by a party of five over three nights (15, 16 and 17 October, 1996) on Moutoki Island. Tuatara were placed individually into short lengths of plastic Novacoil pipe, which were then placed into transfer boxes (robust cardboard pine seedling planting boxes) for later transport to Moutohora Island. Animals were transferred within 2½ days of their capture. Until their transfer they were held on Moutoki in their boxes in a small tent where they were measured, sexed (for the second time) and marked. Twenty had transmitters attached to them. They were then uplifted from the island and transported in the transfer boxes (about 4 - 6 animals per box) by the *Takapau*, a large boat (used as our operational base) to Moutohora Island. Here an official welcome ceremony hosted by 30 members of Ngati Awa took place on the beach. The press, television and other conservation staff were in attendance. After lunch, in the late afternoon, and with the visitors off the island, we released the tuatara. Twenty were released into previously prepared artificial burrows designed by Graham Ussher (Figure 2), one animal per burrow, while the other 12 were placed into either natural petrel burrows, or on to the open ground. Eight tuatara (5 females/3 males) were released at the four separate sites.

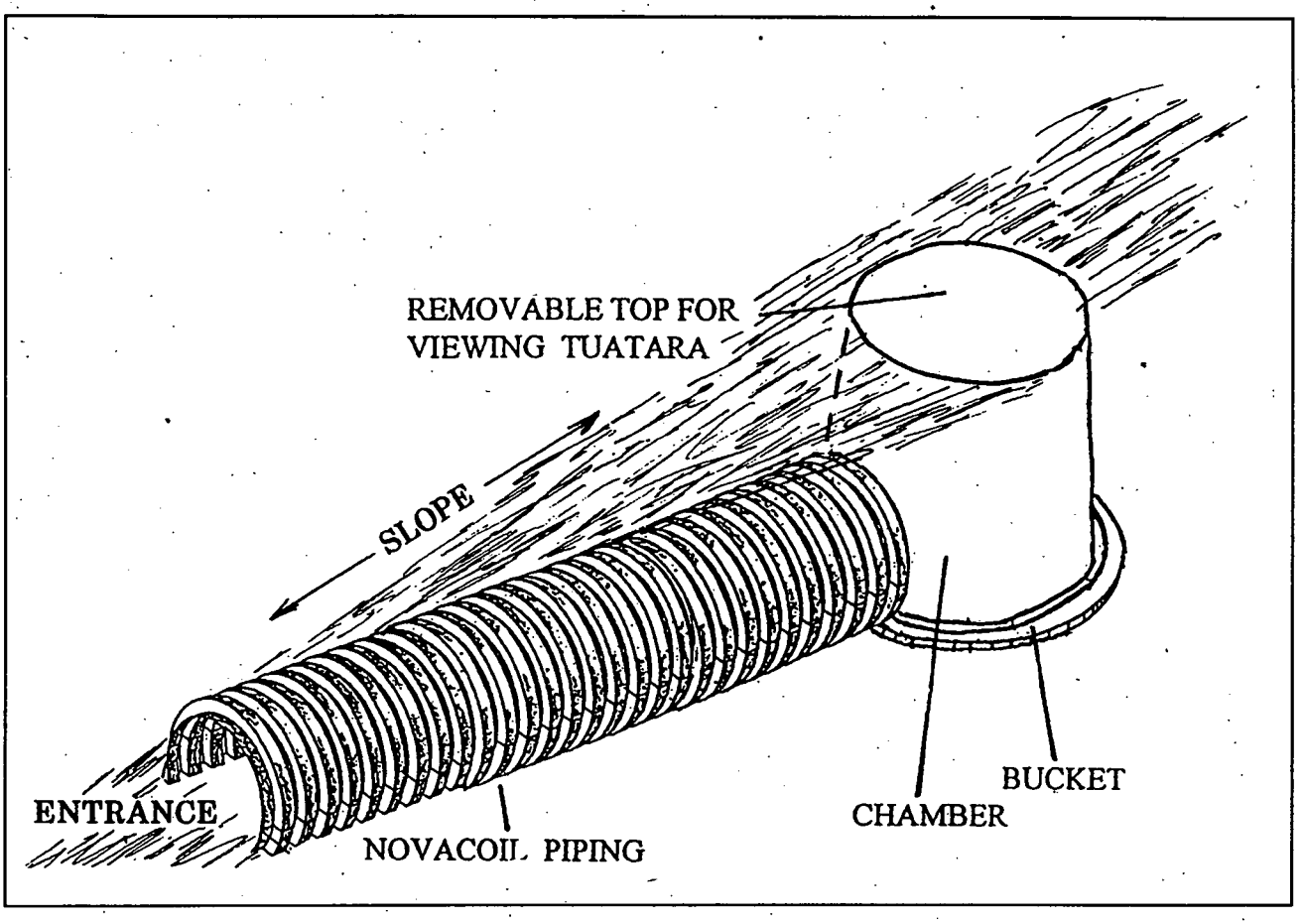

FIGURE 2. ARTIFICIAL BURROW DESIGN.

PRELIMINARY RESULTS

Monitoring/Research/ Management Requirements

Survivorship and dispersal of the transferred tuatara has now been monitored for nine months. This has involved three, two week long trips to Moutohora every three months between October 1996 and July 1997. The monitoring is being done by Graham Ussher as part of his Ph.D. research project with assistance from Department of Conservation officers and volunteers. The principal objectives of Graham's study are:-

a) to assess the relative values of successional and mature habitats for the re-establishment of threatened species using tuatara as a case study to investigate population responses to recent habitat disturbance on islands, and

b) the success in establishing new tuatara populations under varied environmental conditions.

Graham is also assessing the effects of removal of the 32 tuatara from the Moutoki Island population. This study will provide the Department with recommendations to guide future sourcing of animals from small populations for translocations.

To date, most of the tuatara have been located, they have not shifted far from release sites and nearly all have increased their capture weights. The use of artificial burrows has declined from 20 to 2. The majority of transmitters are working well although some animals have shed their harnesses. Some have been re-caught and harnesses re-attached, while the few that remained without transmitters were re-captured when they emerge from their burrows in spring. In March 1997 there was some indication of courting taking place. Next summer should give us an indication whether young have been produced. Twenty -eight (88%) of the tuatara have been observed since the release and the remaining four are presumed well and living near their original release locations (Ussher, 1997).

Confirmation that a self-maintaining population of tuatara has established may take some time as tuatara live for at least 60 years (Castanet *et al.*, 1988), and females breed, on average, just once every four years (Cree *et al.*, 1991). The transfer will be judged to have been a success if by October 2001 at least 50% of the liberated animals have survived and there has been some recruitment to the new population (at least five island-produced juveniles). This represents a ***minimum*** standard. We hope that a much better result is achieved as the average clutch size on Stephens Island is between nine and 10 eggs (Newman and Watson, 1985; Newman, Watson, and McFadden, 1994), thus over five years 15 females are likely to lay about 300 eggs. Subsequent releases may be necessary if more than 40% (13) of the transferred tuatara die within five years of their release (see contingency plan below). A review of the monitoring data will take place two years after release. It may be necessary in future to shift animals to more suitable locations on the island if research shows existing habitat is poor, or breeding success is low.

Contingency Plan

If tuatara do not establish successfully on the island an effort will be made to determine why. If the cause(s) are not apparent, or can be identified but not rectified, no further attempts at release will be made. If it is considered that action can be taken to rectify the problem(s) this will be put forward in a new transfer proposal after consultation with Ngati Awa, the Bay of Plenty Conservation Board and other stakeholders.

Public Perception

The transfer generated considerable public interest. Publicity for the attempt emphasised that:

a) Tuatara were being returned to part of their former range made possible by successful eradication of Norway rats , goats and rabbits from the island.

b) Re-introductions were being fully researched and monitored.

c) Ngati Awa as tangata whenua were fully supportive of the transfer.

The presence of tuatara on Moutohora will enable the public to view a 'wild population' and an island restoration programme. This would reduce endangering current Bay of Plenty islands with tuatara as most are small, difficult of access, and extensively burrowed by seabirds - consequently they are particularly fragile environments. This is especially so in the Bay of Plenty Conservancy where tuatara were confined to only three small islands, all less than five hectares in size.

Establishing tuatara on Moutohora will reduce the public pressure to be granted access to the 3 small, fragile islands. Instead of visiting these islands to see tuatara they can now go to Moutohora for this purpose. As a result of the release there is an expectation of an increased demand from the public to go to Moutohora to see animals. Public access to Moutohora is currently restricted to entry by permit. The public are restricted to marked tracks and the southern coast. This level of access is considered to be compatible with the protection and conservation of the island's vertebrates and invertebrates. Greater public access is generally supported by the draft Moutohora Island Management Plan (Hunt, 1992). The tuatara transfer programme could be incorporated into the existing visitor interpretation programme and should generate excellent publicity for conservation.

It is unlikely that the re-introduction of tuatara to Moutohora has foreclosed other options for future indigenous fauna relocations. This is important because Moutohora is managed for ecological restoration rather than for favoured species (Smale and Owen, 1990). If the transfer is successful, over the long term, this would enhance the island's importance for conservation education. Permission could be granted for special interest, closely supervised, small parties to visit and see tuatara and other wildlife so that they could learn about the restoration programme.

With extensive publicity there is a danger that poachers could be tempted to land and catch tuatara, but I believe that the island is secure due to the presence of regular visits from Conservation Officers and surveillance by the

boating public around the island. Even if animals were removed, public indignation and their assistance may quickly lead to the apprehension of offenders.

ACKNOWLEDGMENTS

The transfer was undertaken by Keith Owen, Andy Garrick, Kei Merito, Derek Gosling and Graham Ussher. Logistical support was provided by the Whakatane Field Centre. Dave Harding and Kathy Semmens prepared Figures 1 and 2.

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An attempt to translocate weka from the Chetwode Islands, Marlborough Sounds, to The Glen, Nelson

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ABSTRACT

In 1993, 112 Western weka were relocated from the Chetwode Islands in the Marlborough Sounds to The Glen near Nelson. They were banded, and held for periods of 4-6 weeks at the release site prior to release. No weka have been observed near the release area since the initial release period. The lack of effective monitoring has meant that the fate of all but two of the released birds is unknown. Predation and the "homing instinct" of weka are assumed to be the main reason's for the failure of translocated individuals to settle at the release site.

INTRODUCTION

Western weka (*Gallirallus australis)* were introduced to the Chetwode Islands (Nukuwaiata and Te Kakaho Islands) in the late 1920's/early 1930's (Brown, 1996). Removal of the species from the Chetwode Islands, along with other introduced predators, was advocated to facilitate restoration of the islands to their natural state (Brown, 1996). It was decided to move the birds to The Glen, a coastal site 12 km northeast of Nelson. The rationale behind attempting their relocation was to increase the range of the western weka, a category B species (Molloy and Davis, 1994; Beauchamp, 1995) and to help mitigate negative publicity associated with the Chetwode Island weka eradication programme by having a positive outcome.

The Glen was chosen as a suitable relocation site because it used to have a weka population (until about the late 1940's when the birds declined in numbers and disappeared). Walker (1987) suggests low numbers were present in the area up into the 1980s'. Close to the release site are several areas of remnant forest and scrub, with a total area of about 350 ha, a similar sized area of gorse and scrub exists contiguous with the forest. On the basis of Beauchamps (1987) estimate of territory sizes (c. 5 ha/pair), the area could theoretically hold in excess of 100 pairs of birds.

The purpose of this report is to summarize the outcome of this transfer and release. The background to the removal of weka from the Chetwode Islands is

only recorded briefly because it has been comprehensively covered by Brown (1996). This article has been based largely on the records and notes compiled by Ian Millar (Nelson/Marlborough Conservancy Office) who coordinated the project.

METHODS

Capture, holding, feeding and transport

Weka on the Chetwodes were mostly captured using hand-held nets, while others were caught using wire cage traps designed for catching possums. Birds were captured between 24/8/93 and 23/9/93, then transferred to a holding pen on Nukuwaiata Island, banded, and held for two weeks. Food provided during this period consisted of oatmeal, pet roll, and fish.

Birds were transported from Nukuwaiata Island in cardboard pet boxes (usually in pairs if known), with the first group of 77 arriving at The Glen on 10/9/93, and the second group of 35 on 2/10/93, a total of 112 birds. An enclosure was built at The Glen to cater for the birds. Its location was chosen as a compromise between a release site close to ideal habitat and the practicalities of managing the birds.

The enclosure was sited next to a large area of gorse with regenerating forest in the gullies. The actual enclosure encompassed an area of gorse and pasture, with some parts offering dense cover and shade, along with open areas suitable for feeding out. The enclosure's fence was 1.8m high chicken wire, dug into the ground to a depth of approximately 10 cm. Water was gravity fed from a nearby stream to a trough. Birds were fed once daily by local resident Nicky Bowering. During the period when maximum numbers of birds were held, daily food comprised; 8 cans cat food, 1.5 kg apples, 5 kg peas/corn, 1 kg rice and 3-4 loaves of bread.

These quantities were reduced proportionately as birds were released and fewer birds held. If food was not being fully eaten then lesser amounts were placed out.

Release strategy

The release strategy was to:

- hold the birds in captivity long enough to overcome their 'homing instinct'
- bring all birds up to an acceptable weight prior to release
- release them in several groups

It was considered that a period of one month would be sufficient to lose the homing instinct, based on the experience of Robertson (1976) and advice from Tony Beauchamp (pers. comm.). Appropriate weights for release of male and female birds were set at 750 g and 600 g respectively, Tony Beauchamp (pers. comm.). Attainment of these weights was considered essential to cope with the stresses associated with relocation.

Several independent releases spread the workload for staff and avoided large numbers of birds competing for resources at the same time. When the birds

had reached prescribed weights they were released at the site by placing them outside the enclosure door in separate groups. Food was placed outside the enclosure for some time after the release.

Banding and measurements

After capture on the Chetwodes all birds were banded. Birds were individually color banded to facilitate individual identification post-release. In addition, measurements/observations of weight, culmen length, bill depth, tarsus width, wing spur length, and eye color were made to enable an assessment of age. Weights were taken with 2 kg Pesola scales, and all other measurements with Vernier calipers. All banding and measurement details and other data are held at Nelson/Marlborough Conservancy and Motueka Field Centre Office on file PES:145/2.

Monitoring methods

Monitoring has included:

- After release local residents were asked report on any birds seen.
- Letters were sent to residents(residing between the capture and release sites) asking for sightings of banded birds (or any other weka) to be reported(April 1996).
- Letters went to local community committees(May 1996).
- Newspaper articles were placed in Nelson Evening Mail and a local newsletter(May 1996).
- Evening listening/weka call tape playing (March 1996).
- News reports on local radio(May 1996).

RESULTS

Release information

Of the 112 birds brought to the enclosure, 97 fully banded birds were released; 2 died of unknown causes; 2 banded birds escaped; and it is assumed that the remaining 11 unbanded birds escaped.

Release dates and numbers were:

DATE OF RELEASE	NUMBER OF BIRDS RELEASED
7/10/93	20
11/10/93	15
15/10/93	19
27/10/93	37
3/11/93	6
?	2 escapees
Total	99 fully banded birds released

Most birds were released after having spent between four and six weeks inside the enclosure. Forty-three birds were identified by measurement as males, 54 as females. One of the birds increased its weight by 28% in 12 days.

Banded weka observed since release

Only two bands have been returned to date, one was retrieved from a road-killed bird approximately 2 km from the release site and one from a predator-killed bird found about 400m from the release site (both November 1993). No analysis was done to determine the predator responsible.

No reports of live color banded birds have been received. Two replies from residents suggest that transient birds were observed near the Hira/Whangamoa area although not resident there.

In one evening of listening and call playing on a tape deck in the release area during March 1996 no weka were recorded.

DISCUSSION

Weka were relocated to avoid the negative publicity associated with killing large numbers of native birds and to re-establish a mainland population in part of its previous range. Publicity associated with the relocation attempt was minimal but favorable and the general impression gained was that the public were supportive of the release.

The lack of sightings of banded birds in the area after the initial release period indicates the release was not successful in re-establishing a weka population at The Glen. It is probable that at best, only a few birds survived the release.

Monitoring very much relied on the eyes and ears of the local residents which proved insufficient. The major failing of this project was to identify it as a "research by management" opportunity in order to provide information on translocation as a tool for weka conservation. As this was not stated as an objective of the project, little resources were invested in monitoring the fate of released birds.

Without hard data on the fate of the released birds, the reason for the failure of the release can only be speculated. Prior to the release several factors were considered as hurdles to the translocation attempt to establish a local population. They included a perceived lack of suitable habitat, possible predator impacts and homing instinct of the birds.

No analysis of habitat suitability was undertaken, but it is unlikely this could account for the mass disappearance which has taken place. Some criticism was made that the habitat immediately surrounding the release site was not optimum, but gorse and secondary forest areas are known to be utilized by weka. Birds had access to forest habitat only a short distance away.

Disorientation, lack of familiarity with their environment, a high concentration of released birds in one area and a temporary dependence on food handouts would probably have made the birds more vulnerable to predation than usual. In addition these birds had been taken from an environment free of all

introduced predators except kiore and therefore naive of the much greater diversity of predators on this mainland site. A high level of predation could easily have gone undetected as no efforts were made after the release to search surrounding vegetated areas of gorse and scrub. The one predated bird recorded was found incidentally, at the top of a beach, approximately 400m from the release site.

The most serious reservation held by those involved prior to the release was the "homing instinct" of weka which is often displayed if they are removed from their home. We have no direct evidence of a mass movement of birds towards the outer Marlborough Sounds and Chetwodes. This is not helped by the relatively unpopulated nature of the country to the north, in the direction of their former home. Had the birds moved in a generally southerly direction, toward Nelson they would almost certainly have been observed by the relatively dense human population. Therefore the most likely explanation of the birds disappearance apart from predation, is movement out of the area in a generally northerly direction. Homing instinct was likely to express itself immediately after release, so time spent monitoring the immediate post release period would have yielded valuable information. Transmitters fitted to a sample of birds would have made tracking over long distances possible.

Approximately 10% of birds were able to escape from The Glen enclosure, despite it being 1.8m high and without holes. A higher fence with an outrigger is necessary to contain weka for long periods. The release should also have been trialed in a series of release experiments. This would have provided a better understanding as to why the release failed.

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Removal and reintroduction of North Island weka (*Gallirallus australis greyi*) to Mokoia Island as a result of a Talon 7/20 cereal-based aerial poison drop

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ABSTRACT

Thirty-four North Island weka (Gallirallus australis greyi) were captured and removed from Mokoia Island, Lake Rotorua during July/August 1996. Removal was necessary due to an aerial application of Wanganui 7/20 baits containing 20 ppm Brodifacoum dropped on the island to eradicate mice (*Mus musculus*). The weka were held in captivity for 5 months. Thirty-two weka were returned to Mokoia in December 1996. Weka losses took place but recovery of the population appeared likely. The mice eradication attempt was unsuccessful.

INTRODUCTION

Mokoia Island lies in the Rotorua Ecological District, Bay of Plenty, New Zealand (Figure 1). The island, a circular-shaped dome of 135 hectares, rises to 156 metres above Lake Rotorua and is 451 metres above sea level (Owen, 1997a). Mokoia island is Maori owned and administered by the Mokoia Island Trustees.

An application of 3 g Wanganui 7/20 baits® containing 20 ppm Brodifacoum to eradicate mice from the island was carried out on 18 September 1996 by the Department of Conservation(DOC). It was considered that although mice were not a major threat to birds by removing them from the island it would open up opportunities for protecting existing fauna and liberating rare lizards and insects.

Bait was distributed over the majority of the island in an aerial operation using Lakeland Helicopters Bell Jet Ranger from Murupara (Wilke, 1997). The bait drop, using an under slung bucket, took just over one hour to complete.

The rate of application was 10.99 kg per hectare (Wilke, 1997) in a swathe width of 80 metres using a D-GPS to aid accuracy of distribution (Appendix 1). A further 35.7 kg of bait was hand laid by conservation officers in measured

quantities. Around the margins of the grass areas between Hinemoa's Pool and the Research Hut (old skyline garage) on the south-eastern side of the island.

North Island weka (*Gallirallus australis greyi*) are resident on Mokoia island, being first released on the island in 1952 when four birds were introduced (Axbey, 1994). This was followed by a further release of 12 birds in 1956 and 13 birds in 1958 (Owen, 1997a)

The main reason for the introduction was to shift birds causing damage to Gisborne's residential vegetable gardens, due to large numbers present on the East Coast at the time.

Today the North island weka is regarded as threatened and a recovery plan has been written for weka, including the North Island subspecies (Beauchamp, 1995). As North Island weka were considered to be vulnerable to the poison baits it was decided that a number should be caught and removed from the island prior to the mouse eradication attempt (Wilke, 1997). This paper describes the outcome of this weka removal and the subsequent re-introduction of birds back to the island.

METHODS

Weka are a large, thickset, ground-dwelling flightless rail. They are territorial, breed in pairs and both sexes generally remain around the territory even outside the breeding season (Marchant and Higgins, 1993). Males and females give loud and characteristic calls, most frequently at dawn and dusk and in early evening or on rainy days. The call can be heard from a distance of about 500 metres.

From 15 July to 14 August 1996, over a 10 day period, weka were caught on Mokoia Island for transfer to Rainbow Springs, Rotorua to be held temporarily until all mice were poisoned and the bait had deteriorated sufficiently for the wekas to be returned to the island.

The methods of capture used involved placing wire cage traps in known territories of birds. Each cage trap was baited with fatty bacon rind or mutton flap hung from the roof of the inside of the trap. Outside the entrance of the trap on the ground was placed food (usually canned corn kernel) as an extra attractant.

To locate the territories of pairs the capture team usually heard birds calling (often in the late afternoon or early morning) or observed birds in the forest or on the open flats during the day time. Occasionally tape recordings of weka were played to elicit a response in order to determine territories.

Once a territory was determined one or two traps were shifted into position, usually where birds were last heard and/or seen, and were baited, set and left. Frequently the traps would be set about an hour before darkness, if birds had been heard or seen in the area in the late afternoon. If no birds were caught by nightfall the traps were left baited but closed overnight, then re-set early the following morning. Late afternoon and early morning captures dominated the capture regime. There was less success during the middle period of the day.

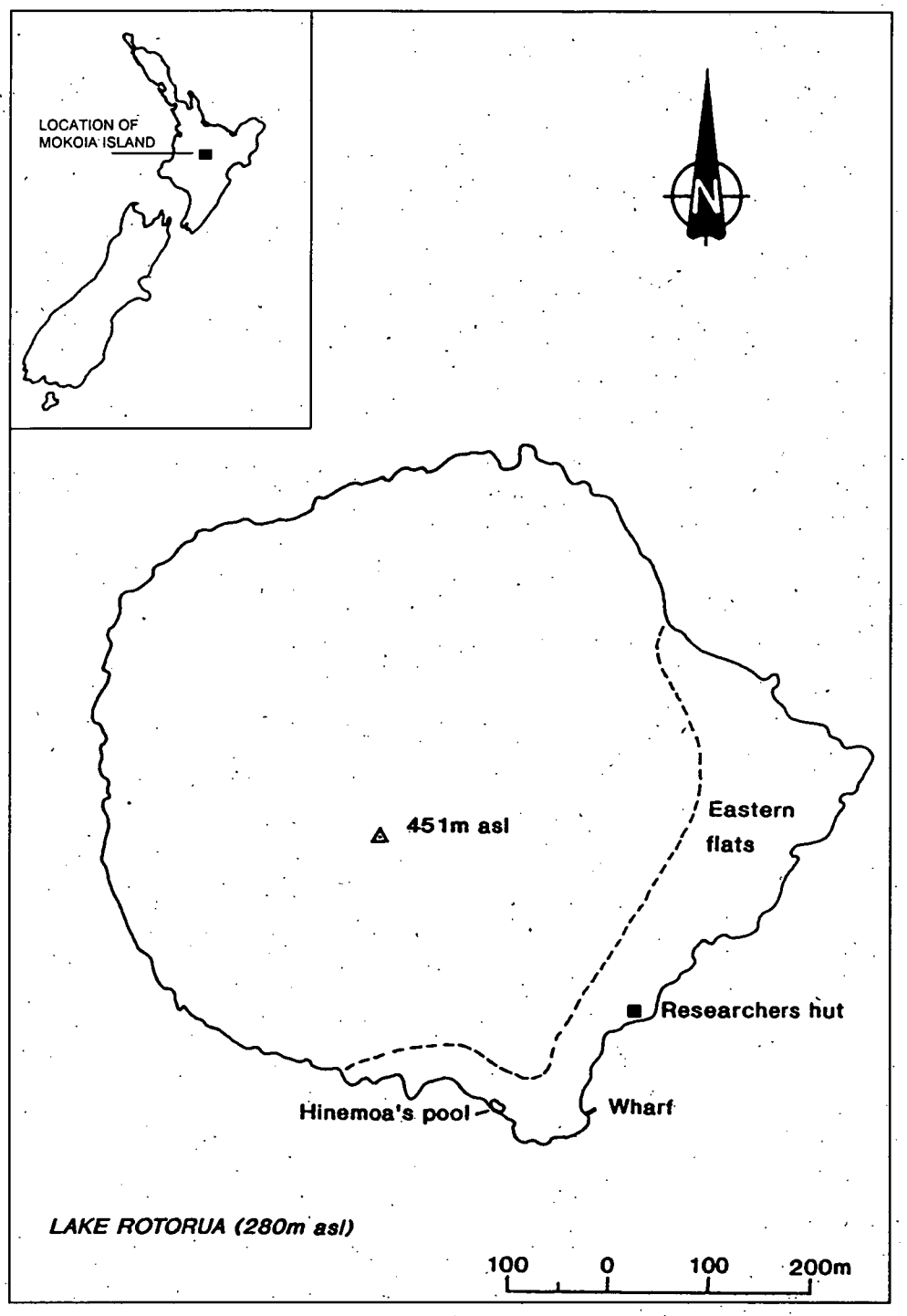

FIGURE 1. LOCALITY MAP OF MOKOIA ISLAND

RESULTS

A total of 34 weka (20 males, 14 females) were caught over 10 days (6 on 15 July, 10 on 16 July, 1 on 17 July, 2 on 19 July, 1 on 24 July, 1 on 25 July, 6 on 26 July, 4 on 2 August, 2 on 3 August and 1 on 14 August). On days when few birds were caught this was often a reflection of bad weather or other duties taking precedence such as capturing and monitoring robins (Owen, 1997b).

The following measurements were taken from each bird: culmen, bill depth, tarsus-length, tarsus width, mid toe, mid toe-claw, claw and wing. Captive weights were taken as were age estimates (based upon wing-spur length) (as designed by Tony Beauchamp). Each bird was banded with a standard DOC Banding Office metal band (sizes 17, 27, L and M were used). Copy of banding schedule is attached as Appendix One.

On the basis of several key measurements and weights each bird was sexed. All measurements were sent to Tony Beauchamp of Whangarei and Andy Bassett (DOC) for confirmation of sexes. In the case of three birds where my initial sexing was incorrect an adjustment on sex determination was made.

Once caught the birds were transferred into separate wooden transfer boxes with food and water provided. In most cases, at the end of each day the boxes and their contents were transported by DOC boat to Rotorua lakefront, a short 15 minute boat trip away. From there they were transported by vehicle to Rainbow Springs on the outskirts of Rotorua. At the Springs they were initially closely checked by experienced staff for any health problems before being dosed with Ivomec oral drench (0.6 ml per kg body weight) then released into a number of aviaries.

About 20 of the weka were held in one large outdoor aviary with an earth floor and wire mesh fences. The aviary had a small area at one end that provided shelter by the door. Several wooden stumps placed around the dirt floor of the aviary provided shelter or roosting sites for birds. Water was continuously available in a small trough set into the ground. Birds were fed a diet based largely on poultry pellets, cooked mixed vegetables, and finely minced oxheart.

The remainder of the weka were distributed amongst a further four smaller outdoor aviaries. These all had concrete floors and wire mesh fences. All aviaries were kept out of bounds to tourists visiting the Springs.

Once the poison drop had taken place on 16 September it was a matter of waiting for a clearance to be given in order to return birds to the island. This took much longer than expected as we had 10 rainless days directly after the day of the aerial poison drop (except for <1 mm the following night) before any rain. Over the next six weeks only six days of rain were encountered.

Thirty-two of the weka were released back onto the island on 5 December 1996, some five months after capture. Two birds died at the Springs, one as a result of a stress-related illness, the other due to drowning in the water trough. These two deaths were 6% of the number held. The health of each weka was carefully checked by Springs staff before birds were released.

One interesting aspect noted with the weka by the Springs staff was that in the large aviary where the biggest group of weka were held little aggression between birds took place.

In the smaller aviaries that held only a few birds, aggression levels between birds was noticeably greater.

The majority of the birds released back on to the island weighed more than their captive weights, so most were in good condition.

While at the Springs several suffered from bumble foot. This was diagnosed by vet Dr David Butler, Animal Health Services, Rotorua. Birds were treated with Tylan DMSO-applied on affected feet twice daily while held in the quarantine area. It took approximately 1 month before the bumble foot improved. Birds contracted this condition from being kept on hard damp ground i.e. concrete floored aviaries. One bird that was released still had a problem with bumble foot however after the Springs staff sought veterinary advice, it was felt that this bird would manage adequately in the wild (Tracy Johnson pers.comm..).

A number of weka had damaged their forehead areas above the upper mandible when making contact with the wire-mesh fences. In hindsight the fences should have been covered by shade cloth, sacking or cardboard around their lower sections to eliminate this situation. In most cases the weka only suffered minor injuries.

At the Springs we took the opportunity to take blood samples from 30 of the birds for DNA testing by Professor David Lambert and his assistants at Massey University. We were particularly interested in sexing the birds by this method in order to compare our own diagnosis of their sex based on measurements. We currently await the outcome of these comparisons.

A permit was issued to Lynette Hartley of Waikato University to carry out a series of trials with the birds during their stay at the Springs. The purpose of the trials was to investigate whether weka have colour preferences and whether it was possible to detect these preferences by offering the birds a choice of different coloured, edible pellets.

Lynette's interim results show that weka did have colour preferences (as measured by pecking). These results are being further analysed.

During the post-poison period our monitoring team searched the island for dead birds. It found four weka bodies in the month following the poison drop (Owen, 1996). Later autopsies taken by the author and Dale Williams (DOC) showed that all had died as a result of Brodifacoum poisoning. This showed as either sign of haemorrhaging (in the neck, gizzard, liver or intestinal area) or from fluorescent sign, left in the body by a bio-marker (pyrinine) placed in the baits, which stood out when viewed under ultra-violet lighting in a dark room.

CONCLUSION

Weka were still present on the island several weeks after the poison drop (D Williams pers. comm., author pers. obs.) and although no post-release assessments took place of the 32 weka returned, pairing, increased calling and breeding (several chicks were observed) took place soon after release.

Data collected shows that the majority of the weka returned to the island weighed more than their captive weights so were in good physical condition on release.

The weka were all released back into their original territories (from where they were caught) so this would have enhanced their breeding opportunity.

I consider that the death of weka caused by the poison operation was only a minor setback as these losses were probably replaced over the following breeding season by recruitment of juveniles into the adult population.

POSTSCRIPT

Monitoring between September and December 1996 at monthly intervals revealed no mice footprint sign for 3 months over 100 tracking tunnels per month. In mid December 1996 a Massey University researcher reported seeing a mouse on the island. Monitoring in January 1997 showed 47% of 33 tunnels in line A on the flats were tracked (Williams, 1997). By March 1997 when further monitoring took place all 3 lines over the island showed the presence of mice (Wilke, 1997).

There is likelihood of a further mice eradication attempt some time in the future (DOC, Bay of Plenty Conservancy, A Baucke pers. comm.).

ACKNOWLEDGMENTS

Thank you to Fiona Hennessey (DOC), Helen McCormack (Rainbow Springs), Jayleen Belmont, Mick Herdman, Junior Hireme (all volunteers), Jasmin Howie and Megan Cooper (both Western Heights High School students) for assistance with the capture of weka. Reg Phillips and Bruce Mossman (both DOC) provided able boatmaster assistance and logistical support.

Rainbow Springs staff, notably Tracy Johnson and Helen McCormick, took care of the captive-held weka and assisted with blood sampling of birds. Isabel Castro and Tarmo Poldmaa both of Massey University and Jonathan Miles (Landcare Research Limited) also assisted with blood sampling of birds.

Tony Beauchamp (Whangarei) and Andy Bassett (DOC) provided guidance with sexing of birds. Dale Williams and Fiona Hennessey (both DOC) assisted with the autopsies. Rotorua Lakes High School, through Morley West allowed us access to one of their laboratories to carry out the autopsies.

The Mokoia Island Trustees allowed access to the island and the use of accommodation while there.

Tracy Johnson provided helpful comments on the text.

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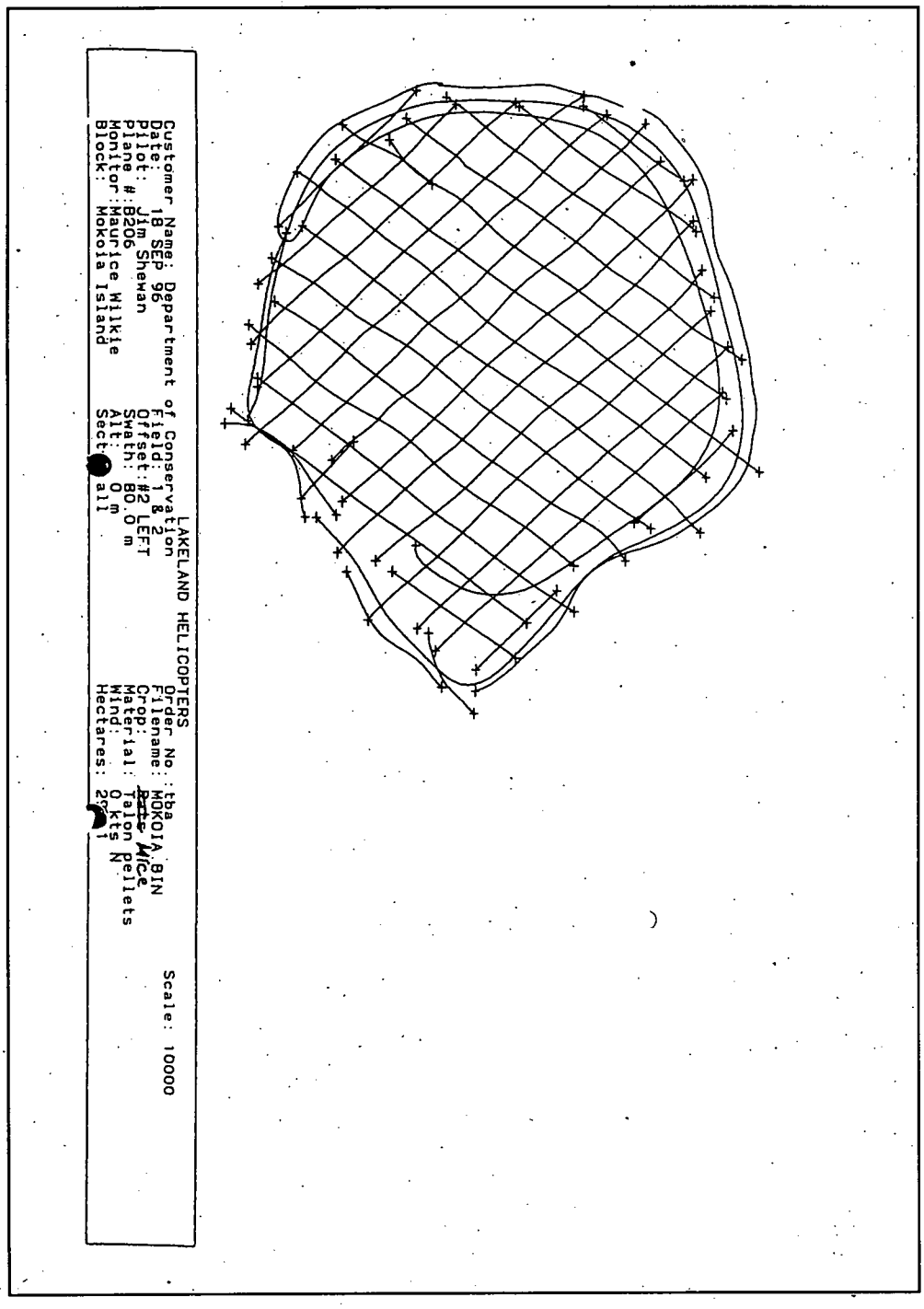
APPENDIX 1. PRINTOUT FROM D-GPS



Preservation and use of dead specimens for research, disease investigation, taxidermy and cultural value to iwi

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ABSTRACT

The method used to preserve dead specimens can limit the potential use of the preserved material. For threatened species, the opportunity to obtain dead specimens for research, museum use, or for traditional Maori purposes is rare. This article outlines the benefits and limitations of common preservation methods, and the optimum preservation method for different uses of dead specimens.

INTRODUCTION

There are several common methods employed for the preservation of dead animals (e.g. freezing, alcohol, formalin, drying). However, the method of preservation used will impose certain constraints on the end use of a specimen. For example, necropsy of freshly dead specimens for disease investigation and to determine the cause of death, generally renders skins unsuitable for taxidermy. Similarly, freezing of these specimens would be the preferred method of preservation for museum and iwi use, but destroys tissues for some aspects of disease investigation.

The Department of Conservation has a draft policy (contact Conservation Policy Division, Head Office, Department of Conservation), which promotes the following national priorities for the allocation of dead specimens of protected wildlife (in descending order of priority):

- Essential conservation research
- Museum of New Zealand
- Metropolitan museums
- Maori traditional purposes
- Research not essential to conservation management
- Other educational institutions
- Storage
- Disposal

There are also legal requirements associated with each of these uses (given in draft policy), which readers should refer to if unsure of their obligations.

The draft policy also states that multiple use of dead specimens should be made wherever possible. Each threatened species programme will have it's own end use for specimens, and methods of preservation have tended to reflect top priorities. For some programmes, specimen use has been more opportunistic and generally carcasses are frozen before determining an end use. In order to achieve the best possible use of specimens, we should take a more pro-active approach to ensure appropriate preservation methods which reflect potential multiple end uses.

This paper briefly summarises commonly used preservation methods and identifies the benefits and limitations of each, with recommendations for management of dead specimens. The preferred methods of preservation for specific end uses are summarised in Table 1 below.

METHODS OF PRESERVATION

Freezing

Benefits

- Domestic freezers maintain a temperature of -20°C, and are generally available at most field sites. Freezing requires little additional equipment or preparation other than a plastic bag and removal of air.
- Preserves skins and skeleton for museum, genetic (DNA) and other scientific research, educational and iwi use.
- Easy and humane method of killing invertebrates

Limitations:

- Very limited use for histology (i.e. the microscopic study of cellular changes of tissues in order to investigate disease processes) or bacteriology investigations. However, frozen tissues can be used for virus culture, toxicology and gross pathology (i.e. naked eye assessments of tissue condition).
- Skin quality decreases with prolonged length of freezing.
- For Protein Electrophoresis, material must be frozen to - 80°C.

10% buffered formalin

Benefits:

- Ideal for preserving tissues used in histology;
- Does not require a power source;
- Can be located at any site.

Use:

- Tissues should ideally be removed from the body, cut into 1 cm cubes and placed in a container, with no more than 10% volume of tissue and 90%

volume of buffered formalin to aid penetration into the tissues. Small animals can have the abdomen split and the entire specimen placed in a large container. Specific protocols are being developed for this type of necropsy, including the best method for preserving parasites.

Limitations:

- Requires some training.
- Intestinal parasites should be placed in saline or frozen before preservation.
- Formalin must be handled with care as it is potentially carcinogenic, and care should be taken to avoid inhalation of formalin fumes. Always work in a well ventilated area, and where possible in a fume cupboard.
- Skins preserved using formalin are unsuitable for other uses.

Alcohol

Benefits:

- Low risk preservative suitable for diet, genetic studies (DNA only), and taxonomic identification.
- No special equipment needed, can be held at all field sites;
- Long term preservative.

Limitations:

- Specimens unsuitable for other uses (e.g. disease investigation, museum skins).

Drying

Benefits:

- Useful for invertebrate identification, skeleton preservation.

Limitations:

- Specimens of little use for other purposes, except cultural use of feathers.

TABLE 1. PREFERRED PRESERVATION METHOD FOR SPECIFIC END USE OF SPECIMEN

END USE OF SPECIMEN	PREFERRED PRESERVATION METHOD
Museum specimen	freezing
Maori and traditional purposes	freezing
Disease investigation	
Histology	buffered formalin
parasitology	saline, then freezing
virology, toxicology	freezing
Genetic research	
Protein electrophoresis	freezing at- -80°C
DNA techniques	freezing at -20°C

DISCUSSION

The preferred method of preservation for museum use is very fast freezing, soon after death (Noel Hyde, pers. comm.). Depending on the species, the specimen will then be used to satisfy the greatest need in the collection. This may depend on how many mounted individuals or skins are already held, and the sex or age of existing specimens. Where dead specimens have not been frozen immediately after death, and there is some decay or body parts missing, the museum will then evaluate the best use of the animal given it's condition. These uses include whole or part skeleton preservation, taxidermy of a wing or tail, provision of feathers for iwi use, or preservation in 70% ethanol. Birds presented in alcohol to the National Museum would likewise undergo an evaluation of their importance to the collection, and would be skinned only if there was a specimen void. Museum specimens are often used in morphometric and systematic studies.

One of the most important but frequently overlooked facets in providing specimens to museums is the accompaniment of related data with the animal. It is essential that data on the collection locality and date, name of the collector and age of the animal (if known) accompany the specimen. Similarly, when providing specimens for necropsy, the same information should be provided. Additional information is required for veterinarians conducting the necropsy including any possible background factors which may have influenced death; changes in diet, food shortages, potential stresses from the environment (e.g. inclement weather); physiological/social changes (e.g. moulting, aggression from con-specifics); evidence of predation; clinical signs if alive when located; local contaminants (e.g. toxins, effluent discharge); how many other animals were located dead (Friend 1987).

Most veterinarians prefer to obtain specimens fresh and chilled (not frozen), within a few hours of death and certainly within 24 hours. If this is not possible and an experienced person is available, tissues should be removed as described above, and placed into buffered formalin. Detailed descriptions of taking specimens and shipment are contained in Friend (1987), Manktelow et al (1988), and TSU (1993, unpubl. report). Where possible you should also consult the local veterinarian or animal health laboratory. Best practice procedures are presently being developed for basic necropsy and preservation of parasites.

In addition to the uses already described, dead specimens can also be valuable for scientific research. Generally most research involving dead specimens is carried out from frozen carcasses or after preservation in alcohol. For example, frozen liver samples may be analysed for concentrations of residual toxins (e.g. Brodifacoum) following pest control operations. Toxin studies require frozen tissues as does genetic research, although the latter is also possible with specimens preserved in 100% alcohol (DNA techniques only). The method of preservation for diet research will depend on what type of analysis is required, and facilities available at collection sites for preserving specimens. Where knowledge of the moisture content of the diet is important, freezing is preferable to preservation in alcohol.

The preferred method for preserving invertebrates (including lepidopterans), particularly when samples are taken for identification, is 70% alcohol (isopropyl or ethanol). However, there are specialised methods for preserving soft-bodied invertebrates such as flatworms and worms, which is usually a 5% formalin solution prepared beforehand (for advice contact Peter Johns, Zoology department, University of Canterbury). Invertebrates can however, be frozen if samples are being collected for genetic analysis (Greg Sherley pers. comm.).

Recent cases exemplify the conflict in potential uses of specimens of protected species, as a result of differing requirements for adequate preservation. The recovery of a freshly dead taiko provided the second ever recorded museum specimen for this species. Priority was therefore clearly on National museum use and the bird was frozen. The value of frozen tissue later placed in formalin for histological determination of cause of death, was therefore limited. Similarly, a kokako (Freefall) sent for necropsy revealed cause of death in the individual, but fixation of tissues in formalin precluded their use for DNA studies, although some frozen tissues were retrieved from the remaining carcass for this purpose. The pathological investigation was also affected by the need for careful dissection, so that the skin was suitable for taxidermy. Consequently the brain could not be removed for examination.

RECOMMENDATIONS FOR THE MANAGEMENT OF DEAD SPECIMENS

It is important for all threatened species recovery programmes that there be clear guidelines for the use of dead specimens. General guidelines are provided within the Department's draft policy on allocation of dead specimens of protected wildlife. Best practice generic procedures for necropsy are presently being drafted through a Massey University Wildlife Health contract. These generic procedures should be further developed by individual recovery groups and lead conservancies for each threatened species.

In the absence of protocols, there tends to be an unplanned and opportunistic approach toward methods of preservation. Short-term actions can then have longer term implications for uses of the specimen other than the primary one intended. Recovery groups should be pro active in their approach to dealing with this issue; assigning priorities for use, identifying methods of preservation for those uses and ensuring that all holders of their species comply with the standard procedures.

An example of where this type of approach has been taken is the black stilt programme. The priority use of a dead black stilt is necropsy to determine cause of death, which may aid in management of the species. A protocol accompanies each dead bird through a taxidermy and disease investigation process. Where a skin may be particularly valuable, the specimen is transported chilled to a taxidermist for skin and brain removal. The remaining carcass(and brain) is then taken for necropsy (within the same 24 hours) to a pathologist. Gross pathology is undertaken, some tissues fixed in formalin and the remaining body cavity frozen for any later genetic work. This approach is variable, depending on priorities of the programme.

I would recommend that where appropriate, species managers talk to local stakeholders (the diagnostic laboratory, National museum, local iwi and scientists from STIS) to determine end uses and preservation methods for dead specimens. Priority uses for dead specimens (consistent with the draft departmental dead specimen policy) should then be assigned, and planning instigated to meet as many end uses as possible. This may involve close liaison with each stakeholder. In some cases, staff from the National Museum would be willing to skin particularly valuable specimens at the site of, and shortly before, necropsy. Museum staff are also willing to train veterinarians how to limit damage to skins during necropsy (Noel Hyde, pers. comm.).

Standard procedures for each species (or taxa) should then be drafted and accompany specimens to taxidermists, laboratories, museums etc. These might include contact names and numbers of stakeholders, methods of transport or preservation, notification of involved parties in regard to shipping arrangements, and any essential background information.

The procedures should be circulated to all individuals who have the potential to provide specimens (e.g. captive facilities, field researchers and managers), preferably appended to a husbandry manual, or species wildlife health management plan.

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Guidelines for submission of manuscripts to Ecological Management

INSTRUCTIONS FOR AUTHORS

Content:

Ecological Management is a journal for conservation workers to present topical information applicable to the management of New Zealand species, habitats, and ecosystems. Appropriate articles include those describing results of management (including field trials and experimental management) and evaluations of existing or potential management approaches. Research results will generally not be published in Ecological Management unless there is a specific management focus.

Article length:

Standard article (1500 to 5000 words); review paper (up to 7500 words); short note (up to 1500 words)

Manuscript structure:

The structure of manuscripts submitted to Ecological Management varies widely, and may not necessarily fit into a standard format (i.e. Introduction, Methods, Results, Discussion). Most articles however, should at least have Abstract, Introduction and Discussion sections. For those new to the writing process, some brief notes on writing Abstracts, Introductions and Discussions are given below.

The abstract should state the purpose of the study or investigation, outline the procedures or methods used, present the main findings and principle conclusions (no more than 150 words). The introduction should present the nature and scope of the problem investigated; review the pertinent literature to orient the reader; and state the method of investigation. The discussion should present the principles, relationships, or generalisations shown by results. The results should be discussed, rather than merely repeat the results section. Exceptions and lack of correlations should be pointed out, and unsettled points defined. The discussion should consider the implications of the work, as well as any practical applications. The evidence for each conclusion should be summarised clearly, don't assume.

Submission of manuscripts:

A hardcopy (two copies) of the manuscript should be forwarded to the Editor, Ecological Management, Department of Conservation, PO Box 10-420,

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Additional manuscript information:

Authors may provide the names and addresses of up to three persons (resident within New Zealand) who would be qualified to review their manuscript. The identity of the reviewers will be kept confidential, and the editor reserves the right to select reviewers other than those named by the author.

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Is the information presented in a logical sequence? Does the manuscript contain irrelevant material? Is it too brief for clarity, or could it be shortened? Does the Introduction provide a clear indication of the project aims and relevant background ?

Interpretation/Conclusions

Are the conclusions justified? Consider whether the interpretation is adequate, not warranted by the data, or suffers from important omissions or loose generalisations.

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