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Behaviour of Invader Ship Rats inside a Pest-proof Fence

Sanctuaries that are fenced to exclude mammal pests are constructed despite the realisation that reinvasion is inevitable during the decades and centuries that follow. Pests outside the fence may jump in from overhanging branches; walk in through holes in the fence caused by falling trees, errant vehicles or scouring by streams; or even be carried in by birds of prey. How do such invader animals behave when inside the fence? Can they be detected and then removed?

To answer these questions, John Innes and colleagues released radio-tagged ship rats into a 65-ha pest-free part of Maungatautari Sanctuary, a forested volcanic hill in the Waikato fenced to exclude mice and all larger mammals. Ship rats were chosen because they are common outside the fence, arboreal, active all year round, highly exploratory, and likely to exploit any breach in the fence.

Male rats living adjacent to the fence were live-captured and collared with a radio transmitter, and released at night inside the fence adjacent to each one's capture site, thus mimicking a neighbourhood breach. Six rats were released one at a time into the pest-free sanctuary, and each one was removed before another was trialled.

Surprisingly, four of the six rats jumped back out and returned to their original home range. The remaining two rats were eventually poisoned. The fence design used at Maungatautari enables animals to climb over it from the inside but not from the outside. All six rats travelled along the fence top at some stage, although only four then took the small leap required to get out.

The rats that jumped out did so after times ranging from a few hours (the night of release) to 7 days. One rat spent a week moving throughout about 25 ha of the Sanctuary, and then returned to its original home range outside the fence, demonstrating considerable homing ability.


Phil Brown

Pest-proof fence at Maungatautari

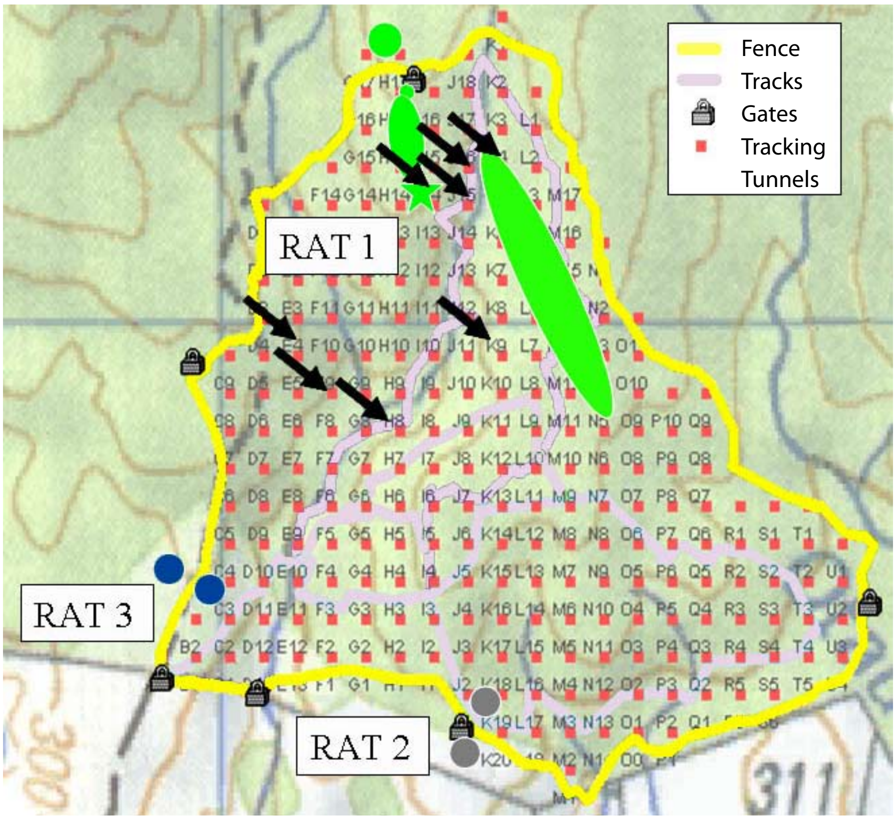

Fig. Movements of ship rats released inside the fence (yellow line) at Maungatautari. Rat 1 was radio tracked (green) over several days and left tracks in eight tracking tunnels (black arrows) before climbing back over the fence after 12 days to its original home. Rats 2 (grey) and 3 (blue) climbed out of the sanctuary the night after and the night of release, respectively, but neither left tracks at any tracking tunnel.

The rats that moved extensively inside the Sanctuary all stayed within 100 m of their release point for about 3 days, and usually denned in a single place (*Fig.*). They then gradually made larger movements into the sanctuary, and eventually changed den sites. Such movements are much larger than those usually recorded for male ship rats in New Zealand forests, for which range lengths on average are about 300 m. By comparison, the lone rats released at Maungatautari moved 500–800 m within a week, and the rat that stayed the longest (before being poisoned after 4 weeks) traversed the entire sanctuary, and moved about 1100 m from its release point.

To check for the presence of invading pests, the sanctuary has tracking tunnels equipped with inked pads placed on a 50-m grid and baited monthly. However, only three of the six released rats left tracks in any tunnels; a concern in itself if the tunnels are to provide early indications of newly invading rats. The most obliging rat moved through eight tunnels in a week, one more than the seven tunnels entered by the rat that spent a month in the sanctuary.

The result that most of the rats returned to their original home range – despite the absence of predators and abundant food inside the fence – was quite unexpected! Perhaps they innately need sociality of some kind, especially access to mates, or perhaps their knowledge of safe den sites and good feeding places in their original home range negates having to find these requirements inside the fence.

The team's research suggests that when a breach occurs, traps should be set on top of the fence as well as on the ground inside, because all rats travelled some distance along the fence top. Tracking tunnels, traps and poison stations should target rats within 100 m of the breach site for the first three days. After this, these devices should be maintained there, but the detection net should be broadened in case rats have moved further into the sanctuary.

In one sense, these results indicate that invading ship rats are less of a threat to fenced sanctuaries than a worst-case scenario may paint, because most male rats apparently don't want to be there. However, it would be dangerous to assume that all ship rats or other mammal pest species will behave this way. The research at Maungatautari needs to be repeated with female and sub-adult ship rats, and with releases of multiple rats, and eventually with other pest species also.

This work was funded by the Foundation for Research, Science and Technology, and supported by the Maungatautari Ecological Island Trust and the Department of Conservation.

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Managing Sika Deer to Ensure Forest Recovery

Sika deer are popular with hunters. They make up about 90% of all deer in the Kaweka Range, inland between Napier and Taupo, and ensure that the forest is a favoured area for hunting. However, despite such activity and the good number of deer shot, the Department of Conservation (DOC) is concerned that under current deer densities, local mountain beech seedling growth and mortality continue to be adversely affected both directly and indirectly by deer browsing.

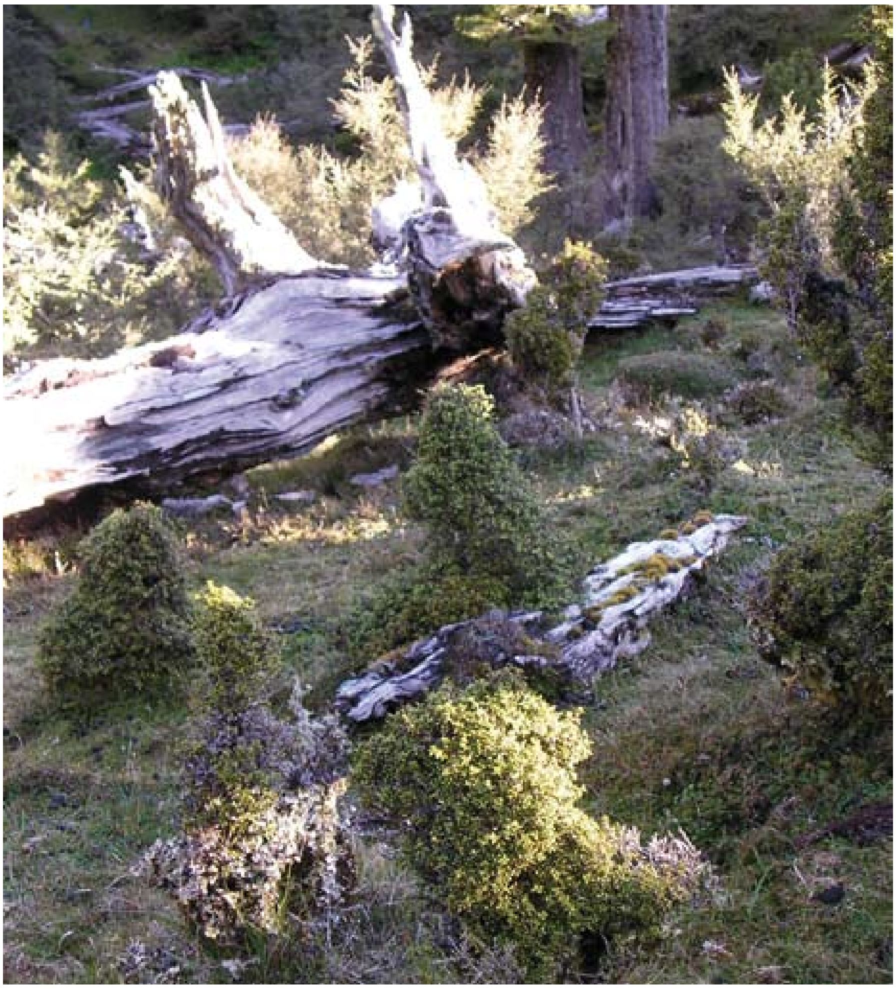
Wendy Ruscoe and colleagues were therefore contracted by DOC to estimate the impact of deer control options on mountain beech in the Kaweka Forest Park. Storms and insect attacks have damaged local mountain beech trees, opening up parts of the forest, and recovery from such damage is thought to be exacerbated by the suppression by deer of beech regeneration.

The project is believed to be the most intensive evaluation of the effects of deer hunting on forest recovery ever carried out in New Zealand. Data documenting the recruitment, growth and mortality of well over 10,000 beech seedlings were meticulously collected by DOC staff over 7 years.

Wendy says initial analyses revealed about 16% of the mountain beech forest surveyed in the Kaweka Forest Park is in an open-canopy state, compared to about 8% across all New Zealand mountain beech forest. Only about 5% of the Kaweka beech forest has enough saplings above deer browse height to allow full future canopy formation. Saplings less than about 1.35 m are browsed by deer and, as long as such browsing continues, they remain as 'bonsai' trees.

Wendy's team also used statistical and predictive modelling to analyse the effects of the options for deer control on the open-canopy state of the Kaweka Forest Park. The modelling indicated that mountain beech recovered most quickly when deer were fenced out of the forest entirely; most slowly under recreational hunting alone; and at an intermediate rate under aerial hunting. If deer are fenced out of the forest, the percentage of damaged open mountain beech forest will on average drop from 16 to 8% (i.e. to normal levels) in 100 years. Under aerial shooting, the amount of open forest will stay relatively constant at about 15%. With recreational shooting alone, best models show this figure could rise to 25% in 100 years.

A 16% open canopy may not sound like much. However, as mature trees die, and if nothing is done to control the deer, the consequences for the Kaweka Forest Park and other beech forest communities may be severe. This is because, as well as the obvious reduction in mountain beech forest canopy and in native biodiversity,


Wendy Ruscoe

Mountain beech trees, up to 50 years old, stunted by deer browsing

Wendy Ruscoe

Regenerating mountain beech inside a deer exclosure

an increase in open forest will encourage weeds and lead to a reduced ability to sequester (store long term) atmospheric carbon dioxide (and for New Zealand to fulfil its obligations under the Kyoto Protocol).

DOC officers in the Hawke's Bay office have the dual goals of protecting the Kaweka Forest Park by ensuring deer numbers are kept to a level commensurate with adequate regeneration and providing a quality experience for deer hunters. The Department believes Wendy's report provides an important source of information on which to base the ongoing discussions it has with hunter liaison groups on improved hunting outcomes.

This article was summarised from that published in Volume 17 (2007) of Landcare Research's newsletter, *Discovery*.

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Management of Multiple Pests

Effective management of invasive vertebrate pests in New Zealand (and internationally) requires an understanding of the pests' ecology, and development of effective strategies and tactics (tools) to control them. Landcare Research currently has three interrelated 4-year research programmes based around the control of vertebrate pests, two of which will provide information for developing improved strategies (i.e. of where, when, and what species to control), and one that will provide improved tactics (i.e. more-cost-effective solutions) for implementing those strategies. All three programmes focus on possums, rats and stoats as the highest priority pests, but independently dealing with a subset of these species for experimental purposes. The research is just over halfway through, and it is envisaged that in another two years, results from all three programmes will be used in bioeconomic models to develop more-cost-effective strategies for dealing with multiple pests over a range of spatial scales.

The first programme (Multi-Species Dynamics, led by Wendy Ruscoe) examines how different mammal pest species interact when one or others change in abundance, mainly as a result of single-species control. Such information will ensure there are no perverse outcomes such as an increase of rats that pose a greater threat to biodiversity than possums when the latter are controlled; that only critical pest species are targeted; and that the timing and frequency of control can be optimised by taking account of any time lags in population responses and differences in species-specific rates of recovery.

The second programme (Spatial Ecology & Modelling, led by Andrea Byrom) examines how possum, rat and stoat distributions are influenced by local habitat characteristics, how these may influence recovery rates of their populations, and how dispersal and immigration influence the size of control buffers and control strategies. Such information will enable control strategies to be optimised by providing information on how control can be better aligned with natural spatial patchiness of pest populations; providing information on where pre-emptive control might be targeted to prevent predicted population increases; and enabling the costs of low-frequency buffer control to be compared with the alternative high-frequency in situ control.

The third programme (Multi-Species Pest Control, led by Bruce Warburton and Graham Nugent) focuses on new and improved tools for detecting, monitoring and controlling possums,

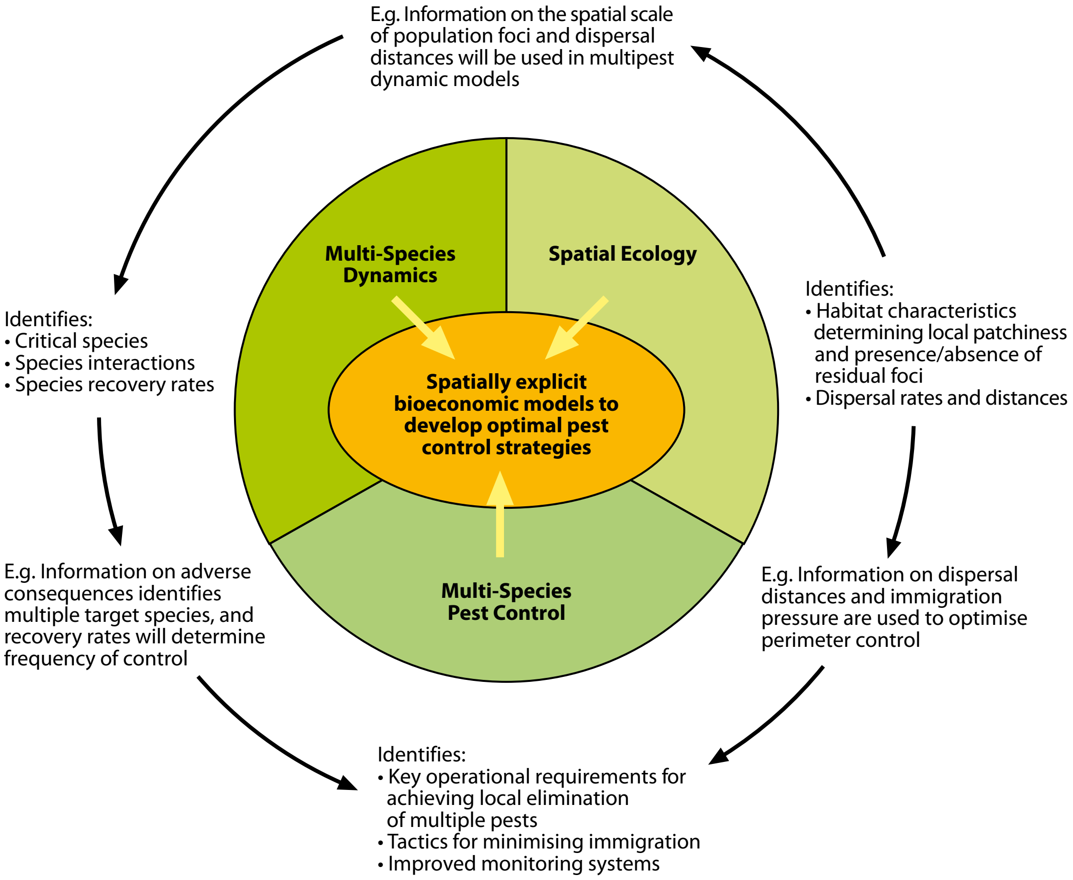

***Fig.** Integration of vertebrate pest projects*

rats and stoats, with the aim of achieving local eradication of all three species and developing perimeter control strategies that minimise subsequent immigration. The results from this programme will enable pests to be controlled over large areas at lower costs, with lower risks to non-target species, lower environmental contamination, and minimal animal welfare concerns. The latest results from this programme are presented and discussed by Graham Nugent in this issue of *Kararehe Kino*.

There are strong links between all three of these programmes (*Fig*.). Readers are welcome to contact the project leaders for information on these projects at any time.

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

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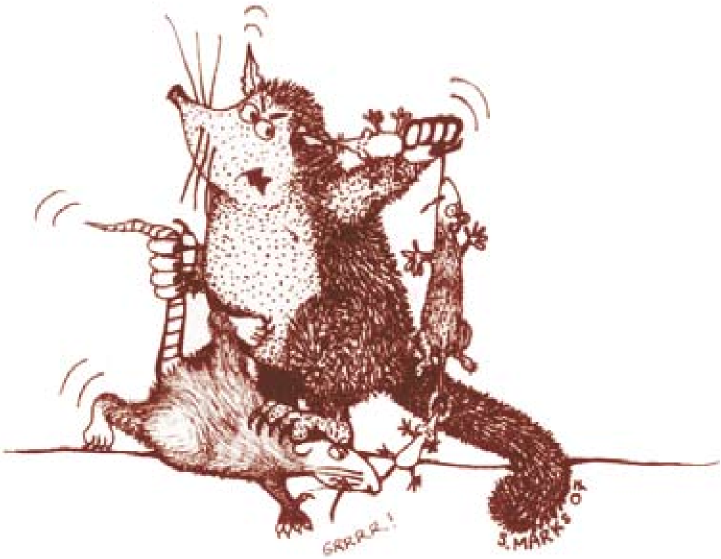
***Wendy Rucoe, Bruce Warburton and Graham Nugent** (not shown)*

Multispecies Control: Killing More Animals with Fewer Baits

Why do pest managers typically aerially sow 200–400 1080 baits (i.e. approximately 2 kg) to kill on average only about five possums per hectare? The answer is that that is how many baits are needed using current sowing strategies to reliably get a high kill of possums. In addition, 1–2 kg/ha of non-toxic prefeed is usually sown before the toxic bait because pre-feeding increases control success. Based on results from recent trials aimed at identifying optimal combinations of sowing rates of prefeed and toxic bait for controlling possums, rats and mice, Graham Nugent and his colleagues now believe good kills may be attained using far fewer 1080 baits than are sown at present.

Their first trial compared kills in 18 immediately adjacent 100-ha blocks in Whirinaki Forest, using carrot bait loaded with 0.15% 1080 in different combinations of sowing rate (1, 2 and 5 kg/ha), numbers of pre-feeds (0, 1 and 2), and sowing patterns (single-direction or cross-hatch). Kills of possums, rats and mice were assessed using pre- and post-control trap catch and/or ChewTrack Card (CTC) interference rate surveys. Excluding cross-hatch sowing, which was not consistently applied, increasing the number of pre-feeds, and (to a far lesser degree) the sowing rate increased the kill of both possums and rats, but had the reverse effect for mice (i.e. their activity increased, *Fig.*).



A second trial, using cereal bait loaded with 0.15% 1080, sought to determine whether making sure baits were close together and therefore easy to find was crucial. For a few possums, their first encounter with toxic bait is a sub-lethal one – bait can shatter during manufacture or sowing, or be partially eaten by another animal. Higher sowing rates increase the chances of possums finding a lethal amount of toxic bait, while pre-feeding encourages possums to look for toxic bait. An alternative approach to overcome the difficulty of possums finding sufficient baits to kill them is to aggregate bait, so that possums quickly find more than one. To test this, the team compared kills at three different levels of bait aggregation, and for the most and least aggregated, whether the effect of pre-feeding was still evident (*Table*). In the first treatment, they aerially broadcast bait at 2 kg/ha along flight lines 100 m apart, as is common practice. In the second treatment, the toxic bait was aerially trickle-sown at 2 kg/ha to aggregate bait under the helicopter rather than broadcast them with a spinner. In the third treatment, bait was hand-laid in 50-g piles at 10–15-m intervals along lines 100 m apart.

Possum and rat kills in this trial were as good as or (usually) better in pre-fed blocks compared with blocks not pre-fed (*Table*). Pre-feeding appeared to have no effect on the kill of mice.

In the pre-fed hand- and trickle-sown blocks, kills of possums and rats were as good as if not better than those in the pre-fed broadcast blocks. For mice, kills were clearly far poorer when bait was more evenly distributed (broadcast) than when it was more aggregated.

Daily monitoring of 136 hand-laid bait dumps showed that only about a quarter of the bait was eaten. Most whole baits were eaten on the first night, indicating that most of the possums killed died that night. Feeding by rats and/or mice of bait continued after the first night, suggesting they took longer to find the baits.

The best overall kill of possums, rats and mice was obtained using pre-feeding and aggregated baiting. The hand-sowing strategy achieved high kills despite using >80% less toxic bait than normal baiting.

Table. *Overall design and results of the May 2007 trial at Whirinaki. There were two replicates (North and South) of the five treatments described in the first two rows. Percent kill was assessed using either trap catch indices (possum TCI) or ChewTrack card interference (rat and mouse CTCI).*

Prefeed (kg/ha)	0	1 kg	1 kg	1 kg	0
Toxic (kg/ha)	2 kg Broadcast	2 kg Broadcast	2 kg Trickle	0.4kg ‘dumps’	0.4 kg ‘dumps’
Possum TCI %kill – North	89.4%	90.8%	93.1%	89.9%	75.7%
PossumTCI %kill – South	36.6%	84.3%	90.8%	84.5%	52.0%
Rat CTC kill – North	87.7%	100%	98.9%	96.7%	60.0%
Rat CTC kill – South	74.3%	95.0%	84.8%	100%	60.2%
Mouse CTC kill – North	67.2%	52.9%	86.7%	64.7%	81.8%
Mouse CTC kill ¬– South	−39.8%	−56.6%	91.7%	98.1%	76.9%

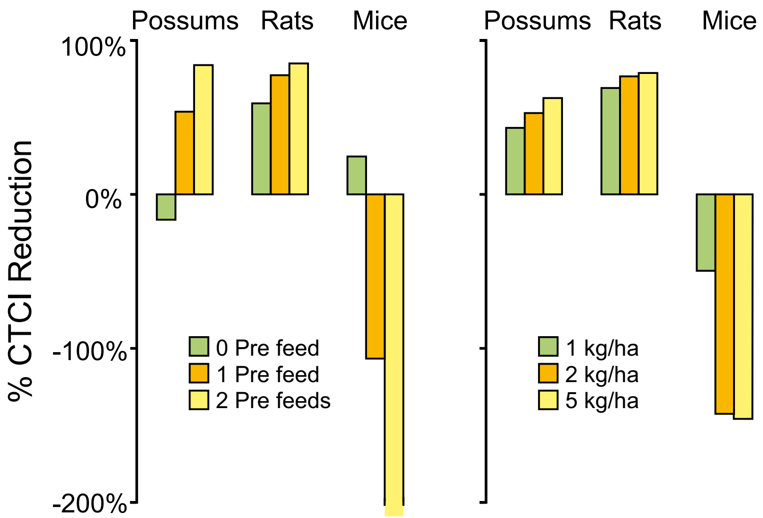


Fig. *Reduction in ChewTrack card (CTC) interference rates by possums, rats, and mice following aerial poisoning with 1080 carrot bait for different sowing rates and numbers of pre-feeds. Each bar represents the average of three 100-ha blocks, with 160 CTCs monitored per block.*

For possums, it appears that aggregating the bait reduced the chance of their finding only sub-lethal quantities of bait. For rats, bait distribution appears to make little difference to kill rates, with pre-feeding being the key factor determining a good kill. For mice, it appears that moderate kills can be obtained with or without prefeed, provided rats and possums are removed first or that any bait fragments left over by possums and rats are close to other baits.

When pre-fed, most possums appeared to have been killed on the first night even with 100-m spacings between bait lines, when less than a quarter of the bait was eaten. This indicates that similar kills could have been achieved with even less bait than was actually sown. If so, it may be possible to greatly reduce the amount of 1080 used, with concomitant reductions in cost and in the risk of environmental contamination and non-target kills. That would make the use of 1080 much less controversial.

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Grey-faced Petrels on Moutohora – Rats, Rabbits, Rahui and Recovery

Moutohora (Whale Island) in the Bay of Plenty has a large breeding population of kuia-oi-tītī (grey-faced petrels) that has been studied on and off since the late 1960s. These petrels nest in burrows and their chicks were traditionally harvested by local iwi. Landcare Research, together with Hauraki and Ngāti Awa iwi, are monitoring kuia-oi-tītī annual survival and breeding rates and their oceanic foraging behaviour to determine how these factors may affect the long-term survival of the population. This project, which is in only its second year of fieldwork, has been named *Mauriora ki ngā oi* (Safeguarding the life force of the oi) and uses modern scientific methods and Hauraki traditional knowledge to guide management of the birds, both on the Ruamaahua (Aldermen) Islands off the Coromandel Peninsula and on Moutohora.

Kuia-oi-tītī chicks were traditionally harvested from


Cationa MacLeod

Charlotte Skeet (Te Rūnanga o Ngāti Awa) surveys oi burrows for eggs in July 2007

Moutohora by Ngāti Awa up until the late 1950s, when the iwi established a *rahui* (or temporary harvest prohibition) because of concerns about diminishing harvests. The exact cause for the decline was unknown at that time, but Norway rats, introduced around 1920, were later found to be responsible for the loss of up to a third of kuia-oi-tītī chicks from burrows. The introduction of rabbits on to the island in the late 1960s made the impact of rats on the local kuia-oi-tītī population much worse by providing additional food (their carcasses) for the rats outside of the birds' breeding season (when no chicks were available) – a process known as 'hyperpredation'. This allowed the rat population to flourish to such an extent that few chicks fledged between 1972 and 1977 (*Fig.*). Both rats and rabbits were eradicated fom Moutohora by 1987, with subsequent increases in the breeding success rates of kuia-oi-tītī on the island.

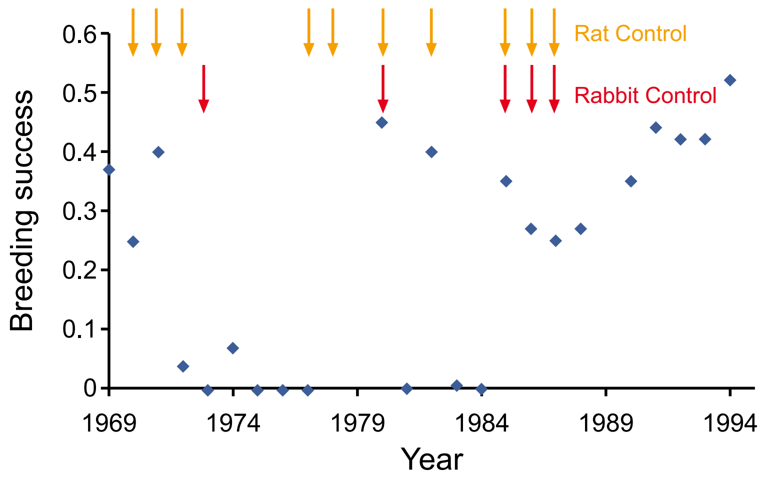


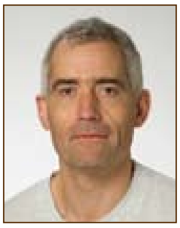
Fig. *Breeding success of kuia-oi-tītī on Moutohora from 1969 to 1995 in relation to sporadic rat and rabbit control that culminated in a sustained eradication programme in 1985–87 (data from Imber et al. 2000 NZ Journal of Ecology 24: 153–160).*

Moutohora presents an ideal opportunity to study how much and how quickly a population of kuia-oi-tītī can recover from predation, or from harvest, which is essentially the same thing. Staff from the Wildlife Service (and its successor, the Department of Conservation) monitored the breeding success of kuia-oi-tītī on Moutohora between 1969 and 1994 (*Fig.*), and their information is being combined with new research findings to build a picture of the population's decline and subsequent recovery now that a major threat has been removed. The researchers are building this picture with a simulation model using data from breeding surveys on the island during the time when rat predation was at its highest and from the years immediately following the rats' eradication. Information currently being obtained on breeding success and survival rates will allow the team to test how good its model's predictions are, by comparing them with 'real' data obtained from the island. These measures will, in turn, allow a 'tweaking' of some aspects of the model to improve the quality of its predictions, before it is used to guide both Hauraki and Ngāti Awa in the management of the birds.


Brian Karl

An adult oi returning to its burrow

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



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Phil Lyver and Catriona MacLeod
(not shown)

Secondary Effects of Possum Control

Possum control benefits native forests by reducing levels of possum predation on native animals and reducing browsing on preferred plants. Possum control can also reduce rodent and stoat populations, further reducing predation of native animals. However, individual pest species are part of an interacting web of both exotic and native plants and animals, so the reduction of one pest species may have unexpected outcomes for other pest species and their impacts. For example, in some podocarp–hardwood forests, reduction of rodent populations can lead to increased predation of native birds by stoats, while possum-only control can lead to sustained increases in rat abundance. The consequences for native ecosystems of such unexpected outcomes are poorly understood.

Peter Sweetapple and Graham Nugent have recently investigated some of the effects of increased rat abundance following possum control in two podocarp–hardwood forests. While monitoring possum and rat population abundance, they also recorded the number of ground-dwelling invertebrates (ground beetles, spiders and wētā) falling into pitfall traps in the Mokau catchment in northern Taranaki and in the Waihaha catchment in the central North Island, and recorded robin encounters at Waihaha.

At Mokau, possum control in 2002 using aerially sown 1080 baits reduced possum and rat populations to near zero. Numbers of possums remained low for the next three years, while rat numbers recovered after one year and rose further to levels significantly higher than in adjacent unpoisoned areas in the next two years (*Fig.1*). In the poisoned block, the number of large invertebrates known to be eaten by rats soared after rat numbers were reduced to near zero, and then plummeted as rat numbers exploded to very high levels. In contrast, in the unpoisoned area, the numbers of rats and of the common large invertebrates remained more or less stable.

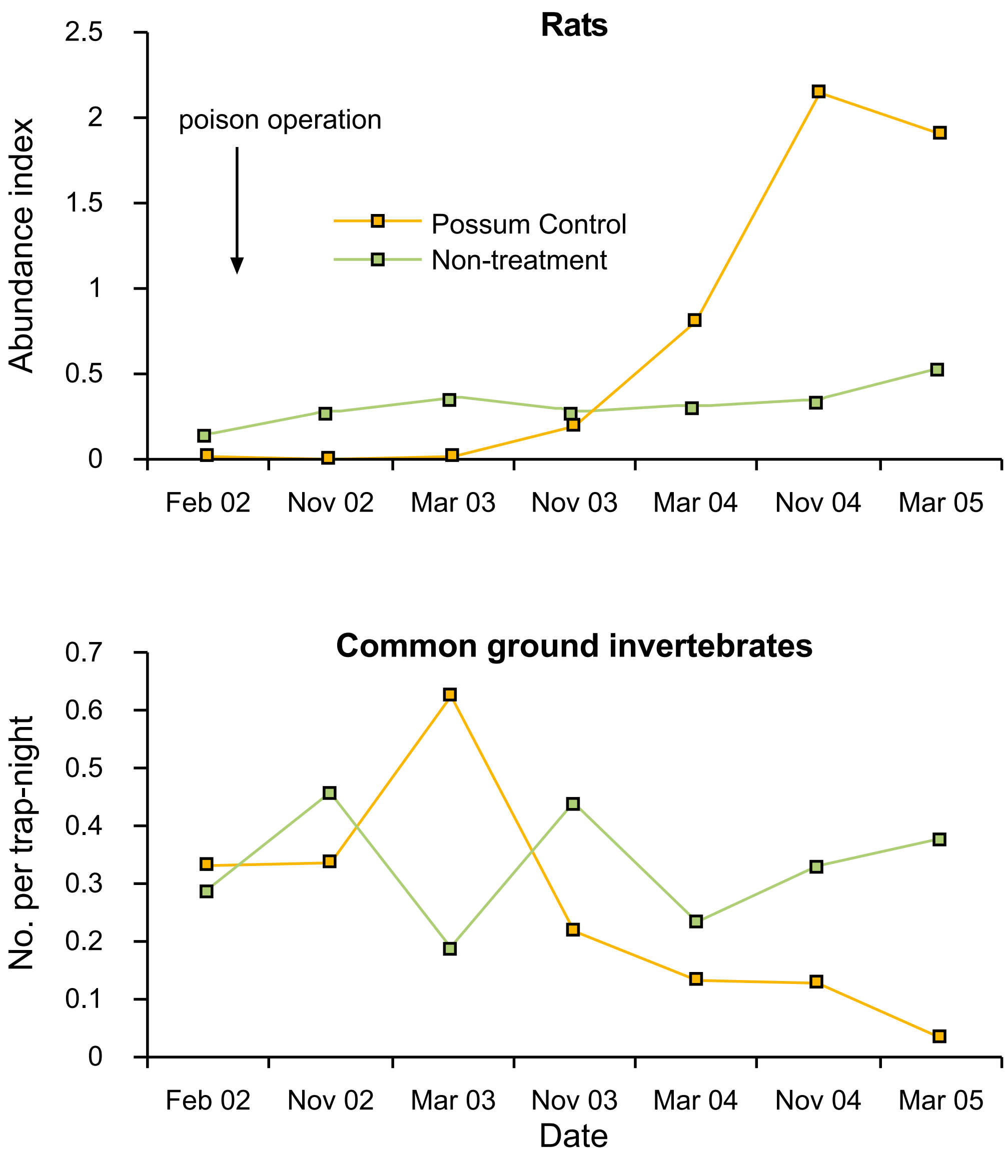

Fig. 1. *Indices of abundance of rats and common ground invertebrates (ground beetles, spiders, and wētā) before and after possum control and in an adjacent unpoisoned area at Mokau in 2002.*

At Waihaha, possum numbers were first reduced to low levels in 1994. This resulted in a sustained 4–5-fold increase in rat abundance. Possum control was repeated in August 2000 using aerially sown 1080 baits and provided effective rat control for about a year before their numbers rose to the high levels seen prior to August 2000 (*Fig.2*). Robin encounter rates rose dramatically during the two breeding periods characterised by low or increasing rat abundance, before steadily declining to pre-August 2000 levels once rat numbers peaked (*Fig.2*). Ground invertebrates were also numerous while rat numbers were low, but invertebrate numbers fell once rat populations started to recover.

Although any inference from the data is weakened by only limited pre-poisoning sampling in each location, the Mokau data worryingly indicate substantial negative impacts of possum-only control on some native invertebrates, with possible flow-on effects to avian insectivores. Similarly, our interpretation of the Waihaha data is provisional, being limited by small sample sizes, the lack of an experimental control (untreated area), and the lack of pre-1994 robin population data and pre-2000 invertebrate data. The peaks in robin and invertebrate numbers during the period of low rat abundance may simply reflect the chance occurrence of one or two very good breeding years for these animals and be unrelated to possum or rat control. Coupled with the Mokau data, however, these results provide Peter and Graham with grounds for two hypotheses. The first is that 1080 poisoning of possums provides a significant but short-lived benefit arising from incidental rat control. The second, more sinister possibility is that, given that overall rat abundance at Waihaha is now markedly higher than it was prior to the commencement of possum control in 1994, robin and invertebrate numbers may have been suppressed since then. In other words, possum-only control may have negative long-term consequences for robins and ground invertebrates. Clearly, more work in this area is urgently needed.

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

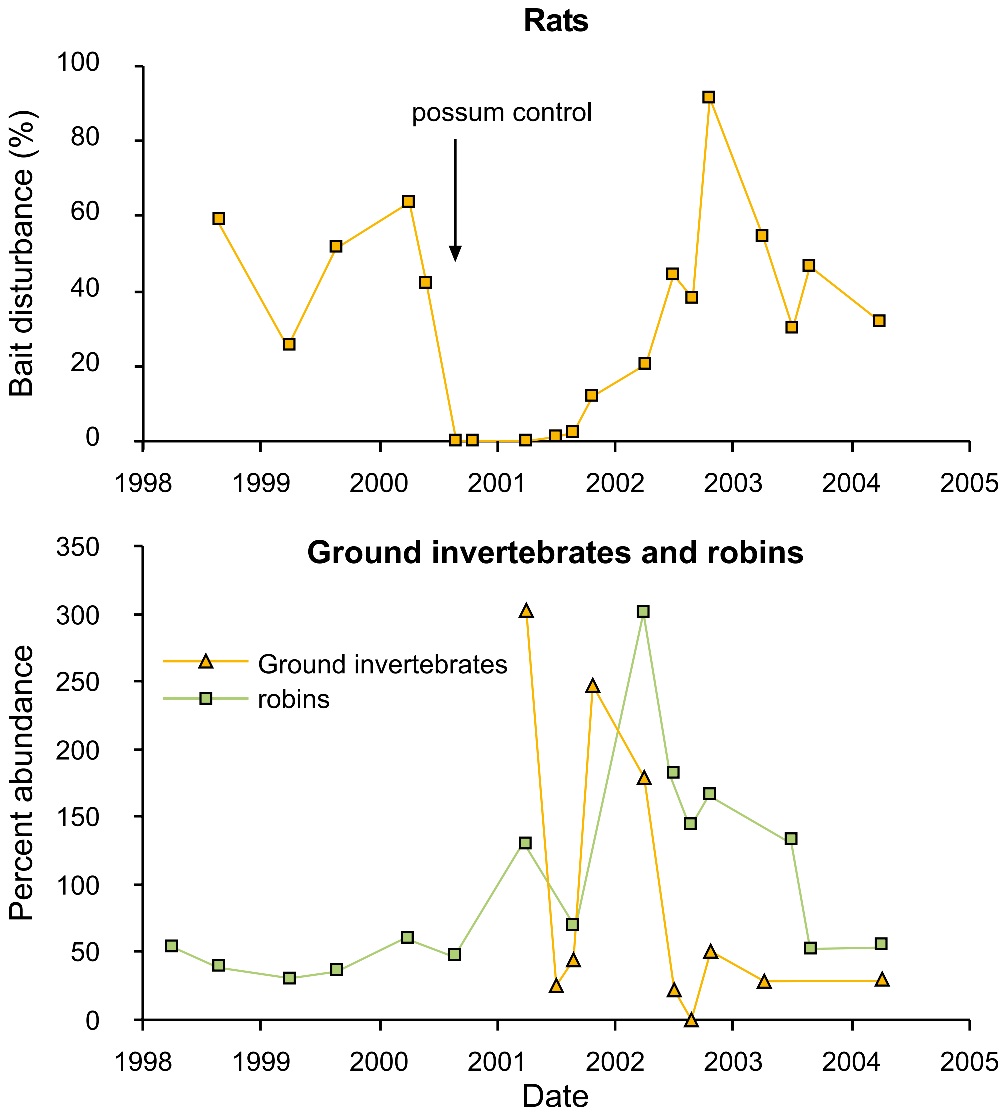

Fig. 2. Rat, ground invertebrate, and robin abundance indices before and after possum control at Waihaha in August 2000. Rat abundance is expressed as the percentage of flour baits disturbed by them, while ground invertebrate and robin abundance is expressed as the percentage of the mean abundance over the entire study period.

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Graham Nugent (not shown)

Examining Non-Lesioned Possums for Bovine Tb

Possum numbers in populations under official control are normally very low, making the cost of recovering sufficient animals for necropsy for Tb surveillance excessively high. To increase the likelihood of detecting Tb in modest samples of possums, it makes intuitive sense to culture the commonly infected tissues from all individuals, regardless of whether they possess visible lesions indicative of Tb or not. Further, as culturing tissue samples is moderately expensive, culture costs can be markedly reduced by pooling samples for culture from non-lesioned (NVL) individuals, as long as there is no or little loss in ability to detect Tb in recently infected possums.

Jim Coleman from Landcare Research and Geoff de Lisle from AgResearch addressed strategies of tissue-pooling to provide recommendations to Tb managers of where and how culturing tissues from NVL possums should be used in surveillance surveys. They did this firstly by reviewing the literature covering the pathology of Tb in possums, and secondly by confirming both the most frequent locations of lesions and proportion infected within lesioned and NVL possums, sampled from four infected populations. For each trapped possum, all superficial (= sub-dermal) lymph nodes, lung and associated bronchial nodes, and mesenteric nodes were sampled and individually cultured. For NVL possums only, subsamples of tissues from these sites were also pooled and cultured for groups of 10, 20, 30 and, where the sample permitted, up to 50 animals. Finally, all other major thoracic and abdominal organs were inspected for signs of the disease.

In total, 283 possums were necropsied from all four sites. Those with culture-positive lesions varied from 1.1 to 19.2%, and culture-positive NVL possums from 4.8 to 11.1%.

Geoff DeLisle

A culture plate showing a few colonies of M. bovis

Thirty-three (11.7%) possums possessed lesions indicative of Tb, and 31 of them (93.9%) cultured positive for the disease (*Table*). Clearly, possums judged at necropsy to possess Tb-like lesions are nearly always culture-positive for *Mycobacterium bovis*. Nineteen of the 31 infected possums had multiple-site infections. Of these animals, lesions were most common in the superficial nodes (i.e. 14 in the superficial axillary node, 10 in the deep axillary node, and 8 in the inguinal nodes), in lung tissue (16), and in the mesenteric nodes (10), and were infrequently recorded in other sites.

Of the 14 possums with single-site lesions, six had lesions in the superficial axillary node, four in the lungs, two each in the deep axillary node and mesenteric nodes, and one in the inguinal nodes. These data confirmed published information on lesion distribution.

Twenty-four (9.6%) NVL possums cultured positive for Tb (*Table*). Single pools of tissue from each of these possums revealed a mean of 1.46 (log$_{10}$) colony-forming units (CFUs) of *M. bovis* across the four samples, and significantly fewer ($P < 0.01$) than the 3.85 (log$_{10}$) CFUs identified from culture-positive possums with lesions (*Table*). This finding is consistent with NVL possums representing early-stage infections. Infected NVL possums appear to have small to moderate numbers of Tb organisms, and when this number is particularly low it becomes a matter of chance as to whether the possum is identified as infected or not.

Despite this limitation, Jim and Geoff identified Tb infections in all four populations of possums in pools of tissue

Table. *Tb in tissue pools from individual lesioned and NVL possums combined from four surveys.*

	No. in sample (%)	No. (%) culture-positive	Mean log$_{10}$ CFUs in culture-positive animals
Possums with lesions	33/283 (11.7%)	31/33 (93.9%)	3.85
NVL possums	250/283 (88.3%)	24/250 (9.6%)	1.46
Total	283	55/283 (19.4%)	

cultured from 10 to 50 NVL animals. Of 43 such pools, 26 were culture-positive and all contained tissue from at least one culture-positive individual NVL possum. Eleven pools were culture-negative, and reflected the absence of tissue from any culture-positive individuals. The remaining seven pools (16%) were culture-negative but contained tissue from one (5 pools) or two (2 pools) culture-positive possums, indicating a minor loss of sensitivity at culture (and usefulness in Tb surveillance) arising from sample pooling.

On the basis of this research, Jim and Geoff believe that where lesioned possums are not identified during surveillance surveys, pools of tissue taken from the superficial nodes, lung, and mesenteric nodes of approximately 30 NVL possums and combined into a single sample would save approximately 90% of the per-animal cost of culture. This would enable greater numbers of animal samples to be cultured and give greater certainty to determining the true infection status of the population. However, for very low density populations (i.e. >1/ha) under ongoing control, where there is a high cost of animal collection or the need to obtain precise locations of infected individuals, pest managers should culture pools of tissue from samples of less than 30 NVL individuals to achieve the same disease assurance.

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

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Modelling the Impact of Tasmanian Devil Facial Tumour Disease

The Tasmanian devil is the largest living marsupial carnivore and an icon of the State. In 1996, a debilitating tumour (devil facial tumour disease, or DFTD) was reported in devils in north-eastern Tasmania. Since then the disease has spread across most of the species' range, and has led to major declines in its population. It is now clear that DFTD is an invariably lethal infectious cancer (which in itself is highly unusual), and its occurrence raises the question of what the eventual disease outcome for devils will be. Whether or not DFTD can cause local or indeed total population extinction will greatly influence the strategy and tactics used in researching and managing this disease.

To help answer these questions, Dan Tompkins has recently constructed a mathematical model of DFTD and used it to predict future disease impacts on devil populations and identify key gaps in the knowledge needed to increase confidence in his predictions.

The model is structured on both age and sex, with discrete yearly age classes (0–6 years) for animals. This structure allows for the inclusion of sex- and age-specific mortality and breeding rates, and for comparisons with data from existing devil populations. Within each age/sex class,

Advanced DFTD lesions on the face of a Tasmanian devil the animals were split into three discrete disease-related subclasses: 'Susceptible' (uninfected), 'Exposed' (infected but not yet infectious), and 'Infectious'. Other, unknown life-history parameters were estimated as those simulating realistic population characteristics.

The model treated DFTD as a disease transmitted by direct contact, with transmission based on the probability that each individual devil bit every other individual in the population each month; a realistic supposition as they commonly bite one another during bouts of group feeding. When transmission was modelled as increasing in an exponential fashion with decreasing density of devils, the data showed a good fit to changes in both disease prevalence and to the decline and structural changes observed in naturally infected devils in Freycinet National Park, during 2001–2006 (*Fig. 1*). This population occurs close to where the disease was initially recorded, and is the subject of the longest and most complete set of data on DFTD. Such increases in per-capita disease transmission commonly occur in wildlife species where interactions among individuals are maintained at low density by periods of co-feeding, antagonistic behaviour, and mating.

Dan's prediction for devil population trends at Freycinet National Park over 2006–2011 is for a continued decline to below 1% of its original size by January 2013 (*Fig. 2*). At this level, the extinction of the population via stochastic events is highly likely.

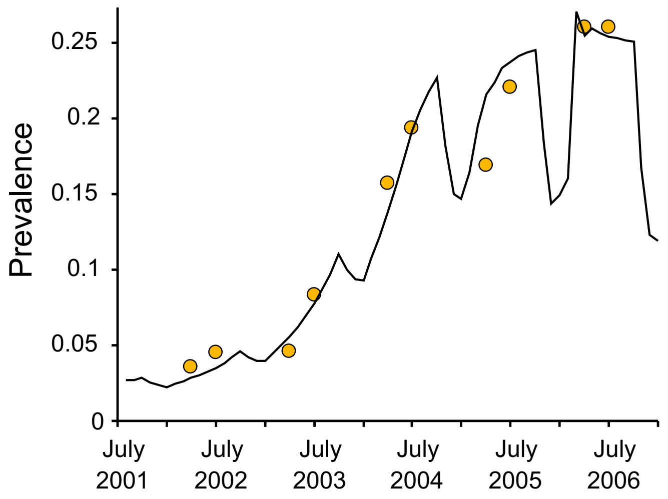

Fig. 1. *Predicted (line) and observed (circles) prevalence of DFTD in Tasmanian devils in Freycinet National Park.*

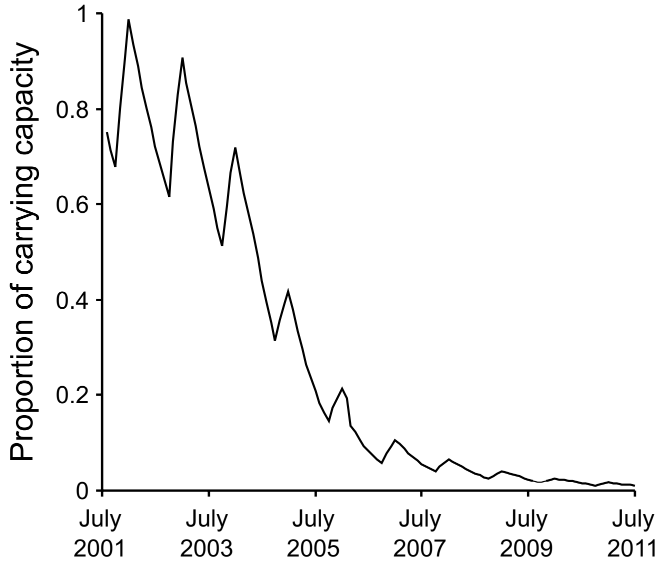

Fig. 2. *Predicted decline in the Freycinet National Park Tasmanian devil population, due to the impact of DFTD.*

However, a sensitivity analysis of the model components and of the unknown life-history parameters used demonstrated that population extinction is not the only potential outcome of such disease outbreaks. Dan identified two key parameters that, when varied, can alter the predicted model outcome. First, a latent period of infection (the time spent in the 'Exposed' subclass) of 12 months is currently used in the model, but recent evidence from a devil that developed tumours after 10 months in captivity suggests that 6 months may be more realistic. A shorter latent period also fits more closely with field observations of juveniles as young as 13 months developing tumours, given that disease transmission from mother to offspring is not known to occur and juveniles do not leave the pouch until they are approximately 8 months old. Altering this value changed the predicted impact of DFTD on the devil population in Freycinet National Park, from a decline to extinction to a decline to a stable population regulated at approximately 15% of carrying capacity with disease persisting at approximately 7% prevalence. Second, changing the modelled relationship between DFTD transmission and devil population density can likewise shift the predicted outcome of disease impact to population regulation rather than extinction.

Irrespective of the predicted outcome of the decline in the Freycinet devil population, the model indicates an ongoing rapid decline there, and is in agreement with results from mark–recapture analyses. Determining whether local extinction is likely to be the ultimate outcome requires more data. In particular, field quantification of the transmission model is needed, along with better estimates of the latent period of infection of DFTD in wild devils.

This work was funded by the Department of Primary Industries and Water, Tasmania.

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Possum Nematode Continues to Show Promise for Biological Control

For the past several years Warwick Grant and Mark Ralston from AgResearch and Phil Cowan from Landcare Research have been assessing the extent to which the possum-specific intestinal nematode *Parastrongyloides trichosuri* possesses traits that would make it a suitable vector for a transmissible form of biological control for possums. The results of that work, reported in the June 2004 issue of *Kararehe Kino*, suggested that the parasite was likely to be a very effective vector – it showed only small seasonal variations in level of infection, infection was consistently high in adult possums, and there was little spatial variation in prevalence. A field experiment in Northwest Nelson showed that the parasite was easy to establish in a parasite-free possum population, persisted for more than 5 years after its introduction, and spread readily from possum to possum.

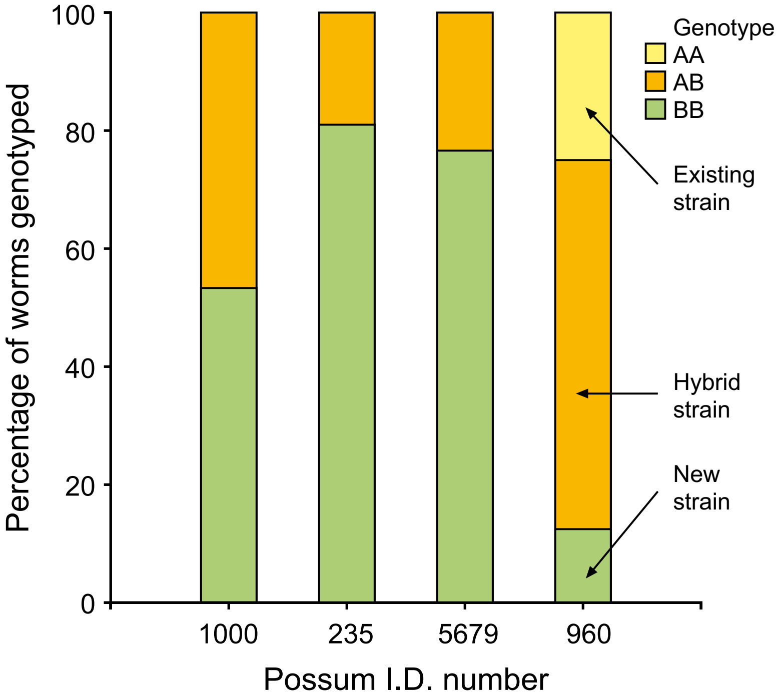

Fig. *Percentage of genotyped nematodes comprising the existing strain (AA), the new strain (BB), and hybrids (AB) in four possums sampled on the study site in Northwest Nelson.*

One key question remained – if a genetically modified strain of the parasite was developed, could it establish successfully in possum populations already infected with a 'natural' strain? Understanding the issue of competition between parasite strains is vitally important for the ultimate success of the project to develop transmissible biological control – for example, a new strain might not establish, or if it did, it might not reach a high enough prevalence to cause a large enough decline in possum numbers to lower the threats to native biodiversity or to reduce the persistence and spread of bovine Tb.

Using a genetically modified strain of the parasite to address the question of competition between parasite strains was not an option at this time. The team therefore decided to use a naturally occurring strain of the parasite that could be distinguished by DNA 'fingerprinting' from the strain present at the study site in Northwest Nelson. The two strains show different DNA bands (*Fig.*) – the original strain was designated AA and the new strain BB. Hybrids between the two strains appear in the DNA analysis as AB.

In May 2005, the team live-trapped possums on the study area in Northwest

Nelson and artificially infected them by applying infective parasite larvae of the new BB strain to their skin, the same method that was used to establish the original infection there in March 2000. Faecal samples collected from the possums at the same time were cultured so that the team could determine whether or not they were also infected with the original AA strain. Possums were retrapped about every 3 months and faecal samples collected for culture of parasites and subsequent DNA genotyping.

From infection to the production of parasite eggs in possum faeces normally takes about 2 weeks. At the first retrapping session 4 weeks after exposure to the new strain, some possums were found with eggs in their faeces of both released strains and of a hybrid strain of the two. At 8 weeks post-infection, some possums that had not been deliberately exposed to the new BB strain were also found to be infected with it, indicating possum-to-possum transmission of the new strain. Thus, the new parasite strain established successfully, and subsequent trapping showed that it persisted for 2 years through until May 2007, when the study ended with the control of the possums as part of the regional bovine Tb management strategy. However, the initially high prevalence of infection with the new strain declined gradually with time and stabilised at about 10–15%.

To check whether the new strain had spread away from the release site, possums were also sampled from near to but outside the study site just before the control operation. The presence of hybrid parasites there showed that the new strain had spread naturally up to 2 km from the release site.

The team is currently planning to repeat this experiment at a second site in the North Island in early 2008 to assess whether the final level at which the new strain of the parasite stabilises is sufficient to achieve the desired reduction in possum numbers.

This work is part of the research programme of the National Research Centre for Possum Biocontrol, and was funded by the Foundation for Research, Science and Technology and done under contract to the Animal Health Board.

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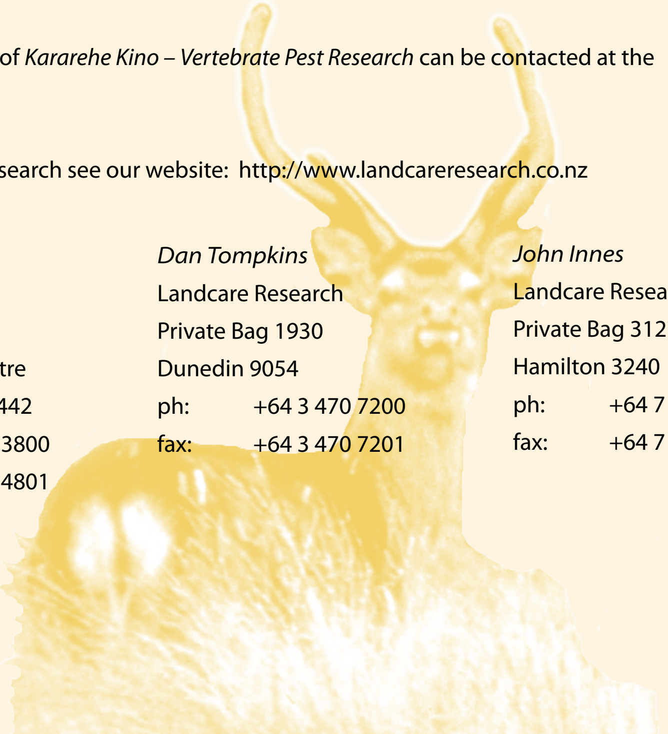

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Some Recent Vertebrate-Pest-Related Publications

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