Mice in fenced sanctuaries
for Sanctuaries of NZ workshop 2012

Compiled by Matt Maitland
Address for correspondence: matt.maitland@aucklandcouncil.govt.nz

Contents

Mice in fenced sanctuaries

Final version 24/8/12

Introduction

On 31st July the Island Eradication Advisory Group (IEAG) met with members of various fenced mainland sanctuaries and scientists to discuss the issue of mice remaining in or reinvading these sanctuaries following multi-species eradications. The aim of this discussion was to share views and experiences around 4 basic questions and to conclude with some practical recommendations for fenced sanctuary projects which can be taken further at the Sanctuaries NZ conference in August. Included in the meeting was Quail Island which has successfully eradicated other pest species but mice remain. The 4 topics of discussion were:

1. What impacts are we seeing or do we anticipate if mice are left uncontrolled in an otherwise predator-free environment?
2. In what circumstances would pursuing an eradication strategy be better than a control strategy for fenced sanctuaries in this situation?
3. If choosing a control strategy what is the best practice for technique, timing and tools?
4. Surveillance & monitoring

A number of sanctuary staff provided information on the subject in response to a questionnaire prior to the meeting. This information was circulated along with summaries of relevant research. This paper summarises the key points from the discussion.

1. What impacts are we seeing or do we anticipate if mice are left uncontrolled in an otherwise predator-free environment?

The impacts of mice are there if you look for them, and not surprisingly uncontrolled populations in predator –free environments reach seasonally high numbers with consequently more noticeable impacts. Besides biological impacts through predation of large invertebrates (especially beetles, weta) lizards and birds with small eggs (e.g., robin), there is also competition with invertebrate predators and seed eaters. Seed predation by mice can also affect regeneration of some species. In addition to this is potential for mice to burrow under fences and thereby create an opening for other pests to enter; create difficulties for surveillance of other pests through interference with detection devices (traps, wax tags, tracking tunnels etc); and create difficulties for control of other pests through interference with control devices (bait or traps).

The biological context in which to judge the severity of mice impacts needs further research. Participants agreed that they felt the eradication of other pest species from the sites created a net benefit even if mice remained uncontrolled (despite the fact they may reach higher densities than when they formed part of a wider pest guild) but this was dependant on individual project goals. They also pointed out the social 'impact' of having mice present in a site which is presented to the public as 'pest free' was potentially damaging to public perceptions. The long term impact of mice as the sole introduced pest on New Zealand ecosystems is not known.

The effect of predation by mice on invertebrates is specific to some (above ground) taxa and may be little more than what rats previously took anyway. However if looked at from a biomass/energetics perspective, a greater number of smaller mammals would require a higher level of food intake. Mice may take small prey that rats do not take, and so impacts may not be equivalent.

For those sites where mice are in relatively low numbers there have been several successful re-introductions of potentially vulnerable species such as jewelled gecko, tuatara and giant weta. Forest and green geckos have successfully been reintroduced to a site where mice are unmanaged. Extant

species such as ornate and shore skinks have demonstrated recovery in the presence of mice when other pests are absent.

2. In what circumstances would pursuing an eradication strategy be better than a control strategy for fenced sanctuaries in this situation?

Sanctuary managers have opted for one of three management strategies:

- Continuing surveillance and incursion response to mouse detections to maintain a 'zero density' (e.g., Rotokare, Maungatautari enclosures, Orokonui).
- Sustained periodic control of mice, usually through periodic poison baiting (eg Zealandia, Maungatautari Mountain,).
- Leaving mice uncontrolled and focussing on managing incursions of the other pest species (e.g., Tawharanui and to some extent Quail Island).

All sites began with an eradication policy for mice and their change to other strategies has been due to necessity based on the nature of the site (usually size) and resources available to 'keep on top of them'. Another factor in the difficulty of mouse control is habitat, sites such as Quail Island, Orokonui and Tawharanui have large areas of grass which provides an abundance of grass seed as a food source for mice.

All sites experienced problems with fence 'leakage' due to various causes and those small enough to resource intensive surveillance and incursion response for mice have managed to sustain 'zero density' of mice at the site 'mice. At other sites strategies have evolved to become sustained periodic control or no control for mice but maintain surveillance and incursion response for other pest species. Evidence of fence leakage include the capture of animals inside the fence which were 'biomarked' with rhodamine B bait fed outside the fence; 'biomarked' with rhodamine B bait fed inside the fence (marked mice turned up outside the fence indicating leakage both ways); observations of gaps in fence joins, culverts or other fittings; burrows beside culverts discovered upon excavation; and observations of birds carrying mice as prey – dead or alive (e.g. kingfisher observed with live prey in Zealandia; dead rats sometimes found on rat free islands in gull colonies).. In addition to this are multiple fence breaches through storm damage etc, operational and visitor biosecurity lapses and in some cases the absence of a barrier such as at coastal fence ends.

The pattern of mouse reinvasion appeared common among several sites. Mice were first detected near the fence and later 'satellite' populations appeared further toward the interior. One mechanism put forward to explain this was that the mice near the fence were actually extending their territories through the fence but subsequent generations dispersed more widely. Also, long-distance movements (e.g. by males) may be seasonal or triggered some time after the initial invasion. Several ideas for further research in this area were put forward:

- Invader and natal mouse dispersal in the context of fenced sanctuaries.
- A better understanding of how they cross the fence and the risk mouse populations near the fence (both inside and out) pose to allowing incursions of other pests.
- The impact control of other pest species outside the fence has on mouse density and behaviour.

Efforts to contain mice to the vicinity of the fence in Zealandia through an intensive buffer of bait stations failed to prevent them establishing beyond the buffer in the interior of the site. A similar phenomenon was reported at Quail Island, where an intensive buffer of traps failed to exclude animals from a core area. Despite this several projects do extra control around known 'weak points' of their perimeter, for example the peninsular projects Tawharanui and Shakespear actively control a buffer zone outside the fence, Quail Island traps for rats and stoats on the mainland around the

closest point to the island. Others trap the outside of their fence line as part of their ongoing fence maintenance programme. The difference this work makes to the risk of incursion has not been quantified but experiments in Maungatautari suggest breaches in the fence will be investigated by pest species within hours of occurring. IEAG members noted that a mainland buffer trapping regime for Kaikoura Island and Ipipiri islands failed to prevent multiple incursions.

Incursion response techniques employed a variety of tools and techniques, sometimes sequentially and other times collectively. Responses often began with localised trapping and/or use of bait stations. Detection devices such as tracking tunnels were in cases modified as trap or bait stations to target animals at a site of known visitation. Poison baiting with brodifacoum baits was sometimes used, if trapping did not eliminate invaders quickly. Baits were typically deployed by bait station but in rare cases by hand spreading. A problem common to those involved in incursion responses was delineating the outer extent of the treatment area, sometimes dogs were used to inform these decisions.

3. If choosing a control strategy what is the best practice for technique, timing and tools?

Most of those involved in a sustained control strategy used brodifacoum baits (Pestoff rodent bait or Pestoff Rodent Blocks) in bait stations during the winter months. Bait stations were laid on a grid with lines 50m apart and stations every 25m along those lines. Mouse control in Zealandia using this technique appears to have maintained mouse population seasonal peaks below the level of seasonal troughs previously observed when mice were uncontrolled. Larger grids were discussed and it was agreed that 50m by 50m grid may work but take longer to achieve control. It would be important to treat a move to a wider grid as a trial and monitor inputs and results carefully to ensure the potential disadvantages to the level of control achieved and time required do not outweigh the labour saving advantages. Forty metres by 40m grids are known to have failed on island eradication projects in the past. Grid sizes larger than this were likely to leave too many mice unexposed to the baits and the required level of control may not be achieved in time.

Maungatautari Mountain uses diphacinone (Ratabate hard blocks) monthly baiting on a 25m by 50m grid around the fence line in combination with traps with some success. This method was also used at Kaena Point in Hawaii with a different diphacinone bait product.

The group discussed the potential residue issues surrounding the ongoing use of brodifacoum baits. There is now plenty of evidence that ongoing use of brodifacoum baiting results in widespread low level contamination of wildlife. However the consequences of these levels, (e.g., sub-lethal effects at a population level), is not known and would be a useful area of future research. Alternative toxins include diphacinone and coumatetralyl, both first generation anticoagulants requiring animals to feed for several consecutive days to effect a lethal dose. These chemicals are proven in rat control and can be effective on mice but because widespread mouse control is not often undertaken there is very little data available to identify best baiting practices or products. Mice tend to be naturally more resistant than rats to first generation anticoagulants, especially for acute single dose strategies. . At Tawharanui and Shakespear the approach is to go straight to brodifacoum when a rat incursion is detected because a single feed will kill a rat and it's uncertain if an invading animal will stick around for multiple feeds.

So far only Maungatautari have changed toxin but others are aware of the issues and take steps to minimise the amount of bait input into the system. For example Zealandia chose winter only baiting for several reasons:

- Mice are relatively hungry with fewer food resources available, so take the bait readily
- Mouse populations are seasonally low so total bait take is low
- Invertebrate, tuatara and lizard activity is seasonally low which should reduce non-target exposure through both primary and secondary exposure (e.g., to birds through insects).

Bait is out in the stations for about 1 month in 12 and this is enough to drive populations to undetectable levels post baiting. From this low level mice populations build to relatively low maximums in autumn.

Other sites have used or experimented with trapping as a control method. Most have found it ineffective during peak population levels but have yet to try it mid-winter. A range of traps have been tried using a range of trap covers but there is little comparable data available to identify a single 'best trap'.

4. Surveillance & monitoring

There was plenty of discussion around monitoring and surveillance techniques. Participants agreed that even though the same tools are often used, the two purposes require quite different approaches. For example surveillance seeks to maximise the probability of detecting animals so devices are placed in the most likely places (whilst still covering the area) and operated for as long as possible with a variety of baits or lures to provide for as many individual tastes as possible. A monitoring index by contrast should have standardised devices on randomly placed transects, operating independently from the grid of devices used for control. The fact that this approach yields fewer detections per device is of little consequence compared with the benefit of measuring an index which is comparable over time at the same site regardless of control technique used and very loosely comparable between sites.

Those involved in a sustained control strategy need a 'common currency' monitoring technique if control methods and pest impacts are to be compared between sites. The most obvious option is to use the DOC standard protocol using tracking tunnels to monitor rodents and mustelids (Gillies and Williams, 2005). It was common for people to try to change details of the protocol which is counter-productive to the objective of gaining a common measure between sites. Often these changes were motivated by other needs but researchers present were keen to point out that because the protocol gave an index of the population, it did not need to be 'enhanced' by changes to achieve the index and in fact was 'harmed' by changes rendering comparisons invalid. However the tunnel spacing recommended by Gillies and Williams (50m) does make it difficult to 'fit' enough monitoring lines into small sites to give robust data.

A key question for further resolution among those moving to the sustained periodic control strategy is whether the potential advantages of using a universally agreed monitoring protocol outweighed the disadvantages, and if so what technique to agree on using and how the data should be shared. It was pointed out in discussion that individual variations which collected more than the agreed minimum data were fine, it was only those that confounded the results that should be avoided if this was to be pursued.

Zealandia have chosen to monitor their mouse populations using a 25m by 50m trapping grid operated for 3 nights, adhering closely but not entirely to the standard trap monitoring protocol (Cunningham and Moors, 1993). This was chosen over tracking tunnels because it allowed collection

of biological data from trapped animals (eg sex, breeding status, age class). Other sites preferred the convenience of tracking tunnels.

Surveillance focussed on more than just mice and for some sites mice were not the target species and represented an interference to surveillance for other species. Ways of reducing or avoiding this interference included:

- Using traps with heavier triggers (i.e. not set off by mice) to target larger mammals such as rats and mustelids (eg DOC 200 trap).
- Collecting tracking cards before they became saturated with mouse tracks or otherwise interfered with. Rat and other mammal prints remain discernable amid a sea of mouse prints even when only a partial print has been made. At some sites tracking cards are checked more frequently and replaced as necessary.
- Undertaking sustained control of mice to keep populations to a level where the interference was not a hindrance.

It was pointed out that in some cases the presence of mice through tracking tunnels or trap boxes may become an attractant to invader Mustelids and therefore be beneficial. It is important that mouse traps are not accessible to rats because rats will be attracted to the same baits and could learn to avoid tunnels if they experience a whack from a mouse trap.

Other innovations discussed for surveillance were:

- Some dog handlers are able to distinguish their dog's reaction to mice vs rats and reward the response of their dogs accordingly which aids the searching for mice in the presence of rats.
- Ka Mate reverse trigger traps are being trialled on Quail Island to reduce lizard and bird by-catch. They found the baits supplied were too big and changed to popping corn soaked in peanut oil with better results.
- Peanut butter is often taken from tracking tunnels by invertebrates rendering them less effective. This can be overcome by putting the peanut butter in a specimen vial secured in the tunnel. The vial has small holes drilled in it to let the odour escape but reduce invertebrate take.

It was agreed by the group that a range of surveillance tools need to be applied to detect multiple pests but given the tools available, mice are readily detected. Research indicates that devices at a minimum 1/ha density and for a minimum exposure of 5 days will detect mice if they are present.

References

D.M. Cunningham and P.J. Moors 1993: A Guide to the identification and collection of New Zealand rodents (2nd edition). Department of Conservation, Wellington.
http://www.doc.govt.nz/upload/documents/science-and-technical/rodent-identification.pdf

Gillies, C.A.; Williams, D. 2005. *Using tracking tunnels to monitor rodents and mustelids.* V2.5.1. Department of Conservation, Research, Development & Improvement Division, Hamilton. OLDDM-118330.

Appendices

Incursions and management of mice at fenced mainland sites and near shore islands – case histories. – Spreadsheet compiled by Matt Maitland DOCDM-1035657

Rodent eradication Research at University of Auckland – Compiled by James Russell DOCDM-1035669.

Interim summary report on mouse impact research at Maungatautari – Provided by John Innes. DOCDM-1035665

List of Participants

Pam Cromarty, Pete McClelland, Keith Broome, Chris Golding – DOC IEAG members.
Matt Maitland, - Auckland Council
James Russell, University of Auckland
Raewyn Empson, Bernard Smith - Zealandia
Mike Bowie ,- Quail Island Trust
Paul Quinn, Maungatautari Trust
John Innes, Deb Wilson, - Landcare Research
Simon Collins – Rotokare Sanctuary
Elton Smith, - Orokonui Sanctuary
Karen Vincent, -DOC Conservation Dog Programme
Eric Edwards, Alastair Bramley – DOC observers

Incursions and management of mice at fenced mainland sites and near shore islands – case histories.

A questionnaire regarding management of mice was circulated in June 2012 to managers of fenced mainland sites and near shore islands (three peninsulas, four ring fenced sites and one near shore island). Below is a summary of responses, some assumptions have been made in compiling information and may contain some errors or omissions.

All sites have attempted eradication of mice. In all cases mice were one target species of multi species pest eradication operations, i.e. none were a mouse only operation. All sites have reduced mice to non-detectable levels following aerial baiting operations, with mice being detected 3-8 months following aerial baiting. Eradication methodology for Kaena Pt was first generation anticoagulant by bait station.

In most cases mice detected have been assumed to be invaders rather than survivors of eradication. This assumption is based upon time from eradication to first detection and general pattern of first and subsequent detections at perimeter of site rather than interior.

A management feature of many fenced mainland sites or near shore islands is an increased pest detection and control activity than most pest free/eradicated offshore islands. This reflects an identified increased risk of pest incursion and consequent impact at these sites due their geography, pest management and restoration goals. This high level of monitoring activity allows for a reasonable understanding of patterns of mouse incursion/invasion or re-establishment following failed eradication.

All sites have observed conservation outcomes, many of these nationally and regionally significant, despite presence of mice and the use of mouse control tools. Negative impacts of mouse presence upon invertebrate and reptile values have been observed at some sites, though for reptiles this impact can be described as observed gains being less than if mice were removed along with other pests. Reintroductions of absent species perceived to be threatened by mice have been deferred or delayed. Where undertaken these reintroductions have succeeded.

Management of mice varies greatly between sites, ranging from tolerated and unmanaged, to seasonal suppression, to manage to zero density. Where sites have shifted focus from eradication (zero density) to some form of lesser control the justification has been an inability to sustain pest management activity at the required level. In several cases this has been supported by an apparent low prospect of achieving the original goal.

Mouse management tools (poisons and traps) also pose a small but real threat to extant or returned native species. Site managers report these observed impacts as low and by extension an acceptable impact when compared with an unchecked mouse population.

Site managers report that mouse presence compromises other aspects of site management, particularly pest management via pest exclusion fence breach (burrowing) or contagion of other pest and wildlife management tools.

Pest detection and control devices vary between sites. Bait stations and anticoagulant poison, snap traps and tracking tunnels are common to all; however they vary greatly in spatial and temporal deployment. All sites appear to currently or historically use a combination of fixed infrastructure and additional response measures. All sites appear to have undergone a dynamic or adaptive management approach tweaking and refining methodology in response to results and other pressures.

Where mice are managed to reduced densities, significant reductions in mouse abundance are achieved (80-90% reduction or maintenance below target tracking threshold). Where monitoring occurs these reduced mouse densities correlate with increased wildlife outcomes.

Incursions generally occur at site perimeter, either at coastal fence ends for peninsulas or along perimeter fence. This can be due to any of the lack of barrier (fence end), fence breach (damage event) or fence leakage. In some cases these pathways are assumed from available clues but in at least two cases proven using Rhodamine B studies. Incursions have also been noted at sites of

human activity (biosecurity lapses). Mice have been observed being carried over exclusion fences by avian predators, although no records of live mice are known by this pathway.
Patterns of invasion, where populations establish, are commonly 'rolling front' of population expansion from detected incursion point(s). Many sites have seen in parallel with this isolated point detections of outlying invader mice, with distances between detections exceeding 300m. This aspect has significant resourcing implications as it challenges the imposition of containment cordons and necessitates a continuous widespread detection effort at reasonably high intensity.
Studies of mice before and after eradication of other mammalian pests has shown that mice exploit a wider range of habitats and are heavier and longer lived than when they compete with other mammals. Initial irruptive peaks of mouse abundance appear unable to be sustained and populations tend to plateau at a slightly lower level.
The table below summarises responses to a questionnaire sent to site managers in June 2012.

Matt Maitland
July 2012
Address for correspondence: matt.maitland@aucklandcouncil.govt.nz

Acknowledgements and permissions
Thanks to the site managers of Zealandia, Orokonui, Rotokare, Quail Is, Kaena Pt, Maungatautari, Tawharanui and Shakespear fenced or island sanctuaries for providing information regarding mice at their sites. Site information contained in this document should not be replicated or referenced without permission of the relevant site manager.

Site	Tawharanui	Shakespear	Zealandia	Orokonui	MEIT mountain	MEIT (Enclosures and wetlands)	Rotokare	Kaena pt	Quail
Site type	Fenced peninsula	Fenced peninsula	Ring fence	Ring fence	Ring fence	Ring fence	Ring fence	Fenced peninsula	Island (near shore)
Area (ha)	550	500	225	307	3400	97 (30+65+2)	230	20	81
Eradication date (aerial op)	Spring 04	Winter 11	Spring 99	Winter 07	Nov 06 and Sep 08	2 x Winter 05, 1 x winter 07	Spring 08	Mar 11 (diphac by b/stn)	Winter 09
Were mice eradicated (undetectable) ?	Probably not	Yes	Yes	Yes	Yes	Yes	Yes	Yes	?
First detection of mice	Dec 2004 (3 mth)	Dec 11 (4 mth)	Feb 00 (5mth)	Feb 08 (8mth)	Dec 08 (3mth)		April 09 (7 mth)	8 mth	Feb 10 (6mth)
Invasion source	Fence end and internal (probably survivors) Fence end movement shown using Rhodamine B	Fence end, mainly southern. Human activity imports (campground and defence	Fence (assumed due fence flaws)		Fence edge	Perimeter via fence breach	Perimeter and internal	Single detection (fence end)	1 x potential incursion, others possibly survivors.

		base)							
Invasion pattern	Multiple rolling fronts, interior and fence	Perimeter (fence end) and pepperpot	Perimeter discreet area in interior	Perimeter with random activity points in interior	Perimeter then interior (historic)	Perimeter.	Isolated detections		Pepper pot
Mgmt focus - shift from eradicate to manage	2005 shift to 1/ha b/stn suppression. Abandoned late 2007, mouse presence accepted		Nov 00. Perimeter mgmt trial 00-02. Nil mgmt 02-04. Annual mouse mgmt 04 - present	2011 after evidence of multiple leakages.	Nov 11.	Eradicate (zero density)	Maintain zero density target	N/a	Feb 2011 - no control
Rationale for change	Control programme unable to deliver gains, resources to upscale not available.	N/a		Sustainability and winnability	Financial sustainability. Success not apparent.	N/a	N/a	N/a	Unsustainable, nil progress

Suppression/ control activity	Track tunnel 1/ha, denser at hot spots/weak points. B/stn 1/ha average, most lie idle for incursion response	TT 1/ha Mouse trap 1/ha inside/beside DOC 200 or B/S Mouse buffer external Mouse control tools exceed detection tool density Camera traps at fence ends	B/stn 25 x 50m grid, 50-100g bait /stn – usually in winter. Unbaited traps in 1 ha encl. Index traplines bi-monthly as audit.	TT 50 x50m, with extras at hot spots. Ttunnels used as snap trap/bait delivery. B/stn in mouse areas.	Was TT 1/ha, At incursion points 4ha 25x50m b/stn and traps. Now fence edge mgmt only.	TT 50 x 50, detect and eradicate.	TT 50 x 50, denser at hot spots. Run quarterly/biannual directed by historic site risk. Snap trapping continuous.	TT 50m, 25m within 100m fence end Live and kill traps Camera traps	Trapping 10m grid 50m around point, bait broadcast 50m
Habitat or seasonal mouse activity patterns	N Goldwater MSc thesis Autumn to spring peak, all habitats Mice heavier and longer lived	n/a	Grass habitat held higher numbers. Lowland forest winter peak. Breeding period extended when @ low density					N/a	Feb/mar peak. Winter low.

Non target impact of mouse presence	Mice reduce but not preclude shore skink juvenile recruitment (Wedding MSc thesis) NZ dotterel non target death via brodifacoum b/stn use High mouse density reduced efficacy of incursion response 2008 ship rat breeding population (non target bait consumption, snap trap clogging). Mouse presence compromises efficacy of	Ornate skink mouse snap trap bykill. Mouse presence compromises efficacy of incursion surveillance and response tools	Reptile and giant weta reintro postponed. No observed impact when released. Tuatara bred successfully in presence of mice. Ornate skink increase where mice controlled, high mouse density impact on this spp unknown but presumed to be high. Bird supp feeder use compromised. Mouse presence compromises efficacy of incursion surveillance	None identified	Ref Innes study.				cave/ground weta & scarab beetle numbers significantly down (ground beetles also effected) when mouse numbers high (& vice versa)

	incursion surveillance and response tools		and response tools						

Non target impact of mouse control	NZ dotterel non target death via brodifacoumb/stn use		Snap trap by catch. Weka impacts. Other birds difficult to discern impact of brodi use inside v outside use by other agencies. Most spp increasing.	Tomtit +ve brodi, snap trapped passerines, possible saddleback via b/stn operation.	Snap trap avian bycatch		Snap trap avian bycatch (low)	Mynah and crab bycatch	Mallard and pheasant bait victims, skinks and exotic birds trap bycatch

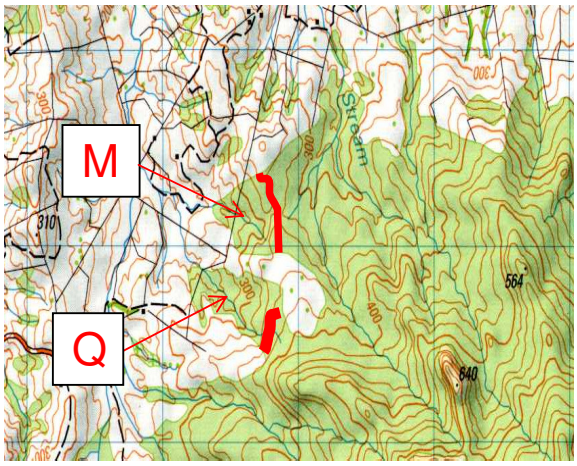
Interim summary report on mouse impact research at Maungatautari, to May 2012

Prepared for funders (Waikato Regional Council, Auckland Council), the landowner (Bill Garland) and research participants (Deb Wilson, Neil Fitzgerald, Corinne Watts, Mark Smale, Scott Bartlam, Danny Thornburrow, Maj Padamsee, Gary Barker, Peter Johnston, all Landcare Research; MEIT).

Background: Bill Garland's 17 ha QE II block was pest-fenced in 2006 and all mammal pests except mice were removed in the following 2 years. Mice were eradicated in May 2008 and the block remained pest-free until May-Aug 2009, since when 80-100% of tracking cards placed there have shown mouse tracks.

In April 2011, Waikato Regional Council agreed to fund Landcare Research to take advantage of the opportunity offered by the QE II block to examine the biodiversity impacts of mice. The question was regarded as important because the main 3400 ha pest-fenced Maungatautari reserve by this time also had mice in the absence of other mammals, as have several other pest-fenced sanctuaries around NZ. Landcare Research also uses public good science funding to address this question, and Auckland Council funded some extra work on mouse impacts on fungi in the 2011-12 year.

Study sites: We use one pest-fenced block with just mice ('Q block'; the more southerly of the two shown below), and an adjacent part of the main mountain reserve that until February 2012 had no mice ('M block'). Since February 2012, mice are steadily increasing in the previous 'non-treatment' M block. Forest and aspect and slope in the two sites are similar.



Study strategy: The study is likely to be funded for for a maximum of 3 years. We are measuring mouse density plus a range of biodiversity attributes in both blocks for up to this time. For the first 7 months there were no mice in the M block and many in the Q block, and so the first biodiversity measures were taken at a time when mice had been abundant for 2 years in the Q block and nearly absent from the M block. Maungatautari Ecological Island Trust staff will eradicate mice in the Q block during August-September 2012, while mice have now been 'let go' on the main mountain, including in our M block study site. This is then effectively a treatment switch between blocks, in terms of mouse abundance.

Methods: Techniques used to monitor various components of this study are as follows:

1. Mice: One night tracking tunnel index using DOC SOP but with systematic tunnel placement, each 3 months (May, August, November, February). Immediately after, an absolute density assessment using 64 Longworth traps in a 8x8 grid in each block, set for five nights and cleared daily, again each 3 months. Tracking rates at tunnels placed at head height (November 2011), and much higher (May 2012), to see if mice are up trees.
2. Invertebrates. Pitfall trapping and extraction from litter samples (Tullgren funnels) in both blocks, sampled April 2011, November 2011, April 2012.
3. Seedlings sampled in both blocks April 2011.
4. Fungi. Some filming at cafeteria situations where mushrooms were placed at a feeding site. DNA and microscopic analysis of faecal pellets to look for evidence of fungus consumption.

Results:

1. Mice (Deb Wilson, John Innes, Neil Fitzgerald, Scott Bartlam).

Provisional estimates of mouse density are shown in Figure 1. The estimates will change as additional trapping sessions are completed, because capture probabilities of mice in relation to their location and movements will be estimated from the entire data set.

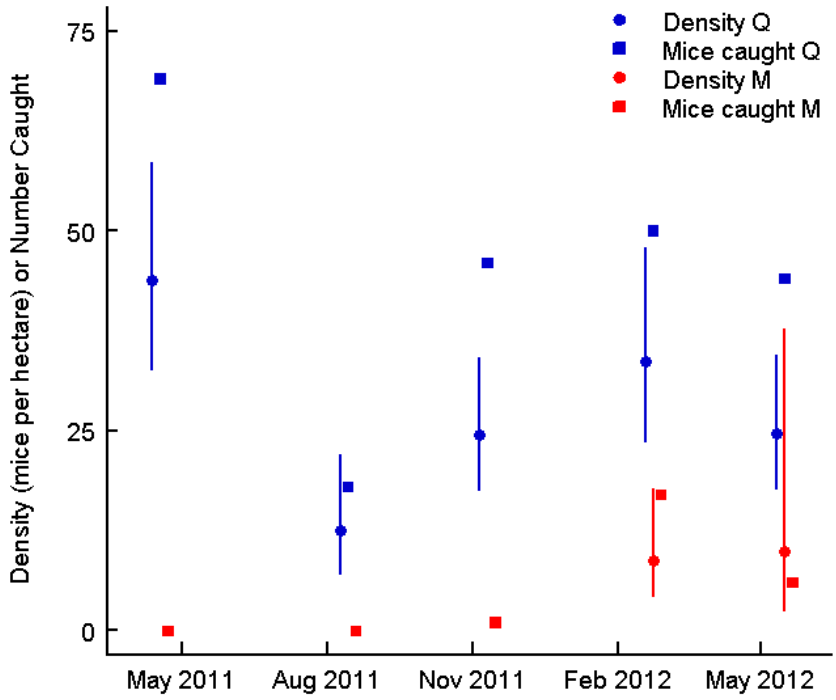


Figure 1. Provisional estimates of house mouse density (number of mice per hectare), and numbers of individuals captured in each trapping session, in the Q (QE II) and M (Shorty) blocks at Maungatautari Ecological Island. There were too few captures on the M block to estimate density until February 2012. Error bars show 95% confidence intervals on density

estimates. The large confidence interval in M block in May 2012 occurred because there were only two recaptures in that session.

So far, these results show typical seasonal fluctuations in mouse density on the QE II block, with high density in summer and autumn following spring and summer reproduction, a decline in winter after reproduction ceases, and a gradual increase during the following breeding season. Densities in Q block (15–50 per hectare) are similar to estimates in forest and alpine ecosystems after masting events (Ruscoe et al. 2001, 2003; Wilson and Lee 2010), but lower than an estimate (160 per hectare) in rank kikuyu grass in the partially fenced sanctuary at Tawharanui (Goldwater 2007, 2012). Density in Q block was lower in autumn 2012 than in autumn 2011.

On the M (Shorty) block, mouse density is clearly beginning to increase. Now that mouse control there has ceased, density may rise to a similar level to that on the QE II block and may even be greater on the main mountain than in the QE II block for a while, given that a large food supply will have built up there in the preceding years with very few mice. (Although far fewer individual mice were captured in M than in Q in May 2012 [6 vs. 44], density did not differ significantly between the blocks because there were only two recaptures in M, leading to a very imprecise density estimate; Fig. 1).

At ground level, tracking rates have been near 100% all the time in the Q block and up to 40% recently in the M block. Note that the tunnel lines cover a much bigger area and are more widely spaced than the live traps, explaining the disparity between the biggish recent index in M block and the sparse live captures. Ten (67%) of 15 tunnels placed at head height up trees for 6 nights were tracked by mice in Q block in Nov. 2011, and 2 (15%) of 13 tunnels placed at 8-20 m above ground for 7 nights in May 2012 were tracked. In the latter case, the two tunnels tracked were at the lower end of those placed, but they were still quite high (see tracking tunnel) for a mouse to be.

2. Invertebrates (Corinne Watts, Danny Thornburrow, Scott Bartlam, Gary Barker).

Only samples from April 2011 have been fully extracted and processed. This snapshot showed that the pitfall trap samples from the Q (mouse) block had approximately half the number of beetle adults, spiders, pill millipedes, weta and total invertebrates of the M block. Furthermore beetles and weta in the Q block were on average half the size of those in M. Litter samples told the same story. There was half the number of caterpillars, beetle larvae, adult beetles and total invertebrates in Q block samples, and again beetle adults were half the size of those in M block. Landsnails have been (painstakingly!) sorted from the dry litter remaining in Tullgren funnels, but not yet analysed. In vertebrate samples collected from November 2011 to February 2012 and in April 2012 have yet to be sorted and analysed.

3. Seedlings (Mark Smale, Danny Thornburrow, Maheswaran Rohan).

So far, seedling numbers have been analysed as totals only, combining cotyledonary (weeks old), mixed-leaf (months old) and true leaf (several years old) individuals together. Of the individual species in sufficient numbers for analysis, total numbers of (large-seeded) nikau and supplejack seedlings are indicatively ($p<0.1$) more common in M (low mice) than Q.

Table 1: Mean densities of cotyledonary, mixed-leaf and true-leaf seedlings (<15 cm tall) in thirty-six 0.25 m2 plots in each of Q and M blocks, western Maungatautari. I = indicative ($p<0.1$).

Block	Q				M			
Species/Size	Cotyledonary	Mixed-leaf	True leaves only	Total	Cotyledonary	Mixed-leaf	True leaves only	Total
Kawakawa	4.7	2.9	0.8	8.3	2.6	0.8	0.8	4.3
Mangeao	0.03	0.03	1.8	1.9	0.1	0	3.2	3.2
Pigeonwood	0.1	0.2	1.8	2.6	0.1	0.03	1.7	1.8
Nikau	0	0	0.5	0.5 I	0	0	1.6	1.6 I
Kanono	0	0.1	0.3	0.4	0	0.2	0.3	0.4
Supplejack	0	0	0.9	0.9 I	0	0	1.7	1.7 I
All species	0.6	10. 8	8.5	25.6	3.2	2.7	10.1	16

4. Fungi (Maj Padamsee, Peter Johnston)

No mice were filmed visiting fruiting bodies of known edible and other mushrooms in the 48 hours that they were presented. Fungal DNA was successfully amplified from 14 of 54 examined faecal pellets, however good quality DNA sequence data were obtained from only three of these. When the DNA sequence data was compared with the data from GenBank (a repository of DNA sequences) via BLAST searches, the sequences were found to correspond to species from Polyporacease (bracket fungi) or Corticiaceae (crust fungi). None of the sequences corresponded to fleshy mushrooms. Several kinds of fungal spores were observed in 12 of 17 pellets examined microscopically, but most were in small numbers. These were typical of mushrooms, bracket fungi and arbuscular mycorrhizal fungi. Several spores from plant pathogens, including rusts and hyphomycetes were also observed. The results suggest that fungi are not a major constituent of mouse diets, although the pellets examined were not collected at the time of the main autumn fruiting by fungi.

Interim conclusions and future work:

IF these results are paralleled on the adjacent main mountain, then mouse densities will be high (15-50 per hectare) on Maungatautari in the absence of other mammals, with density varying seasonally from a summer-autumn high to a winter low. In the QE II block, mice are most abundant on the ground, but routinely forage to head height and occasionally much higher. Whatever impact they have, it will not be confined to the ground. A halving of invertebrate biomass and size, and reduction of nikau and supplejack seedlings in the Q block is consistent with mouse impact but we cannot conclude a causal relationship between factors until we have completed the eradication in Q block and then monitored biodiversity responses to the treatment switch. It is uncertain how much time after the switch will be required to detect invertebrate and seedling responses, if the impacts are real.

Mice clearly eat some fungi but further work is required to determine whether this is ecologically significant; however further funding for this is unavailable at present.

We are planning to use translocated bird nests and eggs to explore whether mice will eat bird eggs, in early 2013.

John Innes (and team)

Landcare Research, Hamilton, Dunedin, Auckland

6 July 2012.

References

Goldwater N 2007. Ecology of house mice within the Tawharanui Open Sanctuary Unpublished MSc thesis, University of Auckland.

Goldwater N, Perry GLW, Clout MN 2012. Responses of house mice to the removal of mammalian predators and competitors. Austral Ecology doi: 10.1111/j.1442-9993.2011.02356.x.

Ruscoe WA; Goldsmith R; Choquenot D 2001. A comparison of population estimates and abundance indices for house mice inhabiting beech forests in New Zealand. Wildlife Research 28: 173-178.

Ruscoe WA; Wilson D; McElrea L; McElrea G; Richardson SJ 2004. A house mouse (*Mus musculus*) population eruption in response to heavy rimu (*Dacrydium cupressinum*) seedfall in southern New Zealand. New Zealand Journal of Ecology 28: 259–265.

Wilson DJ; Lee WG 2010. Primary and secondary resource pulses in an alpine ecosystem: snow tussock grass (*Chionochloa* spp.) flowering and house mouse (*Mus musculus*) populations in New Zealand. Wildlife Research 37: 89–103.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Rodent Eradication Research at University of Auckland

Prepared for DOC IEAG Mouse Workshop
31 July 2012, Wellington

Dynamics of an experimental house mouse invasion

Helen Nathan (PhD Candidate) <hnat005@aucklanduni.ac.nz>

In December 2010, an experimental population of house mice mouse (*Mus musculus*) was established from a single founding pair on Saddle Island, in the Hauraki Gulf, simulating an island invasion. The population was intensively studied over an eight month period to determine the rate and pattern of population growth from the arrival of the founder pair, and to investigate the detectability of mice at low population density.

Population growth was recorded using regular Capture-Mark-Recapture sessions (m = 6) to estimate population size. We estimated population dynamic processes using a Bayesian integrated population model incorporating both a process model of density dependent logistic growth and an observation model of capture-recapture population size estimates. The island's carrying capacity was assumed to be known, based on estimates of abundance from a mouse population previously resident on Saddle Island and eradicated in 2008. The experimental population grew to a peak density approaching carrying capacity within five months of the founders' release (Figure 1). Population growth followed a classic logistic growth pattern, and with the onset of winter, seasonal weather became the most important factor regulating population growth. In addition to monitoring the invasion we also took genetic samples from the invasive population (n = 61). A surprise result was that not all sampled individuals were descended from the founding male and female. An unrelated adult female was first captured in March (three months after the invasion commenced), and the first of her offspring were captured in April. We concluded that the appearance of this new female in the population was the result of an independent incursion on the island.

Detectability of mice and the relationship of detectability to population density were investigated using selected common methodologies. Two detection devices were trialled; tracking tunnels and peanut-butter baited wax-tags. In addition, two strategies for tracking tunnel placement were also trialled; a single line at the likely point of future rodent incursions (a beach), and a widely spaced distribution within the interior of the 6 ha island. In both cases, devices were employed at a density of 1 ha-1.

Upon incursion on the island, the population founders ranged widely. Mice were highly detectable, even at low population density. Both tracking tunnels and wax-tags successfully detected mice at all levels of population density, although tracking tunnels had higher average success per line than wax-tags (95.0% ± 11.2 vs. 53.3% ± 32.2). Average success per line of tracking tunnels was shown to increase linearly with increasing population density (R^2 = 0.97, p = 0.02, d.f. = 3). However, detection success was satisfactory even during the initial incursion phase with success per line averaging greater than 50%. In terms of device placement, tracking tunnels were effective at detecting mice wherever they were placed, although tunnels spread out within the island interior (97.6% ± 6.3) were more successful on average than those placed in a single line along the beach (82.9% ± 30.4).

This experiment shows that house mice can rapidly establish populations of sufficient density to have negative impacts on native biota and ecosystems. Therefore, to prevent the establishment of stable invasive mouse populations, frequent surveillance of mouse-free areas and swift deployment of contingency measures upon detection are necessary. It is encouraging that currently employed detection methodologies appear to be adequate.

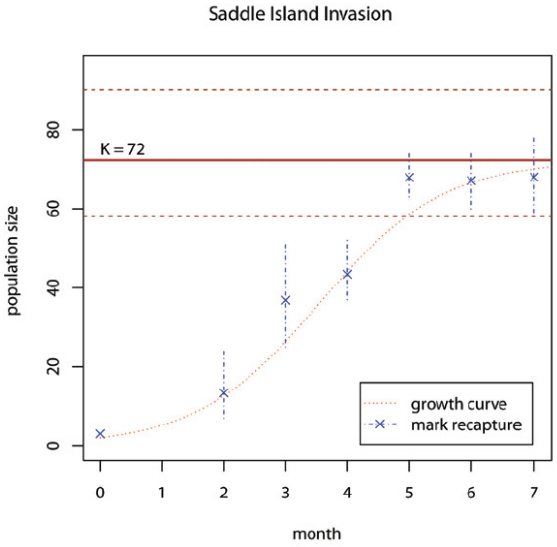


Figure 1: Integrated population model of introduced house mouse invasion on Saddle Island; incorporating capture-mark-recapture data collected over an eight month period from experimental introduction of two founder house mice. Dashed straight lines are 95% credible intervals for mark-recapture population size estimates and carrying capacity, K.

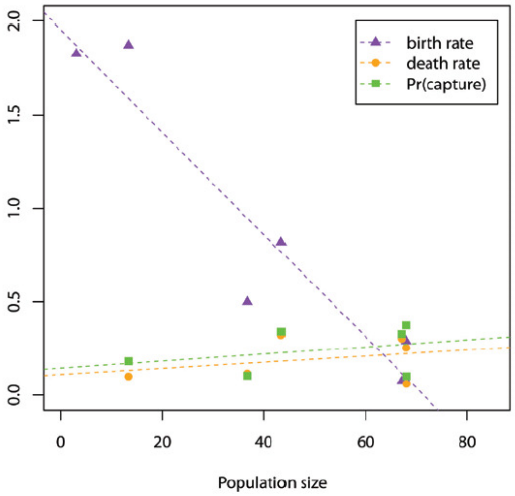


Figure 2: Relationships of birth rate, death rate, and probability of capture to population size during experimental colonisation of Saddle Island by house mice.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Rapid assessment of rat eradication after aerial baiting

Araceli Samaniego-Herrera (PhD Candidate) <araceli.samaniego@islas.org.mx>

Eradication of introduced rodents on islands is increasingly implemented as a conservation tool. Aerial broadcast of toxic baits is surpassing ground application of bait as the main eradication technique. Aerial baiting itself provides no information on whether eradication has been achieved, while in contrast monitoring bait-take from bait stations does provide information on success or failure during the application process. Eradication success for aerial baiting has been usually evaluated by waiting a standard period of two years with no sign of rodents. It is clearly advantageous to assess the success or failure of aerial eradication operations immediately after the bait application so that survivors, if any, could be located and killed by localised control methods. This avoids repeat aerial baiting of the whole island if and when failure becomes apparent. Here we describe a novel approach to assess success on a project to eradicate *Rattus rattus* using aerial baiting from Isabel Island (82 ha), a Mexican tropical island. A spatial-survey model that uses the detection-survey data in which no rats were detected was developed using detection and home-range parameters obtained from a capture-mark-recapture study prior to the eradication. The spatial-survey model estimated a > 99% probability of success after three surveys with no rats detected within two years. This model is a useful tool for (a) assessing the probability of eradication within weeks, rather than years of an operation, and (b) for predicting the required survey effort to achieve a probability of success consistent with the costs and risks of falsely declaring eradication success. Rapid assessment results in financial savings by potentially reducing the duration of the eradication operation. Improvements in biosecurity guidelines might also accrue since delays in detecting rats after an operation may confound their identification as offspring of survivors or reinvaders. Advancing techniques and predictive modelling will increase confidence among partners and donors and speed the development of regional programs.

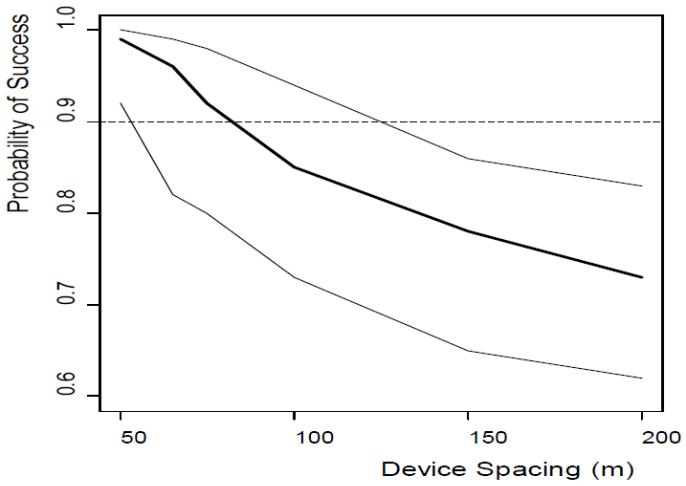


Figure 1: The median and 95% credible intervals (CI) of the probability of operational success after the rat eradication on Isabel Island decrease with increasing spacing of wax tags (devices). The horizontal dashed line is the threshold above which the lower 95% CI should be above.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

See how they run: potential mate-finding Allee effect avoidance in house mice

Jamie MacKay (Research Fellow) <j.mackay@auckland.ac.nz>

The behaviour of individuals at low population density and the potential Allee effects exhibited in low density populations are important aspects of conservation biology, particularly in the management of invasive species. In order to successfully establish in new areas invaders must overcome the Allee effect. Understanding how invasive species such as the house mouse do this will allow better surveillance systems for mouse-free sanctuaries to be developed. Sixteen mice were experimentally released in pairs (one of each sex) at opposite ends of a newly mouse-free island to investigate mouse behaviour at low densities by simulating a new invasion with each release. Behaviours shown by released animals were compared to those shown by animals living in a moderate-density population on the same island prior to successful mouse eradication. Released animals showed significant increases in ranging behaviour that allowed them to come into contact with each other. Range areas were ten times larger than those in the established population and nightly movements were double. Comparing range overlaps between breeding and non-breeding seasons suggested the drive behind increased ranging was mate finding. The altered behaviour exhibited by released animals may be an adaptation to avoid Allee effects.

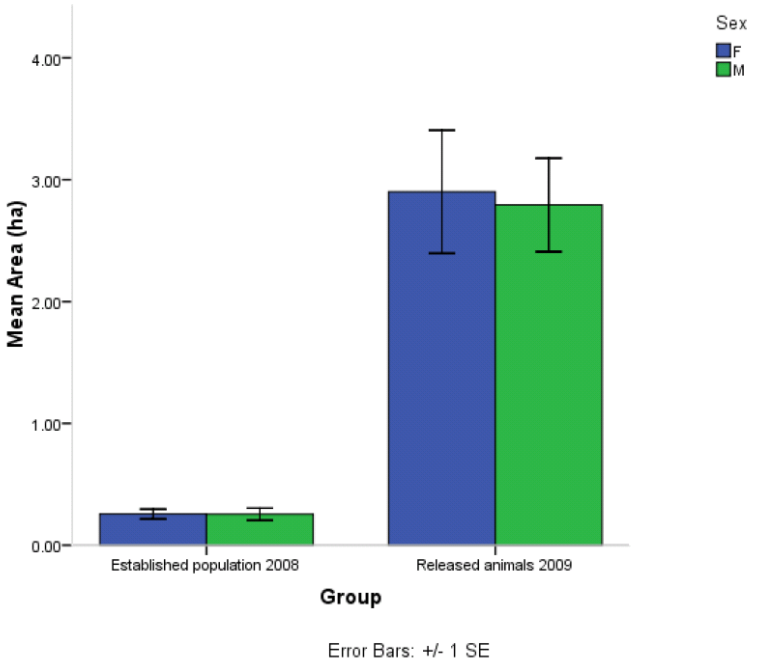


Figure 1: Mean area covered during tracking by males (blue) and females (green) in the established population and released animals

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Spatio-temporal patterns of introduced mice and invertebrates on Antipodes Island

James Russell (Lecturer) <j.russell@auckland.ac.nz>

House mice (*Mus musculus*) are a widespread introduced species with major but often overlooked impacts on ecosystems, proportionally greater when they are the only introduced mammal present. Studies conducted on the ecology of mice on Antipodes Island, where they are the only introduced mammal, are presented and compared to previous work over the past four decades. Mice live-trapped on grids were more abundant in dense coastal tussock (147 mice/ha) compared to inland plateau grasslands (59 mice/ha), with a significant effect of age, but not sex, on both capture probability and range size. Body-size of mice has not changed over four decades, providing no evidence of gigantism, which on other Southern Ocean islands has been speculated to increase the predation risk to birds. Over 2,405 invertebrates from fourteen Orders were identified from pitfall traps and litter samples across five sites. Differences in invertebrate communities and taxonomic units attributable to habitat and altitude were detected among sites in both pitfall and litter samples on Antipodes Island. Differences in invertebrate communities were detected from litter samples on a neighbouring mouse-free island, with significantly greater abundance of large Amphipods and Collembola, but fewer Spiders. These data on introduced mouse ecology and invertebrate distribution on Antipodes Island contribute to the body of knowledge on Southern Ocean islands.

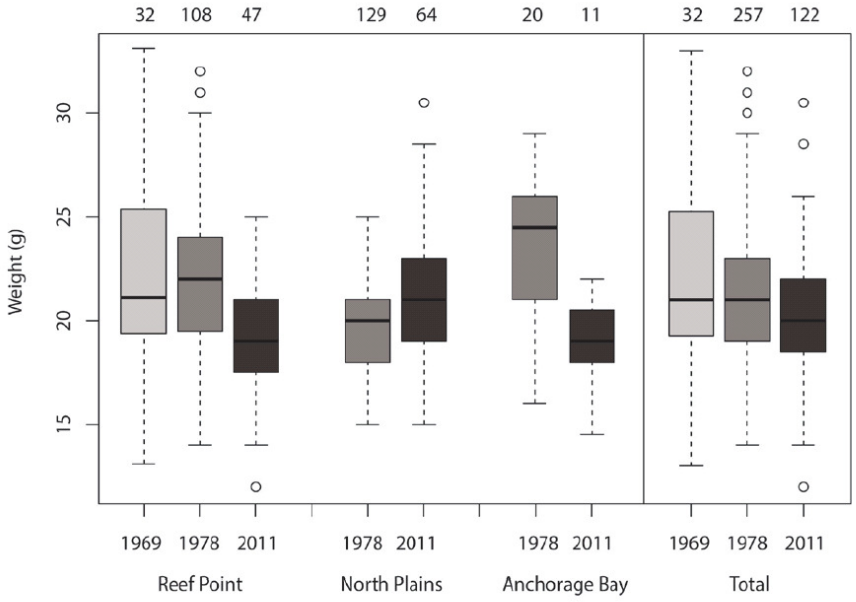


Figure 1: Weights of adult mice (body length >72 mm) at three sites and overall on Antipodes Island in 1969 (Taylor), 1978 (Moors) and 2011 (this study). Bar lengths correspond to 75th and 25th percentiles, *dark lines* within bars medians, and whiskers 1.5 times the interquartile range. Sample sizes are above.

Reference: Russell, J.C. Spatio-temporal patterns of introduced mice and invertebrates on Antipodes Island. *Polar Biology*, 35 (8), 1187-1195, 2012.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Body size of introduced rodents on Pacific islands: A test of Bergmann's rule

Aaron Shiels (Research Fellow) <ashiels@hawaii.edu>

Body sizes of animals are affected by several factors, including temperature, resources, and trophic interactions. Bergmann's rule applies to warm-blooded animals and states that the body size of a given species increases with decreasing temperature, and latitudinal gradients are often used as proxy for temperature changes among areas. Introduced rodents, primarily three species of rats (*Rattus exulans, R. rattus, R. norvegicus*) and the house mouse (*Mus musculus*) are among the most widespread vertebrates in the world. In the Pacific, *R. exulans* was introduced to most islands over 700 years ago and the other three rodent species were introduced around 140 years ago. Because these rodents are highly fecund (ca. 20-40 individuals/year from each adult female), changes in their body sizes from adaptations to island temperatures (latitudes) may already be detectable in extant populations. We assembled rodent body size data from approximately 150 Pacific islands, and used weighted mixed regression models to investigate species-specific variation and to test Bergmann's rule with the following predictor variables: latitude, hemisphere, elevation, island size, island type (atoll vs. non-atoll), habitat type, coexisting rodents and predators. There was strong support of Bergmann's rule for *M. musculus*, and tropical islands generally had much smaller mice (avg. body mass: 11.9 g) compared to temperate islands (avg. body mass: 20.9 g). There were no latitudinal relationships involving body sizes of *R. exulans* and *R. rattus*. Instead, local environmental relationships and interactions were the main predictor of rat body sizes. These species-specific patterns are likely to be explained by differences in fecundity, island introductions, dispersal, and arboreal behavior, as well as associations with the island rule and island syndrome.

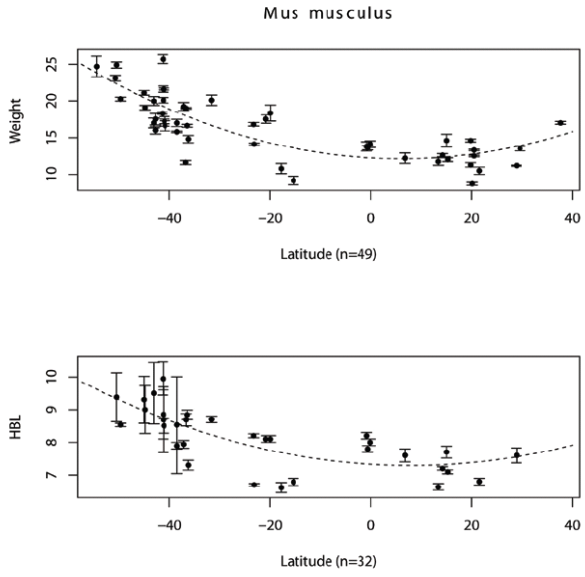


Figure 1: Relationship of mouse body-size to Latitude (negative are southern hemisphere)

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Genetic tools for sourcing invaders and database and analysis software

Rachel Fewster (Associate Professor) <r.fewster@auckland.ac.nz>

Since 2004, we have been collecting DNA samples from Norway rats (*Rattus norvegicus*) and ship rats (*R. rattus*) from around New Zealand, particularly focused on island groups and island-mainland systems. We now have over 1500 rat DNA samples, focused on the wider Auckland region, Hauraki Gulf, Great Barrier Island, Bay of Islands, and Stewart Island. We have also been involved with parallel work on stoats (*Mustela erminea*) conducted by Andrew Veale and Landcare Research.

We have found that genetic information can be helpful in determining the source of rodents and mustelids that are found on islands after eradication attempts. The genetic approach is particularly strong for detecting whether post-eradication animals are survivors of the eradication attempt, or reinvaders from a nearby source. In some situations, genetic results will give a conclusive source: this will usually happen if the source populations are separated enough for their genetic profiles to be distinctive, and if the number of possible sources is small and geographically tight – for example, if the only possibilities are survivors of the eradication, or swimmers from the adjacent mainland. An example of a conclusive genetic chart is given below, from the Broken Islands, off Great Barrier Island. The chart shows that post-eradication rats found on Flat Island (yellow squares) were certainly sourced from the Great Barrier mainland (blue triangles), and not survivors of the eradication (red circles). In other situations, DNA results may not be conclusive. However they are still likely to be useful at some level, because a lack of genetic distinction between populations tends to indicate that there is no barrier to movement or interbreeding between the populations.

Genetic information can also suggest locations suitable for eradication, because the level of genetic isolation indicates the amount of interaction between the target location and nearby locations that are potential sources of reinvaders. This approach must be used with care, as we have seen cases where island populations are genetically isolated, but the islands nonetheless experienced rapid reinvasion after eradication (the Broken Islands case is such an example). However, containing the reinvasions has been more successful on these islands than on islands that were not genetically isolated. The level of genetic connection might alternatively be used to suggest groups of populations that should be eradicated together as eradication units.

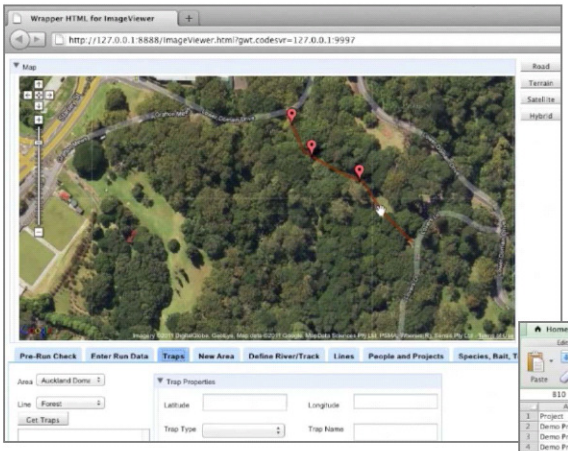
We are now developing software to act as a one-stop-shop for management of trapping records and DNA data, and to produce genetic charts like the one below at a few mouse clicks. The software is written by Sunil Patel and funded by the TFBIS scheme in collaboration with Dianne Gleeson and Landcare Research. The field-data component is linked to Google Maps: users can define trap-lines and place or move traps on the map, or alternatively import trap locations from a spreadsheet of GPS fixes. Catches are input to the database via a web entry form. The system provides ID labels for DNA samples which will be linked back to the catch records when the DNA data is returned from the lab. (Processing a single rat sample at the EcoGene lab costs about $45 + GST.) Once the DNA results are in the system, genetic charts can be produced very easily by selecting populations to compare and pressing Go.

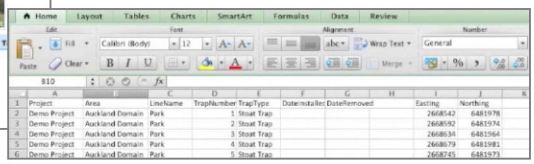
Although there has not yet been much work done on mouse genetics, we anticipate that the tools will be useful in the same ways as they have been for rats and stoats.

Reference: Fewster, R.M., Miller, S.D., and Ritchie, J. DNA profiling - a management tool for rat eradication. In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds) *Island invasives: Eradication and management.* IUCN, Gland, Switzerland, p. 430-435, 2011

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

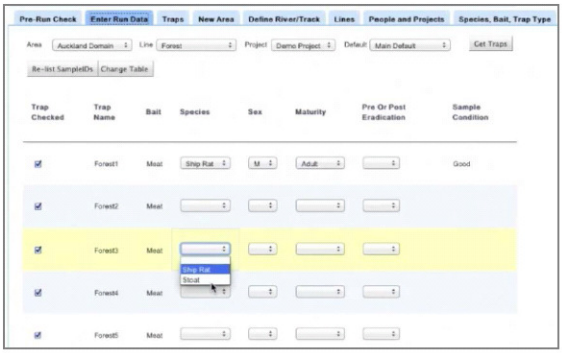
Screenshots from the database and analysis system:





Set up trap-lines and traps

Users can specify trap locations by clicking on the map (left), or by importing GPS data from a CSV file (below)



Web entry forms for trapping data

Easy-to-use data entry forms for trap checks and catches (left)

Genetic Data Analysis:

Create genetic charts

The chart gives invasion-source results for ship rats on the Broken Islands, off Great Barrier Island. Each point is one rat.

- *Red points are pre-eradication Broken Islands rats;*
- *Blue points are rats from the source on the main island;*
- *Yellow points are post-eradication rats found on the Broken Islands.*

The chart shows the post-eradication rats are swimmers from the main island, not survivors of the operation.