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ERADICATION CAMPAIGNS AGAINST KIORE *(RATTUS EXULANS)* ON RURIMA ROCKS AND KORAPUKI, NORTHERN NEW ZEALAND

by

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CONTENTS

ERADICATION CAMPAIGNS AGAINST KIORE (*Rattus exulans*) ON RURIMA ROCKS AND KORAPUKI ISLAND, NEW ZEALAND

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ABSTRACT

Kiore (*Rattus exulans*) is the smallest of the rat species introduced to New Zealand. Kiore feed on a wide range of invertebrates, reptiles and seabirds. Conservation of the more sensitive of these species requires the ability to eradicate kiore from islands where their effects are detrimental. Methods are also required that are effective against all rodents in the event of invasions of islands previously free of rats or mice.

Two eradication campaigns against kiore using silos dispensing kibbled maize mixed with sodium monofluoroacetate (compound 1080) and bromadiolone are described. Kiore were apparently able to detect compound 1080, compounds used as dye, or combinations of both, whereas the rats were highly susceptible to bromadiolone. Kiore were eradicated from 7.5 ha Rurima Island following three applications of bromadiolone, and from 18 ha Korapuki Island after one application. The Korapuki campaign was the more cost-effective of the two because (1) the kiore were not bait shy, unlike Rurima where they had been exposed to compound 1080; (2) undyed non-toxic pre-feed was used before application of bromadiolone; and (3) the eradication was conducted when rat numbers were at the annual minimum and alternative food sources were scarce.

It is concluded that use of silos dispensing toxic kibbled maize should be effective against rats on islands up to 50 ha.

1. INTRODUCTION

The kiore, Pacific or Polynesian rat (*Rattus exulans*) arrived in New Zealand at the time of colonisation by Polynesians about 1000 years ago (Davidson 1984). Kiore subsequently spread through the mainland and to many islands, but following the introduction of other predatory mammals, became confined to offshore islands and the more remote parts of south Westland (Atkinson and Moller 1990). Islands inhabited by kiore usually have less abundant and diverse reptiles and insects than neighbouring islands without rats (Atkinson and Moller 1990, Towns in press, Watt 1986, Whitaker 1978). However, because such comparisons are circumstantial, differences in the composition and abundance of fauna and flora of islands with and without kiore cannot necessarily be attributed to the rats alone (Craig 1986). On the other hand, considerable evidence of feeding and predation by kiore on a wide range of vertebrates is now being compiled (e.g. Atkinson 1986, Atkinson and Moller 1990).

Release of kiore onto islands to determine their effects experimentally would be irresponsible (Craig 1986). Eradication of kiore from an island therefore provides the only means of experimentally testing responses of the remaining flora and fauna to the presence and absence of rats. Removal of rats also provides new locations for endangered species that cannot coexist with rodents (Towns 1988).

Most rodent control in New Zealand to date has been conducted in agricultural or urban environments by commercial agencies aiming to reduce rat populations to acceptable levels. This activity has led to the development of poisons, baits, and bait dispensing methods designed only for 'control'. Eradication of rodents is more likely to be the preferred option for conservation of island faunas. However, as recently as 1978, eradication of rats from islands was regarded as unrealistic (references in Dingwall *et al.* 1978). Crawley (1983) therefore gave 'the development of eradication methods for use on small offshore islands', a very high priority when he made his review of wildlife research priorities.

This report describes two projects aimed at developing methods for eradication of rats from islands. Field trials of two kinds of rodenticides with the potential to eradicate rats from islands are described. Two successful eradication campaigns, on Rurima and Korapuki islands in northeastern New Zealand, are outlined and recommended methods for kiore eradication on islands of 50 ha or less are given. The report follows earlier trials of baits, lures and dispensing methods acceptable to kiore conducted on Lady Alice Island (McFadden 1984).

2. STUDY AREAS

The two study sites were chosen for different reasons. The first eradication campaign was designed to establish cost-efficient techniques for use against kiore. Rurima Island was therefore chosen because of small size, easy access and gentle topography. The second eradication campaign was designed to meet a conservation objective: the eradication of kiore from a highly modified island that could be restored for threatened species of reptiles (Towns 1988). Korapuki Island was therefore chosen as the first location where lessons learned on Rurima Island could be applied to a defined problem.

2.1 Rurima Island

Rurima, Moutoki and Tokata Islands are three small islands in the Bay of Plenty, 18 km northwest of Whakatane (Fig. 1) and known locally as "Rurima Rocks". Rurima Island is a cluster of four small islets covering 7.5 ha (at high tide) and 47 m high. Three islets are joined by an area of sand dunes, and the fourth by an extensive rock platform exposed at low tide (Fig. 2). All four islets are capped with pohutukawa (*Metrosideros excelsa*), and have an understorey of houpara (*Pseudopanax lessonii*), ngaio (*Myoporum laetum*), coastal mahoe (*Myrsine novae-zelandiae*), karo (*Pittosporum crassifolium*), and rangiora (*Brachyglottis repanda*). A coastal fringe of taupata (*Coprosma repens*) leads onto a mostly bare forest floor broken by spleenwort (*Asplenium flaccidum*) and *Carex flagillifera*. Open areas in the forest are dominated by bracken (*Pteridium esculentum*) and the sand dunes by Spinnifex hirsutus (A. Wright, pers comm.).

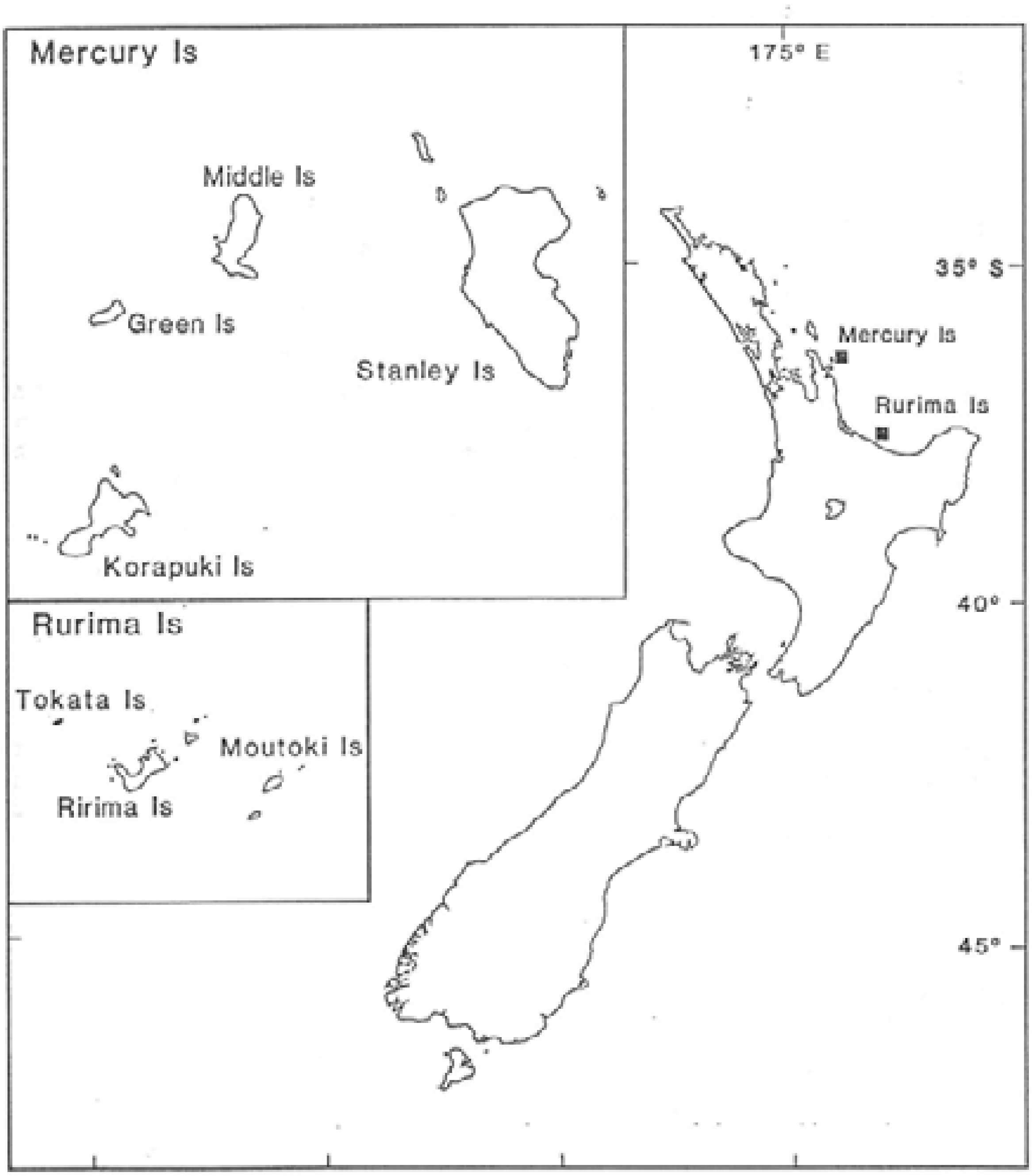

Fig. 1 Locality map of New Zealand showing enlarged inserts of Rurima Rocks and Mercury Group.

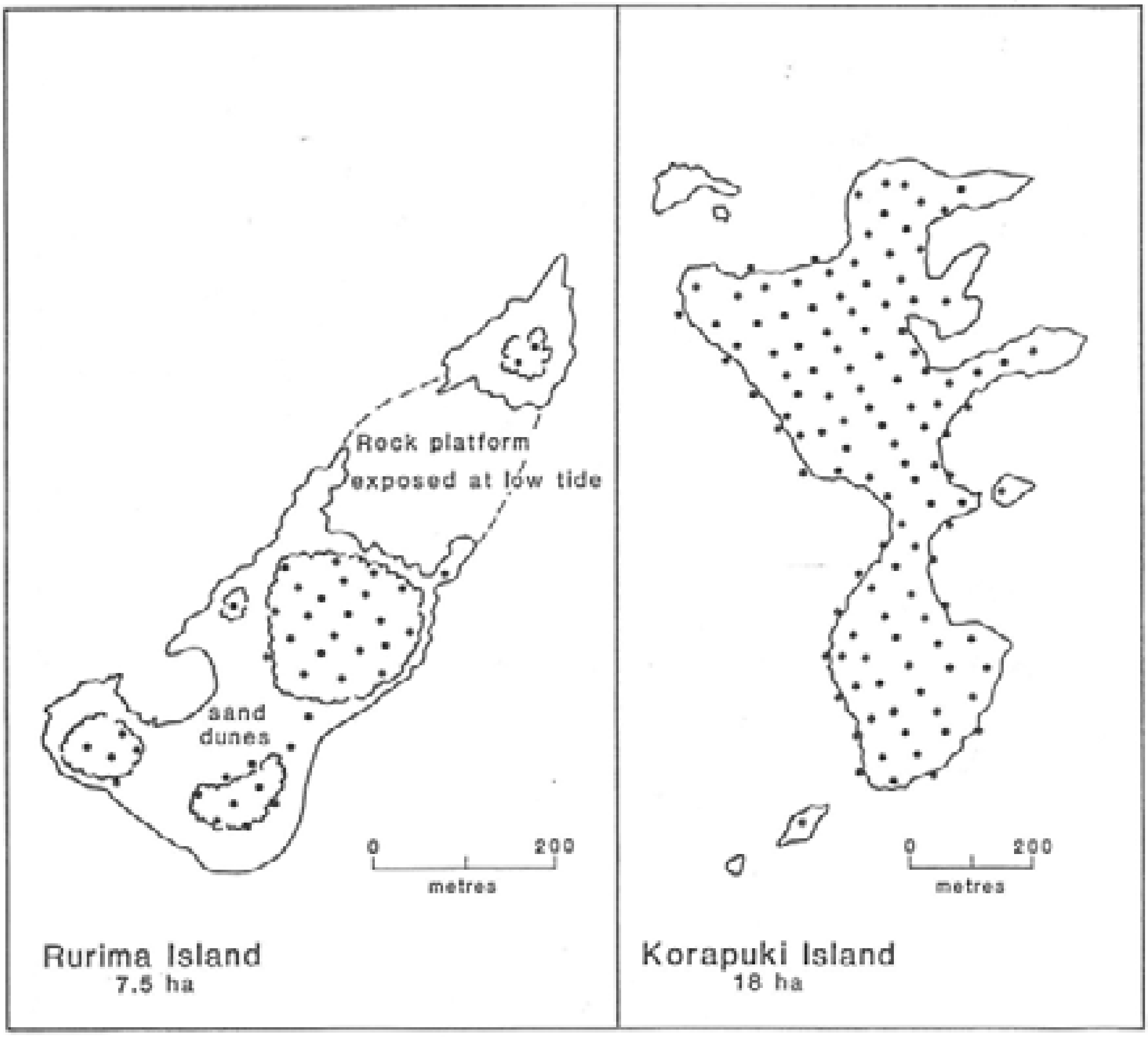

Fig. 2 Enlarged plan showing silo and index for Rurima and Korapuki Islands.

One species of duck, 11 species of sea bird, two species of wader, and at least five species of land bird breed on Rurima. A further seven species of bird have been recorded but are not known to breed there (Appendix 1). Extensive searches have been made for reptiles by IMcF. Moutoki Island, 1 km to the east, has large numbers of tuatara (*Sphenodon punctatus*), the Pacific gecko (*Hoplodactylus pacificus*), and the shore skink (*Leiolopisma smithi*). By comparison only one individual of the common gecko (*H. maculatus*) has been found on Rurima Island.

The island group is a wildlife refuge with public access for day visits. The attractive beach on the east of Rurima Island and sheltered harbour to the west afford easy landing. The landing may have facilitated accidental introduction of kiore to Rurima by Maori at some time during the past 1000 years. A voucher specimen of kiore from Rurima is lodged with DSIR Land Resources.

2.2 Korapuki Island

Korapuki Island (18 ha) is in the Mercury Group 6 km off the east coast of the Coromandel Peninsula near Whitianga (Fig. 1). Korapuki has been extensively burnt in the past leaving remnants of the original vegetation only on two rocky promontories. Species present in the remnants include milk tree (*Paratrophis banksii*), karaka (Corynocarpus laevigatus), kawakawa (*Macropiper excelsum*), karo (*Pittosporum crassifolium*), wharangi (*Melicope ternata*), and some native herbaceous plants. The rest of the island is covered by a canopy of pohutukawa, with a sparse understorey of mahoe (*Melicytus ramiflorus*) and mapou (*Myrsine australis*). Open areas are dominated either by coastal flax (*Phormium tenax*), stunted manuka (*Leptospermum scoparium*), or *Cyathodes fraseri* and rats-tail (*Sporobolus africanus*) (Hicks *et al.* 1975, Towns *et al.* 1990).

Four species of ground nesting seabird breed on Korapuki during the winter, and at least two, including the rare Pycroft's petrel (*Pterodroma pycrofti*), breed during summer. Ten species of native land bird and six species of introduced bird occur but not all are known to breed there (Towns *et al.* 1990). Kiore, probably introduced by Maori some time during the last 1000 years, and rabbit (*Oryctolagus cuniculus*), liberated early this century, are the only known introduced mammals on Korapuki (Towns *et al.* 1990).

Nearby rat-free Green and Middle Islands have up to 10 species of lizards plus tuatara (Towns in press). Only five reptiles have been recorded to date on Korapuki: two species of gecko and three of skink. Duvaucel's gecko (*Hoplodactylus duvaucelii*) and common gecko, are both in low numbers and found mostly about the large boulder beaches or amongst the more dense patches of coastal vegetation (Hicks *et al.* 1975, Towns in press). The shore skink occurs in high numbers on some rocky beaches, and the moko skink (*Leiolopisma moco*) occurs throughout but is more common about the more open areas of *C. fraseri* and rats-tail, whereas the copper skink (*Cyclodina aenea*) occurs throughout the forest in low numbers (see Towns in press).

Observations of the abundance and diet of kiore on Korapuki were made by Hicks *et al.* (1975) who reported a high incidence of vegetation and bird-down in rat stomachs in November and December (spring) 1974 but kiore at low densities. By comparison high densities of kiore were recorded on Korapuki Island in the winter of 1970 (Atkinson, cited in Hicks *et al.* 1975).

3. METHODS

Kiore reach lowest densities from August to November on most northern offshore islands (Craig 1986, Atkinson and Moller 1990). First bait was therefore laid no later than November in order to provide kiore with abundant food when they would be preparing for their next breeding season and when natural food sources would be scarce.

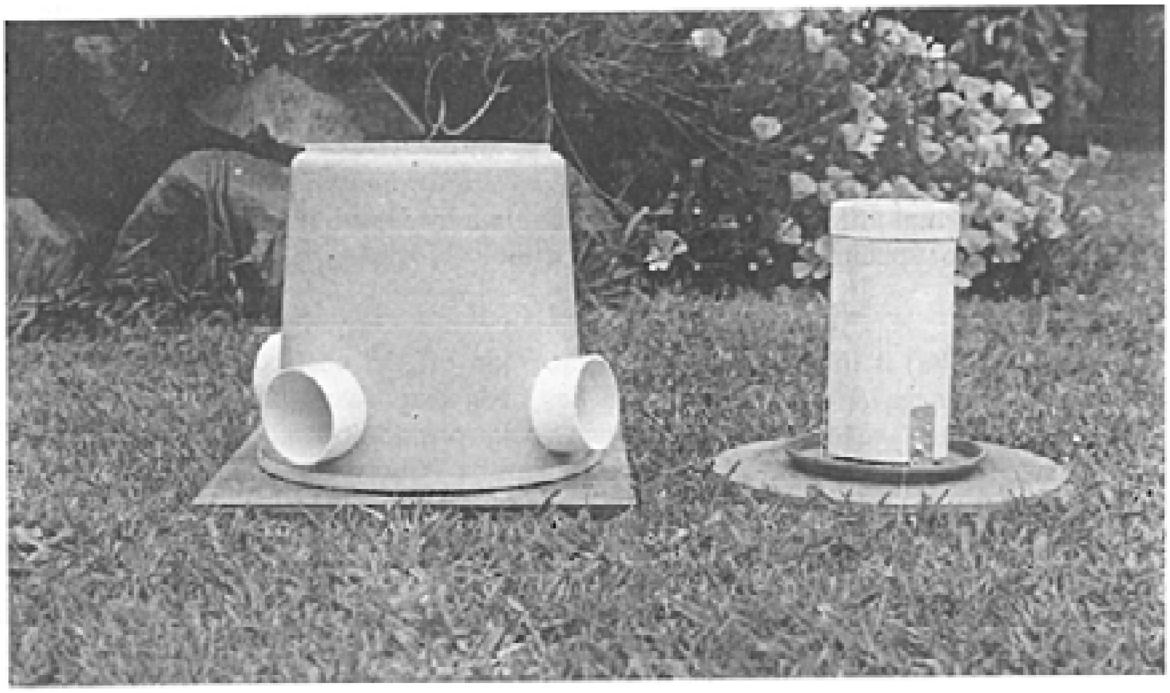

Fig. 3 Photograph of silo in place.

Eradication campaigns on both islands were based around the use of automatic dispensing silos baited with kibbled maize (McFadden 1984) (Fig. 3). Silos were filled with a non-toxic pre-feed of maize then checked daily until a high level of acceptance was achieved. Acceptance by kiore (referred to here as bait take) was shown by spilt and husked grains, rat droppings at the base of the silo, and reduction in volume of grain present. Once high bait take was apparent, all remaining bait was removed and the silos cleaned of spilt grain. Silos were then filled with toxic bait (see 3.1 below) and left for up to 6 months, or until the next visit. On subsequent visits silos were again checked for rat sign, cleaned of remaining bait and the sequence of pre-feeding and laying of toxic bait repeated. In addition to silos, two further methods were used to check for the presence of rats:

1. On each visit an index line of 20 standard break-back rat traps was installed. Traps were set in pairs at 25 m intervals, one trap baited with peanut butter the other with canned (Felix) cat food at each site. Trap lines were permanently marked with plastic trail tape and were set out to pass through a range of habitats. Any female kiore caught were autopsied to determine reproductive status; this was especially important near the end of the eradication campaigns when a few pregnant females would indicate a remnant viable population of rats. If no rats were caught in index lines additional traps were set at other locations likely to support rats.

2. Intensive searches for rat sign were made on each visit. Kiore use husking stations in dry sheltered places to eat large seeds and consume large invertebrates. Once located, these stations provided a reliable indicator of kiore presence (Atkinson and Moller 1990). The accumulation of food remains was

swept away on each visit so that use by kiore between visits was obvious.

3.1 Rurima Island

Thirty bait dispensing silos were set out on a 50 m grid (Fig. 2) to ensure that each kiore had four silos within its home range (Moller 1978).

Artificial lures were mixed with all baits used on Rurima (see McFadden 1984). A different lure was used for each bait session in order to give bait a distinctive aroma and reduce the risk of bait shyness developing. Once the complete sequence of lures is used it can repeated so that several bait applications pass before a lure is reused (McFadden 1984).

Kibbled maize was used throughout except for four applications of bromadiolone-based RENTOKIL Rid-rat Super°, two with kibbled wheat and two with oats.

Poisoning for kiore commenced in August 1983 using kibbled maize as prefeed followed by kibbled maize to which green-dyed compound 1080 (sodium monoflouroacetate) had been added at 0.08% by weight[1]. The green dye used was in accordance with the widely accepted practice of dying toxic bait to make it less attractive to birds (see Caithness and Williams 1971). Manufacturers claims of the dye being odourless and tasteless were accepted. Compound 1080 is also reputedly odourless and virtually tasteless (Rammell and Fleming 1978).

The anticoagulant bromadiolone (a hydroxycoumarin derivative), mixed with kibbled maize at 0.005% by weight, was used as an alternative poison, following application of compound 1080. Mixing of bromadiolone and kibbled maize was carried out by RENTOKIL (a pest control company).

3.2 Korapuki Island

The same poison dispensing methods used with success on Rurima were employed on Korapuki except that kibbled maize pre-feed and kibbled maize mixed with bromadiolone were used exclusively. Unlike Rurima, neither pre-feed nor poisoned kibbled maize on Korapuki were treated with dye. One hundred and twenty six silos were set out on a 50 m grid (Fig. 2) and rat traps on a permanent marked line were set each visit. Traps were set late in the day and triggered each morning to reduce the risk of catching red-crowned parakeets (*Cyanoramphus novaezelandiae*).

4. RESULTS

4.1 Rurima Island

4.1.1 Compound 1080.

Undyed non-toxic prefeed of kibbled maize was loaded into the 30 silos on 15 August 1983. By 17 August, twenty-six silos (87%) had high levels of bait take, including grain husked at the silo. On 19 August all remaining pre-feed was collected and replaced with toxic bait.

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[1] Concentrations set by New Zealand Agricultural Pests Destruction Council.

On 3 and 4 October 1983 all silos were checked and found to have been visited by kiore (rat droppings on the silo base), but no grain had been eaten. The silos were therefore cleared of toxic bait and filled with undyed kibbled maize prefeed lured with aniseed. By 8 October widespread prefeed take was achieved. Silos were then with green-dyed compound 1080 mixed with kibbled maize and aniseed lure.

Silos were checked on 8 November but little bait had been taken over the previous four weeks. Because of the high take of prefeed, but apparent avoidance of toxic bait, the manufacturers' claims for compound 1080 and the green dye were then checked.

Kibbled maize prefeed was added to silos and by 21 November widespread take was achieved. All remaining bait was then collected and 15 silos filled with undyed toxic bait, and 15 with non toxic dyed green prefeed. The two treatments were in alternating silos so that most kiore would have two baits of each type within their home range.

By 13 January 1984 all the dyed prefeed had been eaten but little of the toxic bait had been taken. A check of some silos on 23 November 1983 had shown an initial halt to bait take on both types of bait. This test showed that kiore would not take 1080 mixed at 0.08% but would eat dyed pre-feed.

A sample of the dye was obtained and one of us (IMcF) tested it by tasting a small amount of the dye solution. The solution was found to be bitter. When mixed with kibbled maize it also had an aroma similar to kerosene. In addition to the green dye, compound 1080 is dyed black in accordance with international colour coding for poisonous substances. The dye used is nigrosine (Rammell and Fleming 1978), an iron oxide used widely in the manufacture of shoe polish, inks, fabric and leather dye, and as a shark repellant. A sample of this oxide was obtained and when tasted was also found to be bitter. It is therefore likely that kiore could detect the dyed bait, and may have been deterred by the combined effects of the dyed bait and dyed compound 1080.

These problems with field application of compound 1080 and dye could not be rapidly checked using laboratory trials midway into the eradication programme. It was therefore necessary to make exclusive subsequent use of the anticoagulant bromadiolone without dye (see Table 1 for summary of treatments).

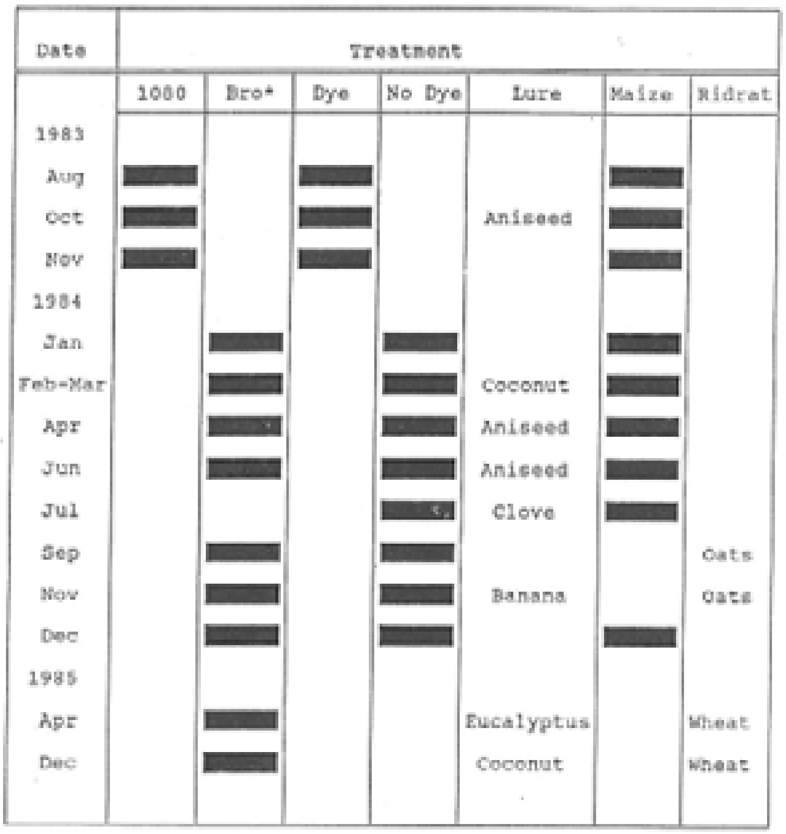
4.1.2 Bromadiolone.

Silos were filled with kibbled maize prefeed on 14 January 1984. By 17 January widespread take was achieved and remaining pre-feed replaced by toxic bait.

When checked on 29 February all silos had been emptied of toxic bait, indicating high acceptance by kiore. Silos were then cleaned of the few remaining husks, and filled with coconut lured nontoxic prefeed. By 3 March all silos showed some prefeed take so prefeed was replaced by toxic bait.

On 27 April six additional silos were set to provide better cover of the islets, and all were filled with aniseed-lure kibbled maize. At least half the silos had bait taken from them by 1 May and toxic bait was again laid. On 11 June five more silos were put out and all 41 filled with prefeed. By 15 June most silos had grain spilt out onto the silo base and in some cases onto the ground outside the cover. The presence of small feathers, and small bird droppings indicated that the flocks of house sparrows (*Passer domesticus*) heard chattering in the canopy were feeding at silos.

Table 1. Sequence of treatments used in kiore eradication campaign on Rurima Island between August 1983 and December 1985 using compound 1080 and bromadiolone (*).



Date	Treatment						
	1080	Bro*	Dye	No Dye	Lure	Maize	Ridrat
1983							
Aug	■		■			■	
Oct	■		■		Aniseed	■	
Nov	■		■			■	
1984							
Jan		■		■		■	
Feb-Mar		■		■	Coconut	■	
Apr		■		■	Aniseed	■	
Jun		■		■	Aniseed	■	
Jul				■	Clove	■	
Sep		■		■			Oats
Nov		■		■	Banana		Oats
Dec		■		■		■	
1985							
Apr		■			Eucalyptus		Wheat
Dec		■			Coconut		Wheat

However no sign attributable to kiore could be found. The sequence of prefeeding and laying toxic bait was repeated in late July with kibbled maize and clove, late September with kibbled oats and coconut, and early November using kibbled oats and banana, but there was no further sign of kiore (Table 1). Index trapping concurrent with the various poisoning trials indicated the effectiveness of bromadiolone compared with compound 1080 (Fig. 4). Highest numbers of kiore were caught in August 1983, followed by a decline to November that might have been due either to poisoning or alternatively to the normal seasonal decline in abundance of kiore. In April 1984, extra traps were set to catch rats in areas where their presence was suspected but not indicated by feeding at silos. One juvenile male kiore was caught for the 80 trap nights on the index line, and four elsewhere. No rats have been caught since April 1984.

Visits were made to Rurima in April 1985 when eucalyptus-lure prefeed was used and in December 1985 when toxic bait with coconut lure was used. No sign of kiore could be detected on either visit. In May 1986, December 1986 and July 1987 extensive searches

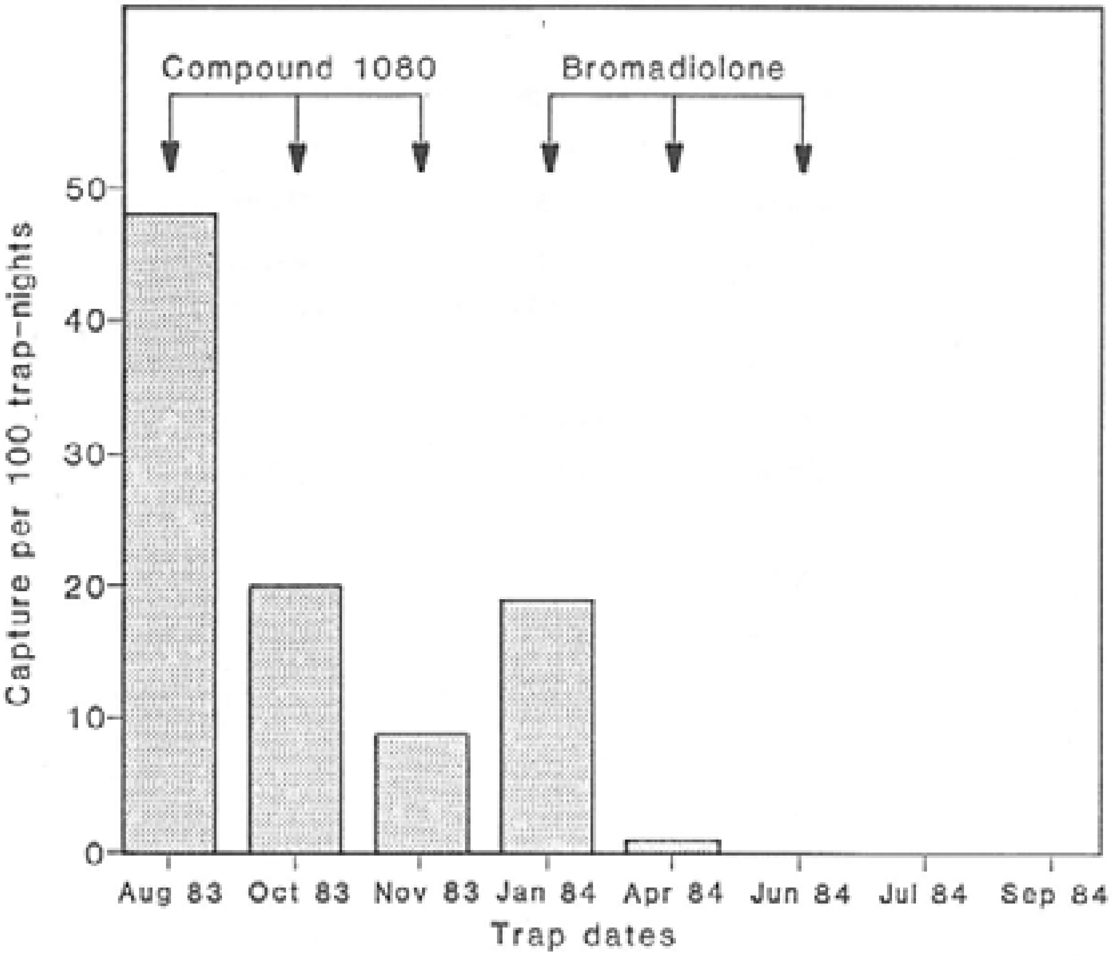


Fig. 4 Numbers of kiore in kill traps on Rurima Island index lines during applications of compound 1080 and bromadiolone.

were made for fresh rat sign, and kill traps were set, but no sign of kiore could be found. It is now reasonable to assume that the kiore have been eradicated.

4.2 Korapuki Island

The eradication campaign against kiore on Korapuki began on 11 November 1986, when the silos were filled with unlured kibbled maize. By 15 November small amounts of grain had been taken from a few silos in three separate areas indicating separate populations of kiore. The non-toxic prefeed was replaced by toxic kibbled maize with bromadiolone on 16 November.

When Korapuki was next visited on 12-19 January 1987 only four silos (3%) showed feeding sign from kiore (spilt and husked grain and droppings on soil bases). All remaining toxic grain was collected and replaced by coconut lure pre-feed. All silos were checked on 18 January, no sign of feeding by rats was found and toxic bait was not laid. No kiore were caught on the index trap line.

During the next three visits only pre-feed with coconut (February), aniseed (March) and coconut (June) were added to silos. Kiore feeding sign was not found on any visits and no kiore were caught on the index line. Red-crowned parakeets had begun to feed at the silos by March but as toxic bait was not being used this would not have detrimentally effected the birds. Because of the interference by birds pre-feed was not put out in subsequent visits to check for kiore. All checks for kiore after June 1987 were instead limited to kill traps and ground searches. Traps were set on the index line and around the three areas where bait was taken in November 1986 but no kiore were caught. Searching involved regular inspection for sign of rats in dry caves, at feeding stations, and on or around vegetables and carrion washed up on the beaches or found on the island.

Seven visits have been made to Korapuki since November 1987. No evidence of kiore persisting on Korapuki has been found since November 1986 and it would appear that they were eradicated by the single application of toxic bait.

5. DISCUSSION

Two kinds of rodenticide are available for use against rats. Acute or single dose toxicants, such as compound 1080, are extremely toxic to a wide range of animals, have rapid symptoms of toxicity, but have no antidote against accidental ingestion (Howard and Marsh 1974, Moors *et al.* 1989, and Fleming 1978). Chronic or multiple dose rodenticides, such as bromadiolone, have lower general toxicity, slow symptoms of poisoning, reduced potential for effects on non-target species, and an effective antidote (vitamin K_1) (Howard and Marsh 1974, Moors *et al.* 1989).

5.1 Use of acute rodenticide: compound 1080

The eradication campaign against kiore on Rurima Rocks incurred additional costs in time, effort, material and transport through acceptance of manufacturers' claims that compound 1080 and the green dye were odourless and tasteless. In August 1983 kiore numbers on Rurima should have been low, food scarce and the rats hungry. The most likely cause for kiore to stop feeding when prefeed was replaced by toxic bait was that they could detect either 1080 in the concentrations used, the green dye, or a combination of both. Tests were not conducted with various concentrations of either dye or with 1080 and it may be that lower concentrations of dye or 1080 are acceptable to kiore. From the results on Rurima it is not recommended that 1080 be used against kiore until tests have been conducted using lower concentrations and alternative dyes.

5.2 Use of chronic rodenticide: bromadiolone

The more successful rodenticide, bromadiolone, is usually regarded as a cumulative or chronic anticoagulant (Moors *et al.* 1989). However, bromadiolone is unusual amongst chronic rodenticides by acting either as an acute or chronic toxicant depending on the concentration used. At 0.005% (the concentration used here) bromadiolone is an acute rodenticide for Norway rats (Marsh 1977). Kiore that ingested bromadiolone in the campaigns undertaken on Rurima and Korapuki islands probably took more than one lethal dose over the several days before symptoms of toxicity appeared (Marsh 1977). One criticism of bromadiolone, therefore, is that toxic bait is wasted when one lethal dose is enough (Moors *et* al. 1989). However the low cost of the toxic bait is outweighed by the potential value of a successful eradication campaign.

5.3 Use of prefeed

Success with this method of eradication relies on two related effects. First, raising susceptibility of target species to toxic bait by use of a non-toxic prefeed. Second, presentation of prefeed and toxic bait at the correct time of year: when rat numbers are minimal and alternative food resources are scarce.

Kiore took at least three nights to overcome initial shyness of prefeed based on a completely foreign food source. Once prefeed was accepted there was no detectable drop in bait take when pre-feed was removed and toxic bait laid. Baits were not dyed green on Rurima after November 1983, and not at all on Korapuki. Where species are likely to be at risk it is recommended that all bait be dyed green (Caithness and Williams 1971) so that non target species do not become attracted to pre-feed, and so that target species cannot detect the change from pre-feed to toxic baits. If birds like red-crowned parakeets become a problem they can be discouraged by inserting short (150 mm) lengths of 65 mm diameter 'NOVAFLO' into the entrance holes to the silos, after which parakeets refuse to enter them. Ensuring that all split grain is collected may also reduce the risk of attracting birds to silos.

5.4 Cost effectiveness

The entire eradication of kiore from Rurima Island could easily have been carried out by one person making it a relatively cost effective exercise. In practice two people were involved on each visit as a safety precaution. On Korapuki two people took an 8-hour day to set out the 126 silos, a further day to put out the pre-feed, then another to remove the remaining pre-feed and put out toxic bait.

The eradication campaign on Korapuki was considerably more cost-effective (basic cost $198/ha) than on Rurima ($1131/ha) because toxic bait was laid only once (Appendix 2). Even without the time expended on compound 1080 trials on Rurima, eradication of kiore took much longer there than on the larger Korapuki Island. This is probably because kiore on Rurima had in effect been fed well on pre-feed for five months and may also have been bait shy due to sublethal doses of 1080. Rat sign on Rurima continued for seven months after the first application of poison. In addition, although virtually no feeding sign was found in silos in May 1984, five kiore were caught in kill traps. These trapped animals illustrated the need to step up kill trapping once feeding sign stopped at silos.

The effectiveness of the campaigns against kiore compare well with the one against Norway rats (*Rattus norvegicus*) conducted by Taylor and Thomas (1989) on 9 ha Hawea Island in Fiordland National Park. The campaigns had one feature in common:

baits were dispensed from fixed bait stations. The Hawea campaign differed from the others in using commercially available TALON 50 WB manually added each day to bait stations until removal of bait by rats ceased (11 days). This was a labour-intensive operation requiring 64 operator-days to complete (Taylor and Thomas 1989). Using the same cost-structure applied to the kiore campaigns, the net cost of the Hawea operation ($1073/ha) was similar to that for Rurima Island. The low net cost of the Korapuki campaign was directly attributable to the low labour requirement of the silos. Minimising labour costs is likely to be a primary consideration when designing other eradication campaigns.

5.5 Precautions

The most valuable lesson learnt on Rurima was that baits, poisons and dyes should all be tested before an eradication attempt begins. Accepting manufacturers claims is not sufficient for expensive field programmes. Assumptions made on Rurima resulted in a delay to the effective start of the programme, and probably made kiore bait shy.

It is important that all toxic bait is applied in one day so that only toxic bait is available over the entire island. Acceptance of toxic bait should be checked the day after its application. If bait take continues uninterrupted then the sequence of pre-baiting and toxic bait laying can be repeated at 6-8 week intervals, or until no rat sign can be found. Regular visits should then be made for at least 12 months to ensure that low numbers of rats do not exist particularly in areas of difficult access. As with any eradication attempt the response of the target animals to the methods employed must be carefully noted so that changes may be made to compensate for or to overcome any problems which may arise.

Absence of rat sign at silos dispensing toxic bait is not sufficient evidence to assume that rats have been eradicated. On small islands (<10 ha) intense searches are a useful means of detecting the presence of kiore. Despite considerable effort expended on these activities on both islands, in August 1988 a virgin female ship rat (*Rattus rattus*) was caught by one of us (IMcF) in a kill trap on Korapuki. The animal most likely reached the island following an illegal landing. Permanent bait stations using wax blocks of TALON 50 WB (brodifacoum) are now maintained at possible landing sites on Korapuki. A comprehensive account of useful measures against invasions of islands by rats is given in Moors *et al.* (1989).

5.6 Conservation potential

The results obtained here suggest that automatic dispensing silos could be used to eradicate kiore from islands up to 50 ha. Beyond 50 ha the exercise could become difficult to coordinate, but may still be more cost-effective than other available techniques. Norway rats (*R. norvegicus*), ship rats, and mice (*Mus musculus*) should also be susceptible to use of these methods.

The speed with which the Korapuki campaign was completed raises the possibility that the operation was made more effective through competition for alternative food resources by rabbits. A project is currently underway by IMcF on Double Island (Mercury Group) which tests this possibility on an island free of rabbits and with a well developed and diverse vegetation cover.

The techniques described here can provide rat-free habitats for threatened species that do not have large area requirements. However, several islands of 100 ha or larger have populations of species under threat from kiore. Examples are given in the recovery plan for tuatara (Cree in press). Mechanised aerial spread of commercially available products could be more cost-efficient on larger islands. This possibility is now under investigation.

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Appendix 1. List of birds recorded from Rurima Rocks between August 1983 and December 1985.

SPECIES	COMMON NAME	BREEDING
Anas platyrhynchos	mallard	*
Ardea novaehollandiae	white-faced heron	
Charadrius obscurus	New Zealand dotterel	*
Carduelis chloris	greenfinch	
Egretta sacra	reef heron	
Eudyptula minor	little blue penguin	*
Fringilla coelebs	chaffinch	
Gerygone igata	grey warbler	*
Haematopus unicolor	variable oystercatcher	*
Halcyon sancta	New Zealand kingfisher	*
Hirundo tahitica neoxena	welcome swallow	*
Hydroprogne caspia	caspian tern	*
Larus dominicanus	black-backed gull	*
L. novaehollandiae		
scopulinus	red-billed gull	*
Passer domesticus	house sparrow	
Pelacanoides urinatrix	diving petrel	*
Phalacrocrax sulcirostris	little black shag	*
P. varius	pied shag	*
Prunella modularis	hedge sparrow	
Pterodroma macroptera	grey-faced petrel	*
Puffinus gavia	fluttering shearwater	*
P. griseus	sooty shearwater	*
Rhipidura fuliginosa	fantail	*
Sterna striata	white-fronted tern	
Sturnus vulgaris	starling	*
Turdus merula	blackbird	*
Zosterops lateralis	silvereye	

Appendix 2. Costings for eradication campaigns on Rurima Rocks and Korapuki Island

To provide a means of comparing the costs of the two campaigns all prices have been standardised to 1990 figures. The costs are derived in two ways: the gross cost and the net cost (Table 1).

The net cost is calculated as a standardised cost of achieving eradication based only on parts of the project that contributed to actual eradication of the rats. Costs of follow-up surveys have not been included because they are elective expenses. Similarly, the cost of trials of dyed prefeed on Rurima has not been included. It might be argued that by comparing only the costs of visits and material involved in the actual eradication process, costs have been underestimated. On the other hand labour costs have been included, when in fact much labour was by volunteers. Another area where costs are over-estimated is in the price of automatic dispensing silos. All of the silos built for Rurima were used on Korapuki. These silos can be used many times over, but the full cost of new silos for Korapuki is used in the estimate (Table 1).

The gross costs include additional costs specific to each location. For Rurima these additional costs were for transport, and for Korapuki they were for transport and construction of a hut.

The net cost for eradication of kiore form Rurima was $1131/ha, and the gross cost was with the additional cost of transport (5 boat charters). The gross cost for Rurima was 3.5 times the cost for Korapuki ($378/ha).

Appendix 2

Table 1. Costings of eradication campaigns on Rurima and Korapuki islands based on standardised prices.

Location	Area	$
Rurima Rocks	7.5 ha	
Silos 4@$5		205
Poison and prefeed		500
Salaries 52 operator-days @ $15/hr		6240
Food and allowances 52 @ $20/day		1040
Other costs		500
Net cost total		8485
Net cost per hectare		**1131**
Boat charters 5 @ $300		1500
Gross cost total		9985
Gross cost per hectare		**1331**
Korapuki Island 18 ha		
Silos 126@$5		630
Poison and prefeed		500
Salaries 12 operator-days @ $15/hr		1440
Food and allowances 52 @ $20/day		240
Other costs		750
Net cost total		3560
Net cost per hectare		**198**
Boat charters 1 @ $750		750
Hut		2500
Gross cost total		6800
Gross cost per hectare		**378**