Karárehe Kino
Vertebrate Pest Research

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New Control Tools for Stoats

Stoats are implicated in the continuing decline in numbers of many native birds. For example, up to 95% of kiwi chicks fail to reach maturity and 50% of their deaths are attributed to predation by stoats. Most stoat control to protect native birds is based on trapping, but this is expensive and of limited effectiveness over large areas. Currently, kiwi are protected over only 5% of their geographic range, and are predicted to disappear from many areas because of continuing stoat predation. Hence there is an urgent need for cost-effective and target-specific stoat control tools.

What makes a good bait for stoats?

Currently, there are no practical options for widespread control of stoats based on toxic baits. Hen's eggs injected with 1080 have proved a successful control method but suffer the same restrictions as conventional kill traps. Fresh rabbit meat is an effective but short life bait as it degrades rapidly and must be replaced frequently. Initial research by Sam Brown and her colleagues, and by collaborators in AgResearch, sought to develop long-life baits for stoats and focused on identifying which properties of bait most affect its acceptance. Bait moisture, texture and fat content were tested in pen trials, and only moisture content had a significant effect–food with moisture levels below 70% were less palatable. Further trials have investigated how to extend the field life of bait without reducing its palatability.

To identify a more suitable bait base, the team used no-choice tests with captive stoats to compare the acceptance of nine different bait types presented as small, cocktail-sized sausages. The baits included minced rabbit, minced rat and minced mouse, combined with a range of preservatives (to extend field life) and humectants (to keep moisture content high). Wax/tallow baits and commercially available meat and gel-based

Grant Morriss

Wild-caught captive stoat as used in the trial lures for predators were also tested (*Fig.*). The minced rabbit and minced rat baits were most readily eaten, with average nightly intakes of 45.7 g and 33.7 g respectively. There were, however, marked differences in bait preference between male and female stoats, with males being less selective than females – in some cases, bait types highly acceptable to males were completely ignored by females.

In a second round of pen trials, stoats were offered a choice between fresh rabbit sausages (as a reference) and the three 'long-life' bait types most acceptable in the previous trial, namely, rabbit sausage with humectant/preservative, rat sausage with humectant/preservative, and a commercially available bait formulation based on rabbit meat. Compared with fresh rabbit baits, all three 'long-life' baits had very low acceptance, apparently due to the addition of the preservatives and humectants. Sam's team is now looking at alternative preservatives and humectants to include in minced rabbit, to identify a long-life combination that retains its high acceptance, especially to female stoats.

Developing a target-specific toxin for stoats?

The vertebrate pesticides currently

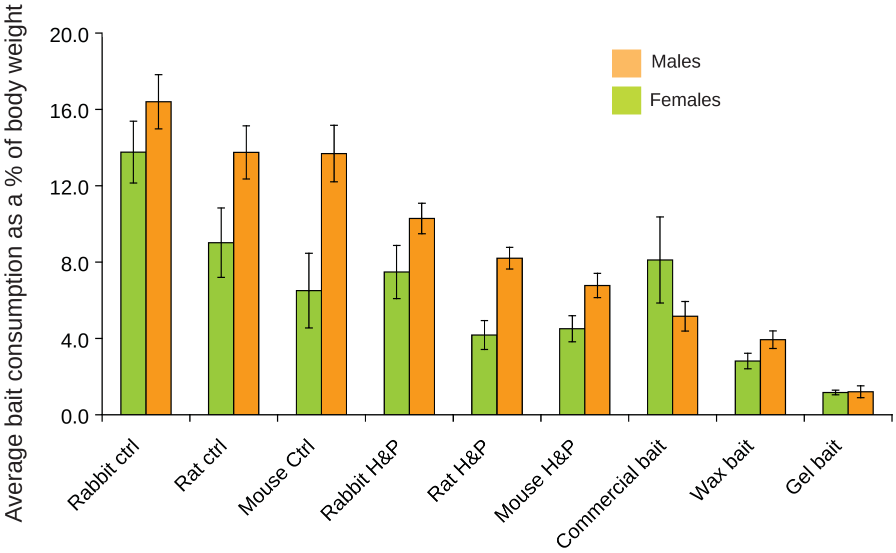

Fig. *Average bait consumption (as a percentage of individual body weight) by male and female stoats in a no-choice bait trial (H = humectant, P = preservative)*

used to control introduced pest animals in New Zealand tend to have broad-spectrum toxicity, pose a hazard to non-target species, contaminate the environment, and be inhumane to some species. Increasingly strict regulations are being introduced on the use of such compounds, particularly the second-generation anticoagulants, in both agricultural and natural environments, making it progressively more difficult to use them in pest control programmes. In response to these constraints, Brian Hopkins and colleagues are developing species-selective toxicants that are lethal to pest species such as stoats, but not toxic to non-target species.

Brian's team has recently demonstrated positive 'proof of concept' in laboratory studies, where intravenous injection of selective toxins has achieved high efficacy against rats and mice, but when tested in *in vitro* cell-based selectivity assays does not affect non-target species such as chickens, dogs, cats, pigs and cows. The compounds trialled were so selective that the rat toxin injected into mice and the mouse toxin injected into rats had no visible or gross pathological effect.

Brian is applying a similar approach to the development of a stoat-selective toxin. His ultimate goal is the development of a technology that can be used to target any vertebrate pest species in a selective manner with minimum risk to non-target species. If achieved, such technology will create a paradigm shift in how pest species are controlled, and will underpin the development of a new range of control tools that have no non-target effects or environmental impacts. Bait delivery of such compounds will be the next research challenge to progress this work towards its field-testing.

Do you trap stoats? You can help this research

Having sufficient numbers of stoats is limiting the progress of these trials. If you

Sam Brown

Captive stoat eating one of the bait sausages

Sam Brown

Captive stoat in its nest box

run a live-trapping programme for stoats, please contact Sam Brown (details given below) as she is keen to obtain healthy stoats and can assist with their handling and transportation.

These projects were funded by the Foundation for Research, Science and Technology.

Sam Brown

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***Penny Fisher, Bruce Warburton** and*
***Brian Hopkins** (not shown)*

Which Tb Host Is the Best Tb Canary?

Since 1994 the Animal Health Board's control programme has reduced the number of cattle and deer herds infected with bovine Tb in New Zealand by 90%. But this success has created a new 'problem' – deciding when to stop local possum control in areas that are apparently free of the disease.

In some areas that, formerly contained infected livestock, no Tb has been identified for many years but it could still be cycling at low levels in wildlife in adjacent off-farm areas. The obvious way to resolve this question is to survey the main wildlife host, possums, for the disease. However, there are usually very few possums left after long-term local control for disease eradication, and as possums have small home ranges, surveying them for Tb is expensive. A better option is to use other hosts as sentinels of the disease – the Tb-equivalent of the canaries that were once routinely taken down mines to signal when dangerous gases were present. The four main alternative candidates for sentinels are cattle, pigs, ferrets and deer. But which of these is the best canary?

Species are most useful as sentinels of Tb if they have a high incidence of the disease relative to the main host, remain infected for a long time, have large home ranges, and cost little to survey. A survey of Tb in the wild animals on Molesworth Station by Graham Nugent, Jackie Whitford and Ivor Yockney provided a rare opportunity to compare the potential of these species as alternative sentinels because it is one of the few places where a free ranging cattle herd shares its range with possums, pigs, ferrets and deer. The results summarised here focus on behaviours and densities of these species in the central and south-eastern parts of the station where there is the greatest overlap between all five hosts.

Possums in the study site occupied small home ranges of about 0.03 km^2, and their densities were low (55–110 animals/km^2). Tb levels were also low – about 1.40–2.80 new cases/km^2 per year. Using existing Tb models, possums had a 33–50% chance of 'detecting' (being infected by) Tb in an infected possum sharing their range.

Pigs had home ranges that were much larger (3 km^2) but their densities were much lower (1.9–2.8 animals/km^2). Most pigs (85%) were infected, with young pigs appearing to encounter infection at least three times per year (5.7–9.00 new cases/km^2 per year). Each pig appeared to detect 40–70% of infected possum carcasses present in their home range.

Ferret home ranges averaged 1.2 km^2, and their densities were low (0.9–1.5 animals/km^2). Many were infected (36%), with young ferrets encountering infected animals on 0.6 occasions per year (0.50–0.90 new cases/km^2 per year). Ferrets appeared to detect 20–40% of infected possums present in their home range.

Wild deer home ranges were assumed to be 2.5 km^2, and their density estimated to be about 1 animal/km^2. One of the seven deer surveyed was infected (14% prevalence). Wild deer were assumed to encounter Tb on 0.08 occasions per year (0.03 new cases/km^2 per year), and appeared to detect only 3–6% of the infected possums in their home range.

Cattle seasonal home range was assumed to be about 2 km^2. Tb was confirmed in 0.6–2.5% of cattle per year over 2002–2006, from an average of 7400 Tb skin tests – a 'density' of four tests/km^2 per year. Tb incidence in cattle was estimated at 0.026 cases per year (0.01 new cases/km^2 per year), and they appeared to detect only 0.9–1.9% of the infected

Graham Nugent

Graham Nugent

The absence of Tb in 2-year-old pigs provides as much confidence that Tb is absent from possums as do 100 cattle skin tests

possums within their seasonal home range.

Comparison of the estimated cost of detecting each Tb-infected sentinel in these surveys indicated Tb-testing of cattle was probably the most cost-effective tool for measuring trends in Tb prevalence in all Tb hosts on the station, although the necropsy of pigs and ferrets for the same purpose was not much more expensive. However, as sentinels for determining the probability of local freedom from Tb, pigs were a more cost-effective detector than ferrets, cattle, possums, or wild deer, in that order.

In simple and very conservative terms, Graham and his team suggest the necropsy of a 2-year-old pig provides the same confidence of Tb presence or absence in possums as the necropsy of 4 1-year-old ferrets, 100 annual tests of cattle or deer, 50 biennial tests of cattle or deer, or 50 necropsies of 2.5-year-old wild deer. Pigs may not be able to fly, but they are good canaries!

This work was done under contract to the Animal Health Board.

Graham Nugent
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Jackie Whitford and Ivor Yockney
(not shown)

Interactions of Mammalian Pest Populations following Control

Despite the annual expenditure of approximately $110 million over recent years on managing mammal pests in New Zealand, they continue to be a significant, immediate threat to biodiversity conservation. Many pest populations are not managed at all. Even where they are, the desirability of controlling them to prevent further decline of threatened native fauna is constrained by the unpredictable consequences of control. The interaction between pest species is poorly understood. For example, rodent numbers sometimes increase following possum control operations, which may lead to an increase in stoat populations and a consequent decrease (through predation) of some bird populations.

To identify what drives interactions between mammal pest species and how these may affect the outcomes of pest control, Wendy Ruscoe and her colleagues have established a large-scale experiment in several central North Island mixed podocarp–tawa forests to test three hypotheses:

- Resource availability (food) drives temporal variation in pest abundance.
- The removal of top-level predators results in increased abundance of lower-order pests resulting from released predation pressure.
- The removal of a pest population results in increased competitor pest populations.

In the experiment, Wendy's team is manipulating pest populations at several forest sites through four 'treatments': controlling possums and rats with a one-off aerial 1080 baiting operation; the same control protocol for possums and rats but with continuous additional control of rats with toxic bait in bait-stations; controlling stoats with continuously set traps; and no pest

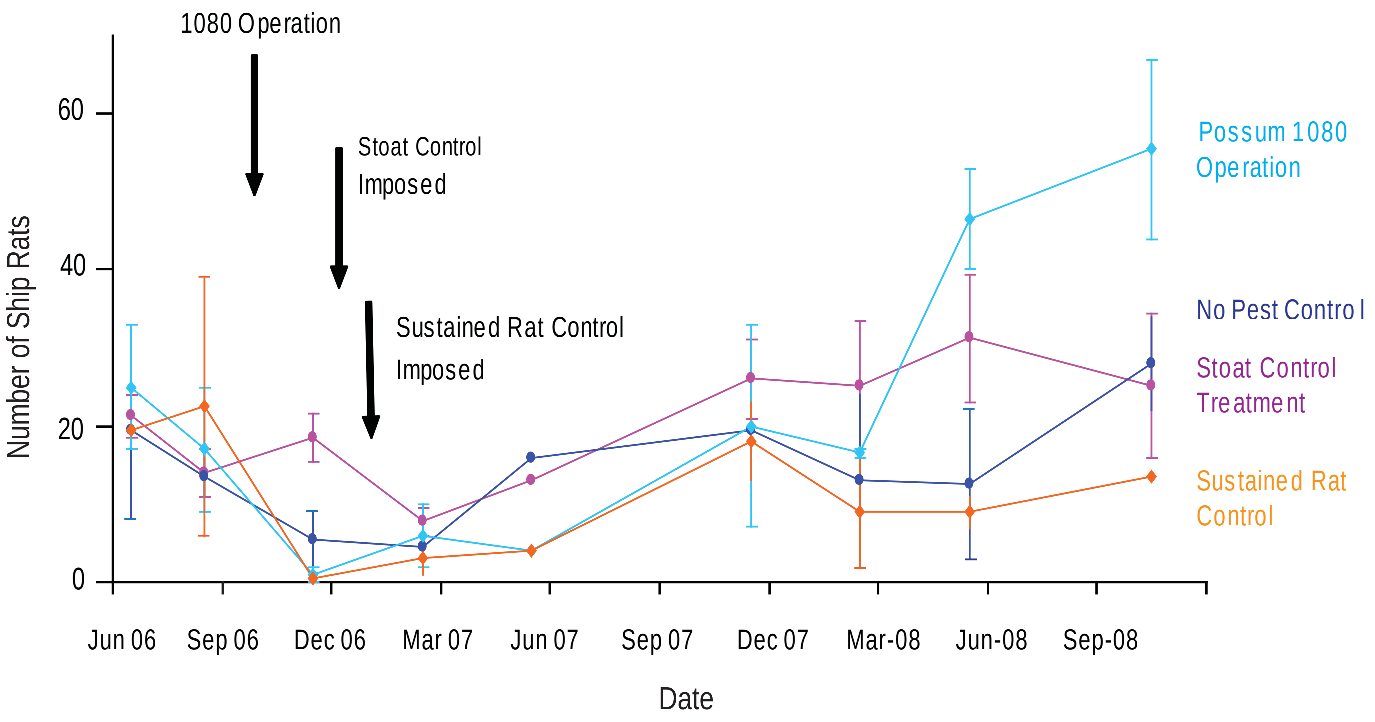

***Fig.** Average number of ship rats on each pair of treatment blocks. Eighteen months post-control, rats are most numerous on grids that received an aerial 1080-control only*

control. Each of these treatments is replicated once over eight 900-ha study sites.

On each site, the baseline population size and temporal changes of rats, mice, stoats and possums are being monitored. Rats, mice and possums are live-trapped, marked with ear tags, and released during 5-night trapping sessions in November, February, May and August. Stoat populations are monitored using tracking tunnels and hair-collecting tubes along the same trapping lines. This hair will be used to identify individual stoats by means of DNA 'fingerprinting' – technology that is available through our EcoGene laboratory in Auckland.

Additional small-scale experiments have been implemented to quantify how stoats (predators) and possums and rodents (primarily herbivores) modify their food intake rate with varying food availability. Additional rats are being snap-trapped, stoats kill-trapped, and possums poisoned with cyanide baits to provide samples of stomach contents for dietary analysis.

To monitor the benefits of the pest-control treatments the population trends in a select group of ground-dwelling invertebrates were monitored using pitfall traps before each control operation and are ongoing. In addition, wētā are counted and released in purpose-built wētā houses attached to trees during each trapping session.

The data collected from all these experiments are being used to build computer models of communities of the four pest species. These models will be used to predict temporal variation in pest abundance, responses of secondary pests to primary pest control, and the relative benefits of alternative pest control strategies to protect conservation assets.

Peter Sweetapple

Possum in a cage trap on a live-capture grid

Peter Sweetapple

Ground wētā captured in a pitfall trap and released

Peter Sweetapple

Wētā house on a tree trunk with the wooden top removed to show the tree wētā beneath a perspex cover

Results to date indicate that the 1080 control operation for possums in winter 2006 had a number of critical outcomes. As expected, possum and ship rat numbers were significantly reduced (*Fig*.). Mouse numbers were not reduced, and with reduced densities of rats and possums, mice rapidly increased to be more abundant than they were prior to the control operation compared with sites not sown with 1080 baits. Now, 18 months after the initial 1080 operation, possum numbers remain low but rat numbers have increased to higher levels than prior to baiting and compared with sites that weren't poisoned. Conversely, mouse numbers have decreased, although they have remained high on the sites that received subsequent ground-based rat control.

This work is ongoing, but these initial results indicate that targeted control of one pest species has led to the decline in its numbers but an increase in the numbers of another pest. These were broadly similar to outcomes of possum control operations for possums, rats, invertebrates and robins reported in issues 11 and 12 of *Kararehe Kino*. It appears the benefits of pest control operations must be assessed at the ecosystem level if biodiversity assets are to be protected.

This work is funded by the Foundation for Research, Science and Technology.

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Peter Sweetapple, Ivor Yockney, Roger Pech, Mandy Barron, Sam Cave and Dave Ramsey
(not shown)

Gannets, GPS and Google Earth

The colony of Australasian gannets at Cape Kidnappers is one of the few mainland-breeding sites for this species. During summer, it is home to approximately 20,000 birds, and is one of Hawke's Bay's iconic tourist attractions. The area has recently been incorporated into the Cape Kidnappers & Ocean Beach Wildlife Preserve and enclosed by a multi-million-dollar predator-proof fence. The colony has been the site of many research projects over the years, but little is know about where and for how long adult gannets forage during the four-plus months they spend incubating and feeding their chicks. Answers to some of these questions are being provided by new technology supplied by Sirtrack*.

In an exclusive agreement with the Cape Kidnappers & Ocean Beach Wildlife Preserve, Sirtrack supplies a variety of tracking solutions for use in the reintroduction of species to the preserve, and trials new technologies on species present there. In December 2007, under this arrangement, Sirtrack provided two rechargeable 'microGPS' dataloggers to Steffi Ismar and Mark Hauber (from the School of Biological Sciences, University of Auckland) to evaluate their suitability for use on species such as gannets. The dataloggers weigh just over 22 g, so are suitable for birds with body weights over 700 g. Gannets weigh over 2 kg, so the units can be easily carried by the birds when attached with tape to two tail feathers (*Photo*). Approximately 10 1- and 2-day Google Earth images of gannet tracks were recorded during the researchers' visits to the colony during the 2007 breeding season (*Map*).

Colin Hunter

Colin Hunter holding a gannet with a microGPS taped to some of its tail feathers

Google Earth image of two different birds on overnight foraging trips from Cape Kidnappers

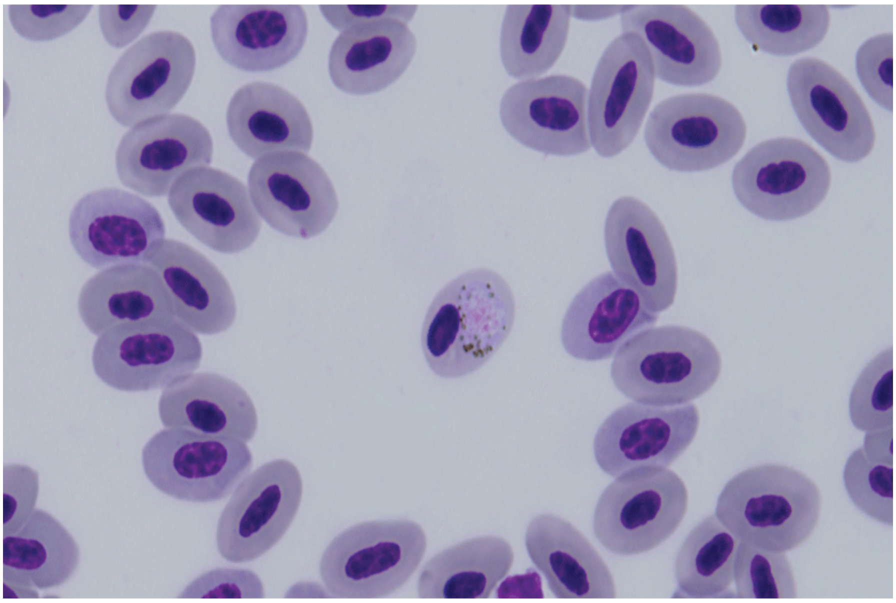
The research has been carried out with support from the Department of Conservation. In addition to the GPS tracking, intensive monitoring of the presence and absence of individually banded birds from their nest sites will document the patterns, routes, and strategies that female and male gannet parents use to forage for themselves and for their chicks. With the proven reliability and suitability of these new products, more microGPS units will be deployed on gannets in the 2008/09 breeding season.

For further details, please contact: *sirtrack@sirtrack.com*

*Sirtrack is a subsidiary of Landcare Research, and is based at Havelock North.

Avian Malaria in Native New Zealand Birds?

Avian malaria is famously implicated in the extinction of almost half of Hawai'i's native bird species. A recent national survey of non-native birds in New Zealand showed that levels of infection of mosquito-vectored *Plasmodium* sp. (avian malaria) are now far higher than they were 50 years ago (Tompkins & Gleeson 2006). Since avian malaria can cause morbidity and mortality in host species with no history of exposure, this raises the concern that 'spillover' of infection from non-native 'reservoir' species into native bird populations may threaten their viability.


Vaidas Palinauskas

Avian malaria parasite developing in the cytoplasm of a bird red blood cell (central cell). Outside cells are normal red blood cells, with the nucleus being the only clearly visible internal structure

Little is known about avian malaria in native New Zealand birds, yet such information is vital for biodiversity conservation for two key reasons. First, bird species with little history of exposure to this disease may be detrimentally affected by it. Indeed, observed impacts on native populations in captivity and native individuals in the wild (*Table*) suggest that there may currently be impacts on wild populations that are going unnoticed or undiagnosed. Second, some populations may be infected by native strains of avian malaria, which may confer some level of resistance to exotic strains.

To rectify this knowledge gap, Dan Tompkins and colleagues analysed blood samples collected during 2004–2007 by DOC staff, veterinary staff, university students, and colleagues from a wide range of native birds from across New Zealand. All samples were tested for the presence of malarial parasites using a Polymerase Chain Reaction assay for a malaria-specific molecular marker, with parasite identity confirmed as *Plasmodium* sp. through DNA sequencing. A total of 475 wild-caught native birds from 21 species were sampled and tested, in addition to 35 captive native birds from nine species, 16 wild-caught non-native birds from three species, and 5 captive non-native birds from one species.

The team detected avian malaria infection in wild individuals of eight native species, including bellbirds, fantails, kererū, robins, saddlebacks, silvereyes, wēkā and yellow-crowned parakeets, and in addition to that in a captive little blue penguin at Auckland Zoo. They also detected infection in magpies in New Zealand for the first time and in blackbirds, where avian malaria has been detected previously. Avian malaria was also present in species-pooled samples from fantails, grey warblers, kererū, silvereyes and tomtits collected from Maungatautari Sanctuary in the central North Island during May 2007.

In addition to the cases detected here, it is likely that many other bird species are also infected, including species only lightly sampled. Prevalence of infection was generally low, although there were several obvious exceptions. Non-native blackbirds had consistently high prevalence, supporting an existing hypothesis that this species is a reservoir of spillover infection to native birds. High prevalence in Australian magpies

Species	Date	Location	Impact
New Zealand dotterel	1996	Auckland Zoo	60% of a captive population
Yellow-eyed penguin	2001	Otago Peninsula	Single wild juvenile
Mohua	2003–05	Orana Park, Christchurch	60–100% of a captive population

Table. Prior records of avian malaria causing mortality in native birds

Steph Hicks

Collection of a blood sample from a silvereye for malaria screening. A capillary tube is used to collect a small amount of blood from the brachial vein following puncture with a fine gauge needle

Cisy Pan

Avian malaria was detected in a captive little blue penguin

detected by Dan and his team suggests a possible similar role.

Prevalence of infection was also unusually high in several native bird species collected from Tiritiri Matangi Island in the Hauraki Gulf in September 2004 and from Long Island in the Marlborough Sounds in January–February 2007. Little information is available about malaria dynamics on Tiritiri Matangi. However, on Long Island, the high prevalence coincided with an unusually high abundance of unidentified mosquitoes noted by DOC staff, supporting the team's hypothesis that high levels of avian malaria in native birds generally only occur when mosquito abundance is unusually high.

Detection of avian malaria in this survey was associated with three cases of ill-health. First, the disease was diagnosed as the cause of death of a little blue penguin at Auckland Zoo in November 2005. Second, an infected North Island saddleback from Mokoia Island in Lake Rotorua, transferred to quarantine facilities at Auckland Zoo in June 2006, lost weight and appetite before the infection cleared. Third, acute infections were associated with saddleback deaths on Long Island in March 2007, following the detection of high prevalence of disease during the months prior.

The survey shows that many native bird species in New Zealand are infected with avian malaria. In addition, the evidence for disease impact on wild populations is mounting. Of particular concern is the potential link of disease outbreak to periods of unusually high mosquito abundance, given the predicted future increases in such disease vectors driven by climate change. Studies are now needed to clarify the impact that this disease can have on birds in New Zealand, and identify potential management strategies.

This work was supported by the Ministry of Research, Science and Technology Capability Funding.

Reference:

Tompkins DM, Gleeson DM 2006. Relationship between avian malaria distribution and an exotic invasive mosquito in New Zealand. *Journal of the Royal Society of New Zealand 36:* 51–62.

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Baxter Massey, Hugh Sturrock and Dianne Gleeson *(not shown)*

Mouse Population Irruption after Heavy Flowering of Snow Tussock

House mice occur throughout snow tussock grasslands that predominate above tree-line in alpine regions across New Zealand, but little is known of the ecology of mice in these habitats. Snow tussocks, like beech trees, periodically flower profusely, i.e. mast, in response to high temperatures in the previous summer. Although it is well known that mouse populations in beech forests increase following beech mast events, mouse population responses following profuse flowering of snow tussock are unknown.

Mice are very flexible omnivores that depend primarily on seeds and invertebrates, but also kill lizards and take bird's eggs. Periodic peaks in alpine mouse populations could therefore result in periods of heightened risk to native alpine prey. Beginning in 2003, Deb Wilson has led a study of the dynamics of mouse populations in relation to flowering of snow tussock to examine this possibility.

Deb and the team established a study site in each of three alpine basins in the Borland Valley, Fiordland National Park. Mice were live-trapped two or three times each year at each site in a capture, mark and release programme that enabled the researchers to estimate mouse population sizes based on the ratio of marked to unmarked animals caught. For the first 3 years of the study, the mouse populations were small and similar to those in beech forest in non-mast years (*Fig*.). Then, in summer 2005/06, snow tussocks in the Borland Valley flowered profusely, and many of the mice present remained in breeding condition through into the following autumn (May 2006), a season when reproduction normally ceases. As a consequence, mouse populations increased on average nearly 8-fold during the subsequent winter, from about 5/ha in May 2006 to 40/ha in November 2006. These peak population densities were similar to those recorded in forests after beech masting. Mouse densities then declined throughout summer 2006/07, and had crashed by the following spring (November 2007), when no mice were caught in 192 live-traps set for 4 nights (768 trap nights).

Joelle Taillon

Checking mouse traps set amongst snow tussocks in the Borland Valley

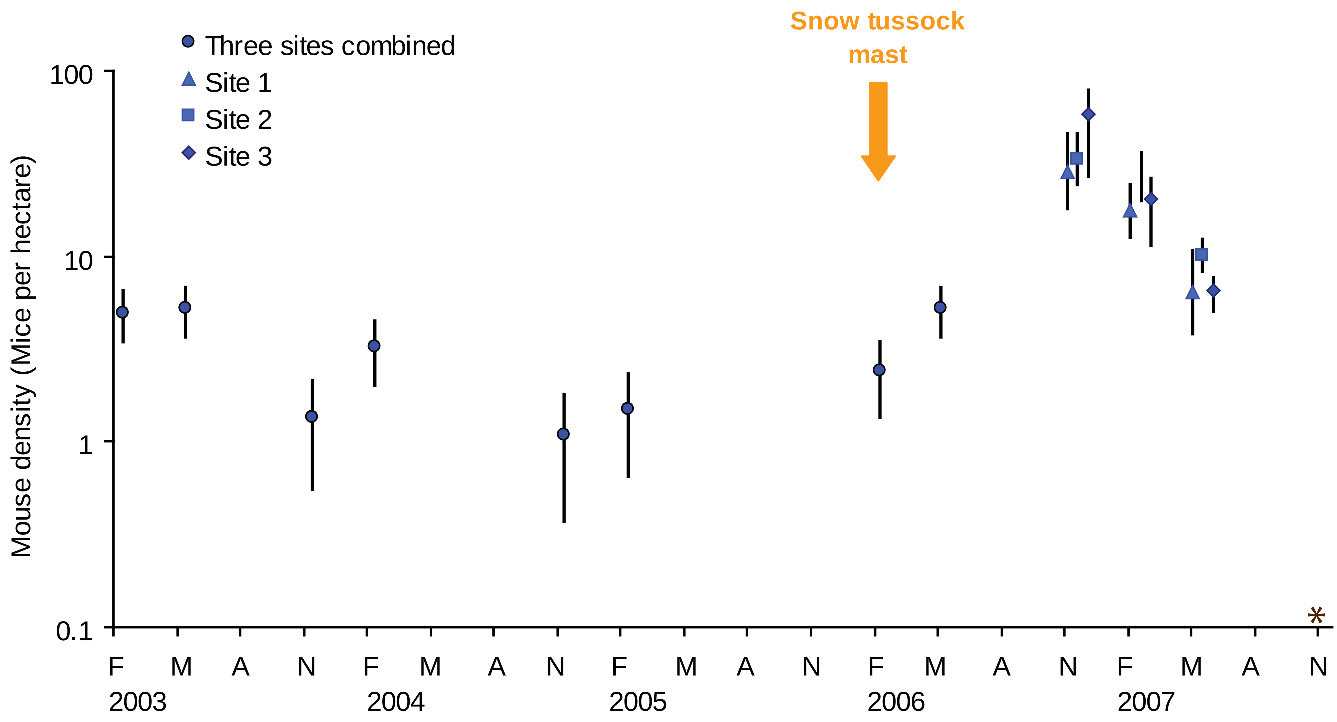

Fig. Mouse population densities at three alpine sites in the Borland Valley, Fiordland National Park, from 2003–2007

Note, the vertical axis is plotted on a logarithmic scale * *indicates no mice were trapped in November 2007*

Deb's team also studied the diet of mice, by catching some of them in snap traps and examining the contents of their stomachs. They found that the number of mice caught was inversely related to the number of ground wētā caught in live-traps, which suggested that mice might be preying on and reducing wētā numbers (reported in Issue 9 of *Kararehe Kino*). In the early years of the study, when few snow tussocks flowered, mouse diets were dominated by invertebrates, primarily ground wētā, spiders, grasshoppers and caterpillars. In contrast, when tussocks were flowering and seeding in February and May 2006, mouse stomachs were largely packed with seed material but still contained some invertebrates – most often a small caterpillar that feeds inside the base of tussock flower stalks. The fact that mice continued to eat insects even when seeds were plentiful suggests that the abundance of seed affords only limited protection to animals preyed on by mice. Foraging among tussocks may have been especially rewarding for mice at these times, with both seeds and caterpillars available to them.

No remains of alpine lizards or birds were found in the mouse stomachs examined, but this does not prove that mice don't eat these animals. Predation events of many alpine animals may be rare, because such prey is often threatened or uncommon. For example, alpine lizards such as scree skinks and alpine birds such as rock wrens may be in particular peril during mouse population peaks. An increase in the risk of predation could occur in two ways. First, if mice continue to prey on animals when tussock seed is plentiful, the number of animals killed will increase as mouse numbers increase. Second, after seed stocks are exhausted, the high but falling numbers of mice may be forced to take greater numbers of native animals.

Finally, mice are eaten by and thus help to support populations of introduced carnivores, including stoats, which live in alpine grasslands. Just as the population dynamics of mice after profuse tussock flowering appear to mirror those after heavy beech seed-fall, a similar parallel is likely in the population dynamics of stoats, their main predator, between alpine grassland and beech habitats. If so, the high numbers of newly independent young stoats in the Borland Valley may have increased the hazards to native alpine animals following the masting of snow tussock in 2006, compared to that faced by prey species in non-mast years.

This work was funded by the Department of Conservation, the Miss E.L. Hellaby Indigenous Grasslands Research Trust and the Foundation for Research, Science and Technology.

Deb Wilson
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Morgan Coleman, Mike Perry, Kate Ladley and Caroline Thomson
(not shown)

Eradicating Pests or Restoring Whole Islands: Île Leprédour, New Caledonia

Islands are important places for biodiversity conservation because they often harbour endemic species and remnant populations of species lost from mainlands, and can act as arks on which to liberate species threatened on mainlands. Island biotas are, however, highly susceptible to the effects of invasive pests, but their eradication is usually more feasible on islands than on mainlands because of their smaller scale and because the risk of reinvasion is usually low.

Landcare Research staff have frequently documented how particular pest species might be eradicated and how such success and its consequences might be measured. The focus of these studies has been on the pests. More recently whole islands have been considered as the unit of management, and management of pests seen as but a first step in the restoration of island ecosystems.

A striking example of this change in approach is being considered for Île Leprédour on the western side of New Caledonia. The native tropical dry forest that once covered this 740-ha island represents a highly diverse ecosystem that has now almost gone from New Caledonia and the world (*Photo a*). It contains many species endemic to New Caledonia and some endemic to Île Leprédour. The total wild population of one tree species, *Pittosporum tanianum*, is down to just two individuals.

This forest has been virtually obliterated by fire and by a suite of introduced pests and weeds, and in many places converted to grassland and bare soil (*Photo b*). The main pests are rusa deer, rabbits, exotic rodents, giant African snails, and a suite of weeds.

In 2007, the Direction de l'Environment of Province Sud government asked Graham Nugent and John Parkes whether the island biota could be restored by eradicating or managing all or some of these pests and weeds. They concluded that deer and rabbits were the key to protecting and restoring the forest habitats. Deer could be removed by shooting, but reinvasion from the mainland, only 200 m away, was possible so ongoing surveillance and 'mop-up' would be required. Rabbits could be removed by aerial baiting with follow-up removal of survivors, and such baiting would also eradicate the rodents. Both

Photo a. A dry forest remnant on Île Leprédour

Photo b. Ultimate effects of herbivores on Île Leprédour – the conversion of dry forest to grassland and bare soil

ship rats and kiore are thought to be present and their removal would doubtless benefit the island's lizard and invertebrate faunas. Even more so than with deer, ongoing surveillance and additional control as required would be needed to prevent reinvasion of ship rats.

The giant snails are thought to be a problem, although it is not clear that they have a critical impact on forest regeneration, and they have never been eradicated at this scale.

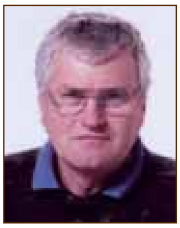
The weeds include some aggressive smothering invaders. New invaders such as rubber vine are being actively removed. However, widespread invasive plants such as passion fruit vine cannot be easily eradicated, and although now kept in check by rabbits and deer, the arid nature of the island makes it unlikely they will become a major problem within healthy restored forest.

Graham and John were faced with the interesting question of what is the right order in which to attempt eradication of this suite of pests? They recommended dealing with the deer first by shooting the 200 or so animals present, using both ground and aerial hunting. The rabbits and rodents could then be removed in an aerial baiting operation using anticoagulant baits, now well tested on many islands around the world. If managers were concerned that the impacts of the snails or weeds might be exacerbated by the removal of the herbivores and predators, they could easily check this before the removal of the animals by using small-scale fencing trials. Equally, the usual non-target effects of poisoning will need to be managed, although none of the native species most at risk are endemic to the island and would easily recolonise it should they be removed during the programme.

The team estimated the total cost to remove these vertebrate pests from Île Leprédour to be about NZ$233,000, but suggested there might be potential to claim some of this back as carbon credits as the forest regenerated.

Removal of the herbivores would allow the remnant forest patches to recover quickly. Recovery of the habitats now in grassland or bare soil and rock would take much longer unless active restoration by planting was undertaken. Whether to do this, as on Mana and Tiritiri Matangi islands in New Zealand, or to leave nature to take its course, as on Phillip Island off Norfolk Island or Macauley Island in the Kermadec Archipelago, is a decision managers have to make.

This work was funded by the Government of New Caledonia.



John Parkes
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Graham Nugent *(not shown)*

How Many Are Left? Auditing Feral Pig Control in Hawaiian Preserves

Like the flora of New Zealand, the flora of the Hawaiian Islands evolved in the absence of ungulates, and their introduction to Hawai'i has resulted in widespread damage to native plant communities. Trampling and browsing by ungulates impairs recruitment of native plants, creates gaps that favour the establishment of non-native weeds, and causes soil erosion and sedimentation of waterways. Feral pigs are thought to be the worst culprits. In many places, their spread throughout native Hawaiian forests was concomitant with the spread of the pernicious strawberry guava tree; the pigs disperse the seeds and create suitable seedling sites through their rooting, and the guava provide valuable food resources for pigs particularly at higher altitudes.

To prevent further degradation of native plant communities, The Nature Conservancy in Hawai'i (TNC) launched an ambitious 'zero tolerance' ungulate control programme in its preserves on Maui and Molakai islands in 2007. It hoped to eliminate ungulate impacts by a near 100% cull of pig and goat populations and, by fencing and relying on natural topographic barriers, prevent their reinvasion. The professional wild animal management company Prohunt was contracted to do the hunting and to assess the effectiveness of the fences and topographic features as barriers to pigs. Mandy Barron and her colleagues were contracted to assess the efficacy of the cull, analyse animal movement data collected as part of the same study, and provide recommendations for ongoing management.

Prohunt commenced culling pigs in October 2007 throughout five zones in the Waikamoi Preserve on East Maui, in one zone in the Kapunakea Preserve on West Maui, and in three zones across the Kamakou Preserve on Molokai. Dogs were used to find the pigs; and helicopters were used to transport the hunters to and from hunting zones and to identify areas inhabited by pigs. Hunting consisted of one to four systematic 'sweeps' covering each zone, followed by targeted forays to mop up survivors. Auditing of the hunting followed, using a modified version of the catch-effort model developed by Dave Ramsey for the eradication of pigs from Santa Cruz Island to estimate the initial population size and the probability of detecting an individual pig per unit of hunting effort. Such detection probabilities can be used

Mandy Barron

Aerial view of pig-proof boundary fence with Haleakala National Park to the left of the fence and Waikamoi Preserve, Maui, Hawai'i to the right. The vegetation in this part of the preserve consists of sub-alpine shrubs and grasses and pig numbers are generally low to calculate the probability of eradication given further sweeps where no pigs are detected. However, once the first preserve (Waikamoi) in the present study was hunted, it became clear that the probability of local eradication was zero. Clean sweeps were achieved in only a few zones and, in some cases, more pigs were culled per unit hunter effort in the later sweeps than in the earlier ones.

If pig populations were closed and culling was the only factor affecting their numbers in the preserves, the team would expect the number killed per unit of hunting effort to decline as more pigs are removed. They offer two potential explanations for the observed contrary trend: pigs were immigrating into the preserve, and/or the hunters were becoming more proficient at detecting pigs with each sweep. Movement of pigs into and out of the preserves was certainly occurring, as one adult boar was ear-tagged in a live-trap located 40 m outside the Kapunakea Preserve, then recovered 3 months later 400 m inside it. Prohunt also identified several holes in the fences and ingress points (identified by tracks and sign) across supposed natural barriers. While some immigration into the preserves is obviously occurring, the team have not yet included this element in the model because they have no empirical data on its magnitude nor know whether such immigration is in response to lowered densities inside the reserves (the so-called 'vacuum effect').

Mandy and her team believe it is reasonable to assume that the hunters became more efficient on successive sweeps of a zone as they learnt the best way to cover it on foot and identified which areas are most favoured by pigs. To try and capture this learning, the team used a cumulative catch-effort model which predicts the probability of detecting a pig based on the hunting effort expended over all sweeps to date rather than just the current sweep. It also allows the rate of increase in pig detection probabilities to change with cumulative effort by fitting a shape parameter. The fitted shape parameter indicated that it became harder to detect pigs as hunting progressed perhaps due to pigs learning to avoid hunters or because naïve pigs were culled early on in the hunt with the wily pigs remaining at large. Thus there is a trade-off between pig and hunter experience as the hunt progresses. However, the pigs should always lose because all of the pigs will be detected and removed if enough hunting effort is employed. The analysis showed that the Prohunt effort removed 76–100% of the pigs present in the different zones. While 100% of pigs were probably removed from two of the zones, local eradication is not achievable because immigration cannot be prevented without further fencing and more intensive fence maintenance. Work is ongoing to determine what control methods are the most cost effective for sustained control of feral pigs to low densities.

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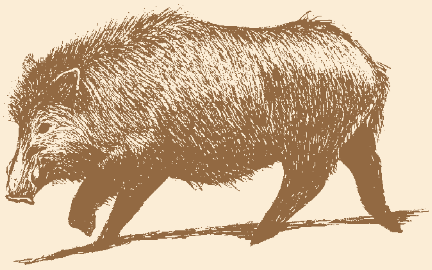

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Some Recent Vertebrate-Pest-Related Publications

Coleman JD, Fraser KW, Nugent G 2007. Costs and benefits of pre-feeding for possum control. *New Zealand Journal of Zoology 34:* 185–193.

Cowan P 2007. How many possums make a cow? *New Zealand Journal of Ecology 31:* 261–262.

Morriss GA, O'Connor CE, Airey AT, Fisher P 2008. Factors influencing palatability and efficacy of toxic baits in ship rats, Norway rats and house mice. *Science for Conservation 282.* Wellington, New Zealand, Department of Conservation. 26 p.

Norbury G, Heyward R 2008. Predictors of clutch predation of a globally significant avifauna in New Zealand's braided river ecosystems. *Animal Conservation 11:* 17–25.

Nugent G, Morgan DR, Sweetapple P, Warburton B 2007. Developing strategy and tools for the local elimination of multiple species. In: Witmer GW, Pitt WC, Fagerstone KA eds. Managing Vertebrate Invasive Species: Proceedings of an International Symposium, USDA/APHIS/WS, National Wildlife Center, Fort Collins, CO, 7–9 August 2007. Pp. 410–417.

Porter RER, Clapperton BK, Coleman JD 2008. Distribution, abundance and control of the rook (*Corvus frugilegus* L.) in Hawke's Bay, New Zealand, 1969–2006. *Journal of the Royal Society of New Zealand 38:* 25–36.

Speedy C, Day T, Innes J 2007. Pest eradication technology – the critical partner to pest exclusion technology : the Maungatautari experience. In: Witmer GW, Pitt WC, Fagerstone KA eds. Managing Vertebrate Invasive Species : Proceedings of an International Symposium, USDA/APHIS/WS, National Wildlife Center, Fort Collins, CO, 7–9 August 2007. Pp. 115–126.

Smith DHV, Wilson DJ, Moller H, Murphy EC 2008. Using artificial nests to explore predation by introduced predators inhabiting alpine areas in New Zealand. *New Zealand Journal of Zoology 35:* 119–128.

Smith DHV, Wilson DJ, Moller H, Murphy EC, van Heezik Y 2007. Selection of alpine grasslands over beech forest by stoats (*Mustela erminea*) inhabiting montane areas in southern New Zealand. *New Zealand Journal of Ecology 31:* 88–97.

Sweetapple P, Nugent G 2007. Ship rat demography and diet following possum control in a mixed podocarp–hardwood forest. *New Zealand Journal of Ecology 31:* 186–201.

Warburton B, Coleman JD, Fugelstad M 2007. Developing a decision support system for improving possum control planning. In: Witmer GW, Pitt WC, Fagerstone KA eds. Managing Vertebrate Invasive Species : Proceedings of an International Symposium, USDA/APHIS/WS, National Wildlife Center, Fort Collins, CO, 7–9 August 2007. Pp. 474–475.

Warburton B, Poutu N 2008. Effectiveness of chain-springs on leghold traps for reducing inuries to captured brushtail possums (*Trcihosurus vulpecula*). *New Zealand Journal of Zoology 35:*147–150.

Warburton B, Poutu N, Peters D, Waddington P 2008. Traps for killing stoats (*Mustela erminea*): improving welfare performance. *Animal Welfare 17:*111–116.

Wilson DJ, McElrea GJ, McElrea LM, Heyward RP, Peach RME, Thomson C 2006. Potential conservation impacts of high-altitude small mammals: a field study and literature review. *DOC Research and Development Series 248*. Wellington, New Zealand, Department of Conservation 51 p.

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