Developing tools to detect and respond to rodent invasions of islands: workshop report and recommendations

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ABSTRACT

Since the late 1970s, rodents have been eradicated from an increasing number of islands around New Zealand. These islands have become important habitats for endangered birds, reptiles, invertebrates and plants. In many cases the only surviving populations of some species are found on one or more of these islands. The potential effects of rodents re-establishing on such islands could be catastrophic. Large investments in time and money have been made in clearing islands and the early detection and removal of invading rodents is vital.

Many of the baits, toxins and delivery systems currently used for eradicating rodents have not been comprehensively evaluated to see how attractive they are to rodents that arrive on an island with an abundance of food. Ship rats (*Rattus rattus*) that established on Fregate Island in the Seychelles in 1995, could not be detected or caught until numbers had increased and they had spread over a large area of the island. Newly invading animals could not be attracted to tracking tunnels or caught in traps. Full-scale island eradication then had to be implemented.

In June 2001 a workshop was held in Christchurch to discuss issues of detecting and responding to rodents as new invaders to islands. Representatives from all Conservancies with island responsibilities were invited. This report provides a summary of management issues and information needs which highlights where further research is required to enhance our ability at detecting and eradicating invading rodents.

Keywords: rodent eradications, islands, reinvasion, rats, mice.

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1. Introduction

Remote and unoccupied islands are conservation treasures but are vulnerable to invasion by predators (Dingwall et al. 1978). Because of their remoteness, it may be difficult to detect rodent invasions of offshore islands before they are well established and causing major problems to island ecosystems. Large capital investments have been made in removing rodents from many of these islands (see Veitch 1995). Effective tools are therefore needed to monitor those islands naturally free of rodents and those from which rodents have been removed to ensure that all rodent invasions are detected and responded to quickly.

The most difficult problem with invasions is detecting species when they arrive and are still at low numbers. This problem was recognised by Northland and Wellington Conservancies, both of which requested from Science & Research Unit of the Department of Conservation (DOC) a more detailed evaluation of how to detect invading rodents. The following report is from a workshop held in Christchurch on 5–6 June 2001 aimed at identifying core issues around the problem of detecting invasions of rodents to islands. Participants at the workshop (Appendix 1) were drawn from DOC conservancies where there are large numbers of islands, were able to provide technical advice (within and outside of the Department), and were involved with policy development.

The scope of the problem was addressed through the following topics (see also Appendix 2):

- The context of the rodent invasion problem
- Recent rodent 'scares' and 'near misses'
- The behaviour of new invaders
  - The invasion of Fregate Island, Seychelles
  - A trial with Norway rats invading Ulva Island
- Methods of detecting rodents
  - Rat dogs
  - Physical rodent attractants
  - Electronic detection
- A review of toxins available for rodent eradication and control
- The results of bait acceptability trials for mice
- The development of an island invasion Standard Operating Procedure (SOP)

From discussions of these, gaps in the technical support were identified and research topic areas proposed that should fill these gaps.

2. Rodent invasions of islands—the national context

Four species of introduced rodents are present in New Zealand. Kiore (*Rattus exulans*) arrived with early Polynesian settlers between AD 800 and 1000 and the other three species, ship rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*) and house mouse (*Mus musculus*) arrived with European settlers in the late 18th and early 19th Century (King 1990).

The successful removal of rodents from islands is a recent development pioneered in New Zealand. One or more of the four species of introduced rodents have been eradicated from a number of offshore islands in New Zealand. Kiore or Pacific rats are used here to illustrate these advances because they have been particularly widespread on offshore islands. Key points are:

- The first known kiore eradication was in 1978, following the invasion of 1 ha Lizard Island (in the Mokohinau Islands) in 1977. Subsequently, the number of successful eradication campaigns rose gradually, with the first systematic development of new methods in the mid 1980s. The number of eradication campaigns peaked in the early 1990s (Fig. 1).
- Although not apparent from Fig. 1, it is likely that the frequency of such operations against kiore will now decline to levels similar to those of the late 1980s. This is because rodents have now been eradicated from the high priority islands where they were a serious threat to wildlife.
- Rodent eradication programmes on most of the remaining islands are likely to be high-risk operations. There are several reasons for this. These remaining islands may be very large (e.g. 2000–3000 ha), or logistically challenging because of their remoteness (such as the Kermadecs). For other islands, cultural issues mean that rodent eradication may be controversial.
- The eradication campaigns completed or under way, or those proposed to start within five years, will greatly increase the total area of islands cleared of kiore, which at present is about 5500 ha. For example, confirmation of success on 1277 ha Tuhua (Mayor) island coupled with the proposed operations on

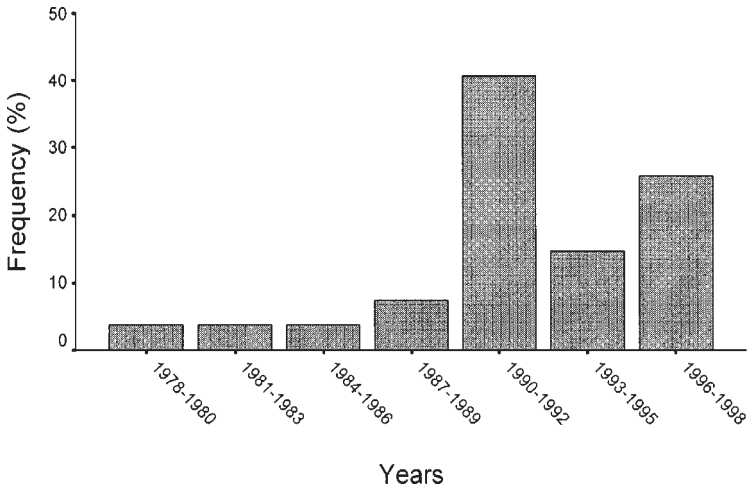


Figure 1. Islands cleared of kiore over time.

Raoul (2938 ha) + Macauley (306 ha) Islands in the Kermadecs would bring the total area cleared to almost double the area cleared of kiore up to 1998 (Fig. 2).

As a result of these eradications of kiore and other rodents, island management faces the following issues:

- Most offshore island nature reserves < 500 ha are at low risk of reinvasion from neighbouring islands within the swimming distance of rats and mice.
- The increased number of rodent-free islands combined with an increasingly mobile public means that there is a greatly increased need for surveillance, as the major risk of rodent reinvasion comes from visitors to these islands.
- There is also an increasingly high potential cost of reacting to any invasion and urgency for this response as the asset value increases on islands cleared of rodents. For example, since removal of kiore there has been considerable recruitment of young tuatara and release of various threatened lizards on Lady Alice Island (Towns et al. unpubl. data) and the endangered tusked weta has been released on Double and Red Mercury Islands.
- However, the existing tools used for surveillance and eradication are of doubtful effectiveness. For example, poison baits used in bait stations are modified from agricultural products and may not be attractive to rodents on islands where there is an abundance of natural food. These baits may have significant collateral effects on resident species, may have limited life in high-humidity coastal environments, and may never have been adequately tested for efficacy (O'Connor & Eason 2000).

These issues raise four main questions that formed the framework for the workshop:

1. What are the risks of rodent invasion or reinvasion now faced by these rodent-free islands?
2. What new tools and technical advances are needed to deal with these risks?
3. What new kinds of opportunities will be tried that have no proven success? For example, will islands < 1500 m offshore (i.e. within rodent swimming range) become the next eradication challenge?
4. What tools will be needed on islands where reinvasion is a very high probability?

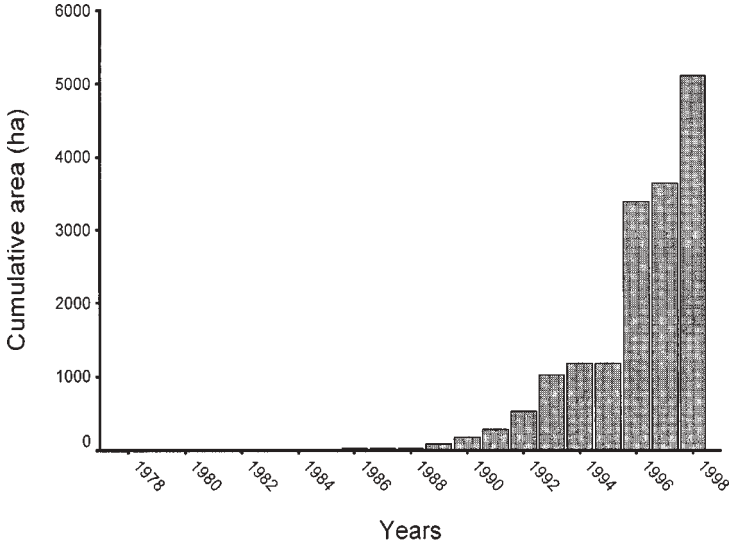


Figure 2. Islands cleared of kiore by area.

3. Recent rodent 'scares' and 'near-misses'

There are a number of recent examples of rodents found in gear destined for islands, where rodents are believed to have been seen on islands, or where potentially rodent-carrying ships have beached on islands. Examples include:

- Rangatira Island: a possible mouse sighting was recorded in December 1998 and, more recently, suspected rodent chewing was found on soap.
- Pitt Island: a rat was reported swimming ashore from a fishing boat moored in a bay at the south end of the island.

In these cases trap and/or poison lines were run and chew blocks were placed on Pitt Island. No sign was detected of invading mice or rats.

- Korapuki Island: in 1987/88 a virgin female ship rat was caught on monitoring lines set following the eradication of kiore and rabbits (*Oryctolagus cuniculus*). No further animals were detected. Because of the distance of the island from other sources of rodents, the animal could only have arrived on a visiting vessel.
- Red Mercury Island: two fishing boats have beached since kiore were eradicated in 1992. There was no information as to whether rats were present on these boats, but rodent invasion contingencies were implemented.
- Coppermine Island: in March 2001 rodent droppings were apparently discovered 3.5 years after the eradication of kiore. A rodent response was activated, but it was later determined that the droppings were probably from large ground weta.

Issues that arose from these 'scares' and 'near-misses' are:

Rapid response methods. Responses to such events vary widely around the country—there are no standard methods. Trapping, toxins and ways of presenting them vary and their efficiency has generally not been tested. A standard plan of attack is required, although the Island Invasion Standard Operating Procedure (SOP) being developed by DOC should help with this.

Early detection. Extremely important on small islands that may have populations of threatened species vulnerable to predation. These island populations may be the last remaining populations of some species. Risk assessments are needed to determine for which islands this is most important.

Identification. Early detection also requires identification of the invading species since responses may need to be species-specific. Droppings and feeding sign are the most common evidence. The Coppermine Island example illustrates the need for ready access to people who are able to identify rodent droppings.

Lures. The efficacy of lures used in baits needs to be rigorously evaluated. What works on the mainland may not be equally effective in an essentially rodent-free environment.

Surveillance. Regular monitoring of bait stations is required to allow reinvasion to be detected as early as possible. This means that the frequency of monitoring should be based around the potential for rodents to proliferate after landing rather than the rate that baits degrade in bait stations.

4. The behaviour of invaders

The following case studies provide examples of actual invasions.

4.1 THE INVASION OF FREGATE ISLAND, SEYCHELLES

Fregate Island is a privately owned resort in the Seychelle Islands in the Indian Ocean and was free of rats until 1995 (see Thorsen et al. 2000). In July 1995 one rat was seen to run from packaged household materials being unloaded, but resort management was not informed until September 1995 when the first animal (a male) was killed.

The first attempt at eradication started in November 1995 and was halted in December 1995. In February 1996 control recommenced and was eventually discontinued in mid-June 1996 due to concerns about the impacts of rat poison on the endangered magpie robin (*Copsychus sechellarum*).

Major problems encountered with the control programme were:

- Difficulty in detecting rat presence because the abundant natural food meant rats did not need to take bait, and non-target species interfered with the bait.
- No droppings were found and feeding sign was found on only three occasions.
- The newly established rat population showed extreme neophobia. Of 87 documented rat captures only five were adult. All were male.
- Captures of juveniles occurred in groups indicating breeding nearby, yet the parents were not captured.
- There was a high loss of bait (17% per night) and a high rate of interference by non-target species.
- Bait (Talon 20P) rapidly became mouldy and unpalatable (within 2–6 days).

Indications were that:

- The original rat landed and settled in one area, its offspring also settled in the same location.
- After eight months rats were noted further afield with some having moved 400 m from the colonisation point.
- By September 1997, twenty-six months after the first animal was seen, rats were spread over the whole 210 ha island and were commonly seen.

4.2 TRIAL WITH NORWAY RATS INVADING ULVA ISLAND

Ulva Island (270 ha) has been subject to 20 years of periodic toxin use (mostly brodifacoum) against Norway rats. Between 1992 and 1994 Norway rat extermination was undertaken using a 'rolling front'. Since then there have been two invasion events (in 1997 and 1999) involving single Norway rats. The

1999 rat was seen swimming ashore from a yacht. Trapping eliminated both rats. There is an acknowledged high risk of further rodent invasions to Ulva Island, and a rodent management plan is in operation.

As a trial of the effectiveness of bait stations on the island, two de-sexed male Norway rats were fitted with radio-collars and released on Ulva Island wharf. Both rats jumped into the sea and swam directly to coastal rocks where they remained until after dark. The night after their release they moved less than 100 m and visited the buildings. Both rats remained in the vicinity of the buildings and one was trapped after 3 days and the other found dead after 5 days (both had eaten poison). The standard surveillance and response mechanism had worked.

5. Methods of detecting rodents

5.1 RAT DOGS

The use of dogs as a means of detecting rodents was demonstrated by a video. Dogs have particular value where a small number of rodents might be involved and the general area in which the rodents are present or likely to be present has been determined.

5.2 PHYSICAL ATTRACTANTS

The use of rodent shelters (Rowley's Rat Hotels) to detect rat invasion was described by Rowley Taylor who has been testing these with Peter Gaze.

The basic idea is that any newly arrived rodent will initially be more attracted to safe dry shelter than to food. If a suitable den/nest is provided along with food then the rodent will stay put and reveal its presence by leaving sign. Baited traps or electronic detection equipment can be incorporated in the design to identify/capture the species.

In 1983, ship rats were eradicated from Tawhitinui and Awaiti Islands 400 m from shore in Tennyson Inlet, Marlborough Sounds. Nest boxes for rodents were constructed and left on the island. These were constructed from plywood (88 mm × 800 mm) with several entrances and contained a cut-down plastic jerry can suitable for a nest site. Dog biscuits were left inside.

These boxes were monitored as follows:

March 1985	boxes placed on Awaiti and Tawhitinui
April 1985	no sign of use
May 1985	no sign of use
July 1985	no sign of use. Biscuits replaced
October 1985	no sign of use
May 1986	Tawhitinui only checked—no sign of use
December 2000	Tawhitinui only checked—rat sign evident

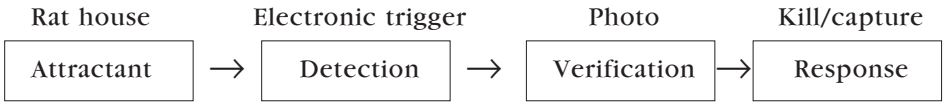
The ‘rat hotel’ contained rat droppings, chewed seeds and extensive chewing on nest-box. Some nest material had been placed in the nest box. The sign was dry and could not be aged.

In February 2001 the island was trapped for rats with 23 Elliott traps and three single Fenn traps baited variously with peanut butter, chocolate or eggs. No animals were caught over 149 Elliott trap nights and 99 Fenn nights. There was no recent activity in the ‘rat hotel’.

5.3 ELECTRONIC DETECTION

Electronic equipment could provide automatic detection, verification and communication of an arrival. The simplest, cheapest and most useful application is a radio or cellphone link triggered by a Peizo motion detector. This activates an alarm. Alarm-fitted devices would require immediate response to verify whether this is a rodent or non-target species. This system is ideal for islands with caretakers. More sophisticated devices using similar basic designs could also be used on remote islands.

In such locations the main problem is non-target organisms activating detectors. This can be overcome if the detection apparatus includes a weight detection device (which only triggers within a set weight range) or tracking tunnels. A simple and effective solution could be to cover entranceways with plastic fly mesh which rodents must chew through to gain entry. For islands within cell-phone range a photo can be transmitted relatively cheaply.



6. A review of toxins available for rodent eradication and control

Two kinds of toxins are available (see O’Connor & Eason 2000):

1. Non anti-coagulants. Examples are 1080, cholicalciferol, zinc phosphate (toxic to birds).
2. Anti-coagulants. 1st Generation anticoagulant poisons such as warfarin and pindone are less potent and require multi doses to kill rodents. 2nd Generation anticoagulants such as brodifacoum are more potent, only one dose is usually required for death, but their residues last longer in the environment.

Other than this range of anticoagulants, no new rodenticides have been developed for about 50 years. The anticoagulants are all very similar with broad-spectrum effects. Furthermore, narrow-spectrum species-specific rodenticides are unlikely to be available in the foreseeable future.

The products presently available seem well suited for use as a means of eradicating rodents from islands and as a means of intercepting invading animals. Brodifacoum is the best poison available for island use, as it can be used without the problems identified with its continual use on the mainland where it may be present in deer (*Cervus* spp.) or pigs (*Sus scrofa*) killed and consumed by hunters.

The history and projected development of toxins is as follows:

1950–95—no significant development in the use of broad-spectrum poisons apart from the development of 2nd generation anticoagulants.

1995–2000—using existing toxins, new potentially selective products based on a choice of active ingredients or delivery system (Campaign, Feratox).

2005–2015—species-specific, smarter generation of rodenticides including selective toxicants and immunotoxins (higher efficacy—lower risk).

2015+—biocontrol integrated with selective toxicants and immunotoxins.

There is a need to develop smarter delivery systems for poisons. E.g. a coating on baits so that they don't break down and release poison until they are in the rodent's gut. The key to maximising the effectiveness of toxins is the delivery system. At present this is where most improvements can be made—by using smarter baits that are designed for specific conditions and are less attractive to non-target species.

Common bait types at present are:

Cereal
Wax coated
Wax block
Paste

} but just how attractive these baits are in competition with abundant food on a recently invaded island is unknown

Commercial baits are not tested in field situations but with captive animals. These baits only have a six-week bait life because of the effects of moisture (mould) and insects. Tropical formulation baits used in canefields include a fungicide, which should give a longer life, but the palatability of such baits needs to be tested in New Zealand conditions.

7. Bait acceptability trials for mice

Using wild-caught mice, Landcare Research conducted the first bait acceptability trials with products commonly used by DOC. Mice were chosen because of the high risk of them invading islands. These results have recently been published in DOC's Science for Conservation series (O'Connor & Booth 2001).

The objectives of this study were:

- To determine the palatability and efficacy of rodenticides for wild house mice
- To determine if the reported lethal dose range is effective for wild rodents

Four rodenticides were tested on groups of 20 wild-caught mice. Mice were fed on commercial mouse pellets and, during the trials, were given a choice of

these or one of four rodenticide products. Palatability was determined from the amount of toxin eaten.

- Pestoff ® was the most preferred bait, and was highly effective.
- Talon 50WB® was also palatable and effective for mice control.
- Racumin paste and Talon 2OP® were not preferred over mouse pellets and were thus considered to be unsuitable for control of wild mice.

Seasonal differences in palatability of baits to each rodent species have not been tested, although they are likely to occur. It is also likely that there are sexual differences in bait palatability.

Wax coating increases bait longevity but decreases palatability. A field test is needed to evaluate how significant this decrease in palatability is.

8. Island Invasion Standard Operating Procedure (SOP)

The SOP being developed by the Department of Conservation will involve the following:

- Database listing all islands irrespective of ownership, GIS linked
- Quarantine (any act to prevent invasion of anything) e.g. carriage of weed seeds on staff socks or clothes to islands
- Surveillance (deliberate checking of islands for invasions)
- Contingency (response to suspicion of invasion)
- Audit (checking of other areas to monitor/check compliance with policy, peer review

The SOP will provide a pick list to design local conservancy quarantine and contingency plans.

The islands database will be GIS-linked and linked to the Bio Web.

By integrating the database it will be possible to develop contingency plans and assess risks.

Future developments to be addressed by SOP are likely to include:

- Rodent eradication from and subsequent management of in-shore islands which are closer to the mainland and likely to be subject to constant reinvasion. Making in-shore islands rodent-free is part of the long-term strategy for Fiordland islands in the Kakapo Recovery Plan.
- An island restoration strategy which will be developed by Conservation Policy Division of DOC.

9. Summary of management issues

- After 25 years of development and implementation, eradications of rodents from offshore islands have led to dramatic increases in the number and size of rodent-free islands.
- The risks of reinvasion by rodents from islands nearby have been reduced, but this is offset by risks of invasion through greater mobility of the public and increased boat traffic.
- The large number of islands now free of rodents increases the need for regular surveillance. It also increases the need for effective tools to be available in the event that an invasion is detected or suspected.
- The main surveillance method is the use of bait stations which are periodically checked for bait interference.
- The design of bait stations used at present is mostly a matter of personal choice rather than being based on rigorous assessments of rodent preferences. These bait station designs need evaluation/standardisation; the SOP should provide a best practice approach to this.
- The frequency of surveillance is largely related to life of the baits in bait stations. Although this frequency is usually six-monthly, variations in bait station design and in formulations of baits are not necessarily taken into account.
- At present the frequency of surveillance is not based on an understanding of the risks of significant damage to the island resources resulting from rates of population expansion of invading rodent species on islands and the vulnerability of the resources present.
- There is no available guide to rodent sign, nor any network of expertise that can be used for advice about suspected rodent sign.
- The existing capacity to respond to rodent invasions is greatest on islands of < 200 ha. On such islands, aerial application of poison bait over the whole island is possible and affordable, and associated risks of collateral damage to native species on the island are generally low.
- The financial costs of response and biological risks of invasion are highest on large islands where aerial application of poison bait may be financially unrealistic and biological costs of collateral damage also high with many species vulnerable to the baits. On these islands (> 500–3000 ha), early detection and containment is vital to reduce control costs and effects on wildlife.
- The second-generation anticoagulants used for detection and elimination of rodents on islands are the best toxins available at present. No new products that are as effective and affordable are likely to be available for the next 15 years. However, we don't know if these baits are attractive to rodents that arrive on an island with an abundance of seeds, fruit and invertebrates.
- The delivery systems (baits) used for initially eradicating rats from islands by aerial sowing have a proven record of effectiveness. Those for mice are only now being tested.
- The baits, lures and bait stations used for detecting rodents in low numbers once eradications are completed have not been subject to rigorous field trials.

In conclusion:

The technology for initially eradicating rats (but not mice) from islands has undergone well-designed field trials and has a record of proven effectiveness. However, the 'border control' methods used to detect and respond to reinvading rodents lack national consistency and either have not been tested or were not designed for their present use. The risks and form of rodent response on islands where there is an abundance of food remain unknown.

10. What information is needed?

Based on the previous assessments, the workshop participants recommended the following areas of information gathering and research to improve the security of islands that are presently free of rodents or from which rodents are likely to be eradicated in future. The requirements are divided into three topic areas and those highlighted (italicised) require urgent attention (to be addressed within 3–5 years):

10.1 ASSESSMENTS OF THE RISK OF INVASION

- *Investigate invasion behaviour of all rodent species, (but especially Norway rats, ship rats, and mice). This must include initial arrival behaviour and subsequent dispersal.*
- *Test probability models and risk assessments for invasion (island type, risk of invasion, endemic and threatened species at risk).*
- Investigate the use of DNA fingerprinting to determine invasion source and frequency on islands (e.g. this should identify whether an irruption of rodents is the result of an invasion or failed eradication).
- Investigate the use of rodent hotels to determine invasion frequency on inshore islands.
- Identify what rodent species are present at departure (reinvasion) points near inshore islands.
- Assess potential effects of new rodent species and strains (e.g. Asian ship rat).

10.2 SURVEILLANCE PROCEDURE TO DETECT INVASIONS

- *Test the palatability and longevity of baits presently used in bait stations on all rodent species.*
- *Test and develop an effective lure for rodents (this may vary for each rodent species and may also vary geographically).*

- *Test the design of bait stations, including construction material, colour, use by non-target species, presentation and preservation of baits, for acceptability to all rodent species.*
- *Provide keys that include field methods for identification of fur, feeding sign, and droppings (update manuals).*
- *Test how accurate dogs are for detecting rodents at low densities.*
- Investigate the use of remote, electronic technology for detecting rodents.
- Investigate the use of indicator species for detecting rodents (e.g. key plant, invertebrate, reptile or seabird species).
- Determine the best sites for placement of control/detection equipment for rodents based on field behaviour studies.
- Develop and test best practices for bait station use, bait presentation, and non-target exclusion to be followed in the event of an invasion by rodents.

10.3 ELIMINATION OF INVADING RODENTS

- *Investigate the risks and long-term effects of brodifacoum availability e.g. toxin build-up in invertebrates.*
- Investigate alternative methods for eliminating invading rodents other than the use of toxins.

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Appendix 1

WORKSHOP PARTICIPANTS

Andrew Baucke	DOC Tauranga AO
Keith Broome	DOC Hamilton NRO
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Mike Thorsen	DOC, Chatham Islands Area Office
Dave Towns	DOC, Science & Research Unit, Auckland
George Wilson	DOC, Auckland Conservancy Office

Appendix 2

WORKSHOP AGENDA

Workshop: Detecting and eliminating rodents as new invaders to islands

Tuesday 5 June 2001

Introduction—Scope of workshop, and expected outcomes (Dave Towns)

Case studies—break into groups 'Scares in your Conservancy'

- Evidence of suspected invasion
- Response
- Outcome
- Technology that would have helped

Behaviour of new invaders/detecting at low densities (Mike Thorsen)

Behaviour of radio-tagged rats introduced to an island (Andy Roberts)

- Present methods, depends on
  - island size
  - species present
  - rodent densities
- Detecting arrival of new species when already a rodent species present

Toxins/baits current and potential new ones (Charlie Eason)

- Currently used toxins
  - advantages/drawbacks
  - discussion

Wednesday 6 June

Detecting arrivals current and potential electronic methods (Murray Douglas/Stu Cockburn)

- Present methods of detection
- New techniques, detecting/monitoring rodents at low numbers
- Automatic/electronic alarms

Responses to suspected invasions

- Confirmed invasions

Where is more work needed (facilitator—Elaine Murphy)

- Behaviour of new invaders
- Potential research topics
- Sites for fieldwork