He Kōrero Paihama
Possum Research News

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Manaaki Whenua
Landcare Research

Poisoning Risks Associated with Brodifacoum

Brodifacoum, a second generation anticoagulant poison, was first used for possum control in 1992. Its use has increased significantly during the last two or three years following the development of cereal-based Talon® and PestOff® baits loaded with brodifacoum. This is partly because increasing concerns over the safety of using 1080, the primary toxicant for vertebrate pest control, have contributed to an increasing user-preference for brodifacoum bait over 1080 and other traditional toxicants (e.g., cyanide and phosphorus). Moreover, brodifacoum bait can be easily obtained. However, its wide-scale field use in New Zealand is unusual. In the USA and UK, brodifacoum use is restricted to the control of rodents around farm buildings, and even this causes concern in regard to secondary poisoning of birds and mustelids.

The acute toxicity of brodifacoum varies from an LD_{50} (the level fatal to 50% of individuals) of < 1 mg / kg in pūkeko to >20 mg / kg in paradise shelduck. In several species of mammals, including rodents, pigs and possums, the LD_{50} is 0.4 mg / kg. Because of the high toxicity of brodifacoum, all vertebrates that eat baits or prey poisoned with brodifacoum are at risk. This includes humans.

While there are numerous reports of non-target wildlife being poisoned by brodifacoum, there are no recorded incident to date of humans being affected by secondary poisoning through eating contaminated meat. However, there may be a risk of this occurring, as brodifacoum is unusually persistent in mammals and birds. Research by Charlie Eason and Geoff Wright have shown that brodifacoum persists in the liver of sublethally

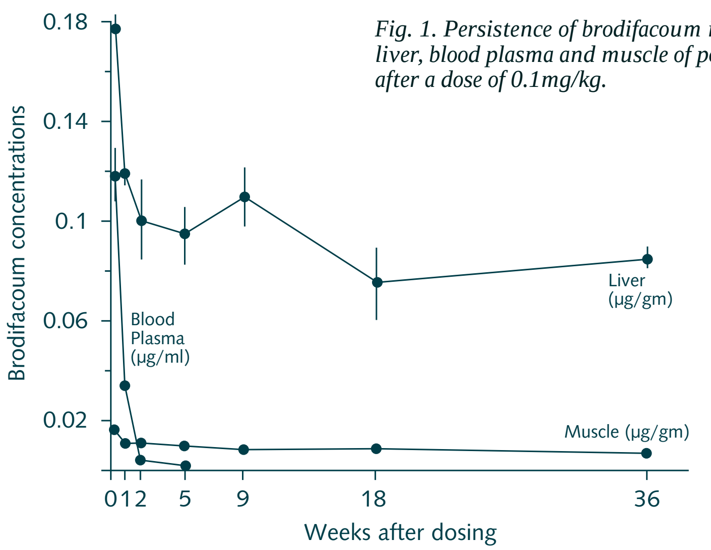


Fig. 1. Persistence of brodifacoum in the liver, blood plasma and muscle of possums after a dose of 0.1mg/kg.

A hunter carrying out a feral pig

poisoned possums for 9 months (Fig. 1). However, until now there has been little consideration of the potential dangers to humans arising from brodifacoum residues in possum carcasses or other wildlife, including game species.

Charlie and Geoff have recently established the presence of high concentrations of brodifacoum in the liver of domestic pigs, highlighting the potential secondary and tertiary risks associated with this toxicant. It appears that pigs scavenging dead or dying possums or rats are at risk of poisoning, and that there is a risk to humans in the subsequent transfer of brodifacoum residues, particularly if the livers of feral pigs are eaten. These risks are compounded by the remarkable persistence of brodifacoum in animal tissue, and will be heightened if pigs gain direct access to bait stations or repeated access to carcasses. People most at risk are likely to be those who occasionally eat possums or feral pigs.

Low levels of residues of brodifacoum have also been confirmed in muscle tissue in possums and pigs albeit at concentrations some 20 times lower than those found in the liver. While it might seem a sensible minimum precaution to recommend that the liver from all game be discarded (as highest concentration occurs in the liver), this may be impractical since game animals processed for sale must be submitted to meat packing plants complete with their livers.

Charlie and Geoff documented mean concentrations in possum livers of 0.08 mg / kg after administration of 0.1 mg / kg of brodifacoum. Based on a LD_{50} value of 2.5 mg / kg, they estimate that a 15-kg dog would need to eat 50 kg of possum liver containing 0.1 mg / kg, or 5 kg of liver containing 1 mg / kg to receive a LD_{50} dose; the latter value of 1 mg / kg being close to levels of brodifacoum obtained in possum and pig livers in their investigation. Similar calculations for humans suggest a 60kg man would need to eat 15 kg of this liver to receive a LD_{50} dose, assuming the LD_{50} for brodifacoum in humans is similar to that in dogs. However, this data may under-estimate the risk. Recent studies have detected concentrations of 1.7 mg / kg of brodifacoum in the liver of feral pigs, which is nearly twice that found in treated captive animals (Fig. 2). These higher levels of brodifacoum present in pig and possum livers could also represent a risk to humans as well as to predators such as harrier hawks and dogs, as the toxicant accumulates on repeated exposure. Also, it is important to remember that there could be sublethal as well as lethal effects in these species, and a sublethal dose well below the LD_{50} will produce significant perturbation in clotting parameters and some haemorrhaging.

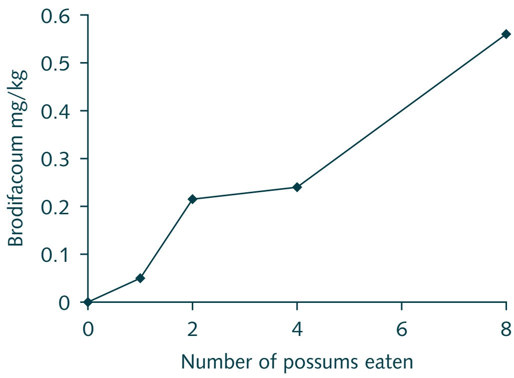


Fig.2. Concentration of brodifacoum in the livers of pigs fed with possums that had eaten 400g of cereal bait containing 20mg/kg of brodifacoum

Geoff and Charlie consider "it is important that we complete ongoing wildlife surveys to establish the actual concentrations of brodifacoum occurring in possums, pigs, and other wildlife and hence the seriousness of the risk to humans". The finding of 1.7 mg / kg of brodifacoum in feral pigs and the detection of brodifacoum residues in an increasing number of wildlife species, including native birds such as kiwi, raises serious concerns about the long-term effects of wide-scale use of brodifacoum in New Zealand. Efforts are being made to limit game hunting in areas where possum control programmes are undertaken. Nevertheless, some restrictions or vigilance on the wide-scale field use of brodifacoum bait seems warranted.

This work was funded by the Department of Conservation.

Charlie Eason *is a toxicologist and Team Leader of the Pest Control and Wildlife Ecotoxicology team based at Lincoln.* ***Geoff Wright*** *manages the toxicology laboratory and works in the same team.*

Guest Editorial

In 1993, my predecessor received requests from some of the agencies responsible for possum control operations for an independent view of the use of 1080 and its alternatives for possum control. These requests coincided with public concern about the use of 1080. The resulting report was published in May 1994. The key conclusions were:

- for possum control over areas of very difficult terrain and poor access, aerially sown 1080 baits are the most cost-effective control available at the present time;
- current evidence on the environmental and human health effects of 1080 can not prove absolute safety, but the risks of using 1080 are acceptable in relation to the benefits of use;
- continuing heavy reliance on 1080, or any other single poison, is not advisable over the long term.

My policy is to check on the progress made by agencies to whom advice has been given in previous investigations. I decided this year to review some of the key findings and recommendations in the 1994 report. It is heartening to report that four years on, many of the recommendations have been implemented. For example:

- there is more effective communication and coordination between control agencies;
- there is standardisation of monitoring control operations;
- most research priorities have been addressed, although reducing the high dependence on 1080, via the use of biological or reproductive controls, is still somewhere in the future;
- there has been some progress in addressing quality assurance issues.

I have also identified a number of strategic risks which may have a significant impact on whether effective possum control is achieved in the future. In summary these are:

1. The necessity for continued investment in possum control

The two major objectives of possum control are:

- reduction of bovine tuberculosis in New Zealand's cattle and deer herds to a level where New Zealand qualifies as a Tb-free country; and
- protection of indigenous biological diversity and the restoration of degraded indigenous ecosystems.

There are strong national and international reasons why these objectives should continue to be pursued in the long term. However, there is a risk that the degree of political commitment may weaken over time if progress to arrest the declining health of indigenous forests and in continuing to reduce Tb levels is not demonstrated.

2. The lack of integration of control strategies

Although the two objectives for possum control are "stand alone", they need to be strongly aligned. The lack of a strong alignment poses two strategic risks. The first is that possum issues may not be seen in their full context. The second risk is that agencies may not maintain linkages to ensure that the research, operational, and quality assurance components of the possum control system are appreciated.

3. Research gaps

Recent research has demonstrated that the possum is a serious predator of North Island kōkako and kūkupa. If this finding is applicable to other regions and other bird species, it could markedly change the assessment of the risks to indigenous biodiversity posed by possums.

Very little social science research has been undertaken into understanding public attitudes and perceptions to possum control techniques, effective means of providing information to the wider community, and who are trusted information providers. There appears to be a lack of support by science purchasers, rather than science providers for such research. The major risk is that when the next generation of control technologies reaches the registration for use phase, the context of the public debate of their risks and benefits will be poorly understood by decision makers while public concerns may be a product of insufficient information on risks and benefits or lack of confidence in information sources.

4. Quality assurance

The National Possum Control Agencies (NPCA) has recently established a project to design and trial a quality assurance system that will cover all aspects of possum control. This project is an excellent start to the wider challenge of developing a quality assurance culture across the whole possum control industry.

In Summary

It is pleasing to note that there has been good progress in many aspects of possum control since 1994. However, despite considerable progress and expenditure, the possum remains a very significant risk to New Zealand, both in economic and environmental terms. Substantive ongoing research investment and improved integration of control strategies is still required.

Dr J. Morgan Williams *is the Parliamentary Commissioner for the Environment.*

Control of Possums Results in Range Shifts of Neighbours

Anecdotal reports of possum populations apparently recovering within six months or less following control are frequently debated by pest control managers and contractors. Debate relates to the timing of post-control monitoring, the distance monitoring is undertaken from operational boundaries, whether operational failures are due to poor control or to rapid immigration, and how the size of control areas and frequency of control can be optimised.

Possum populations can recover from control operations in several ways. One mechanism is *in situ* breeding of survivors. Another is from net immigration — that is, if a neighbouring area is not controlled, more individuals will disperse into and settle in the controlled area than move out of it. A potential third mechanism is localised population 'creep' — the movement of possums living adjacent to a control area, and occasionally using it, then using it more frequently following control.

Murray Efford, Bruce Warburton, and Nick Spencer, have been monitoring the response of possums (particularly the mechanism of population creep) to a density gradient between a controlled and a non-controlled area. They selected a 13-ha site at Pigeon Flat, Dunedin, for their study. In the first year, 197 possums (15/ha) were live captured in wire cage traps set on a 30 x 30-m grid and trapped every second month. Thirty of these possums were collared with radio transmitters and tracked for four nights every month. The trapping and radio-collaring information collected over two years, was used to determine their home ranges, before 80% of them living in about one third of the research site were killed (Fig. 1). The possums in the neighbouring uncontrolled area were then monitored for a further 2 years to determine their response to the control.

Following the control, 34% of the possums that had home range centres within 100 m of the controlled area, had range shifts of greater than 50 m towards it (Fig. 2). Some of these shifts occurred within one month of the control. The possums that did so were individuals that had earlier used the control area as part of their home range and had had the opportunity to detect the significant reduction in possum numbers in this area. Such shifts in home range in the direction of the control area declined with the distance from it, with 23% of possums centred in the 100-200 m area and 6% of those centred more than 200 m from the boundary (Fig. 2) shifting into the controlled area.

This research provides direct evidence of the existence of a vacuum effect, with both female and male possums being drawn into areas with artificially lowered populations. The effect in this trial was, however, very localised with few range shifts exceeding 200 m. Most possums that responded to the control did so in the three months following control. These results indicate that pest managers need to be aware of boundary effects when monitoring control operations that adjoin

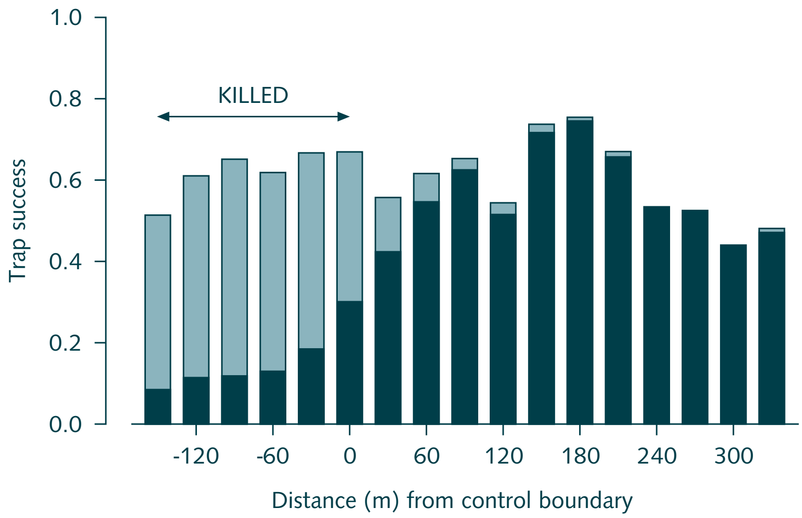


Fig. 1. Induced density gradient after removing 80% of possums at Pigeon Flat. Each bar represents possum abundance on parallel trap-lines across the study site. Lighter bars represent possums removed.

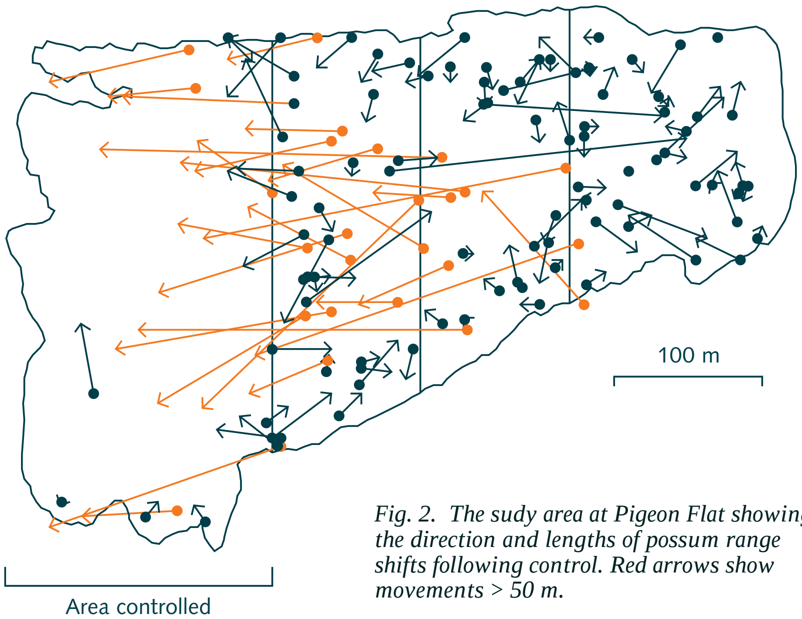


Fig. 2. The sudy area at Pigeon Flat showing the direction and lengths of possum range shifts following control. Red arrows show movements > 50 m.

uncontrolled sites, especially if those sites are small. If some controlled possum populations recover rapidly, then there will be little benefit from control and pest control managers need to question their rationale for implementing such inadequate control strategies.

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

Murray Efford *and* ***Nick Spencer*** *are vertebrate ecologists in the Ecosystems South team of Landcare Research based at Dunedin.*

Bruce Warburton *is a vertebrate ecologist and Team Leader of the Pest Impacts and Management team of Landcare Research based at Lincoln.*

PestCalc: The Pest Control Calculator

The Pest Control Calculator (for Windows 95®) has been developed to make analysis of monitoring data for pest populations simpler and more accurate. Version 1.0 is tailored for analysis of possum trap-catch data. Until now analysis of trap-catch monitoring data has been done using spreadsheet packages, modified for each job. This required inserting or deleting rows, and copying and pasting numerous formulae, all of which increased the risk of errors. PestCalc does away with the need to modify spread-sheets. Using Windows 95® point and click technology, operators simply indicate whether they are monitoring pre- and / or post- control operations, plus the number of nights, traps per line, and lines laid. PestCalc then automatically creates the relevant data input screens.

In addition to this flexibility, PestCalc also provides features such as:

- more robust and advanced statistical analysis
- interpretation of statistical results
- easy analysis of stratified monitoring data
- automatic graphing of data
- exporting data to text files
- archiving data for trend monitoring
- on line help.

PestCalc can be evaluated in demo-mode free for 30 days. Registering version 1.0 of PestCalc costs $350 + GST.

To order, contact:
Manaaki Whenua Press,
P.O. Box 40, Lincoln 8152,
New Zealand.
Fax (03) 325 2127.

E-mail : mwpress@landcare.cri.nz
or download a demonstration package from
www.landcare.cri.nz / information_services / software

Are all Northern Rātā Leaves Equally Tasty?

Possums are fussy eaters. Diet studies show that they selectively browse particular species of plants while often leaving more common species virtually untouched. One species that appears to be a favourite of possums is northern rātā (*Metrosideros robusta*), and the decline of this species in many North Island native forests has been blamed on possums. Should we therefore expect that northern rātā will eventually be browsed to extinction by possums? Hope for the persistence of northern rātā arises out of the observation that many northern rātā survive much longer in the presence of possum populations than earlier defoliation would indicate. Why should these trees survive whilst others have not? Are some northern rātā not as tasty to possums as others? (see article on fungi in foliage).

In Australia, the presence and abundance of leaf-eating marsupials (including brushtail possums) in eucalypt forests has been related to soil fertility. Eucalypts growing on low fertility soils have leaves low in nitrogen and high in phenolic compounds (known to deter herbivores). Trees with leaves containing less than 0.9% dry weight of nitrogen are considered unfavourable habitat for possums and other leaf-eating marsupials.

Two northern rātā trees - one killed by browsing, the other still alive

Bruce Burns has been extrapolating these observations to New Zealand. He has recently investigated whether northern rātā surviving in the North Island are those that also have leaves containing low levels of nitrogen and high levels of phenols, making them less palatable to possums. With help from Patrick Whaley and Malcolm Douglas, Bruce sampled leaves of 47 northern rātā trees from five sites with differing soil parent materials, from the King Country to Northland. Because the foliage of most rātā sampled were out of reach by conventional means, they used a shotgun to bring down small diameter branches. Leaves were stored in dry ice for transport, then dried and analysed for nutrients and phenols. Sampled trees were also assessed for the intactness of their canopy (tree health), assumed to reflect the intensity of recent possum browsing.

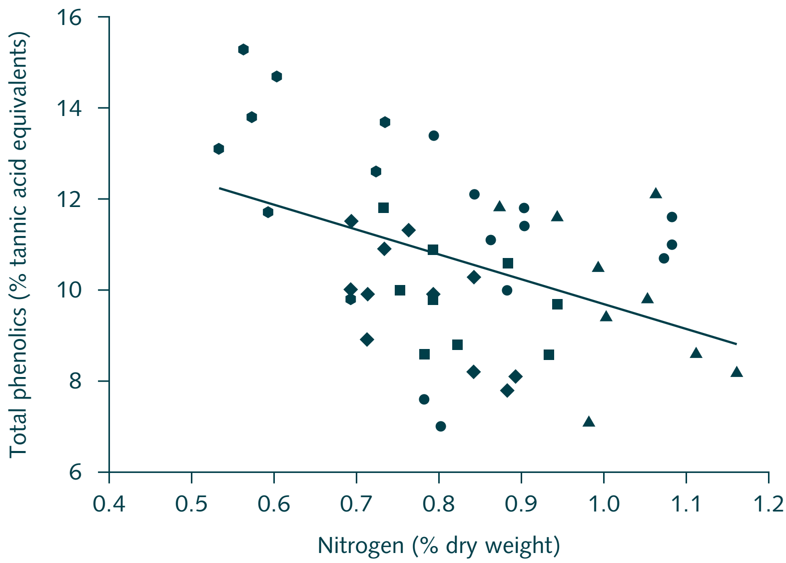
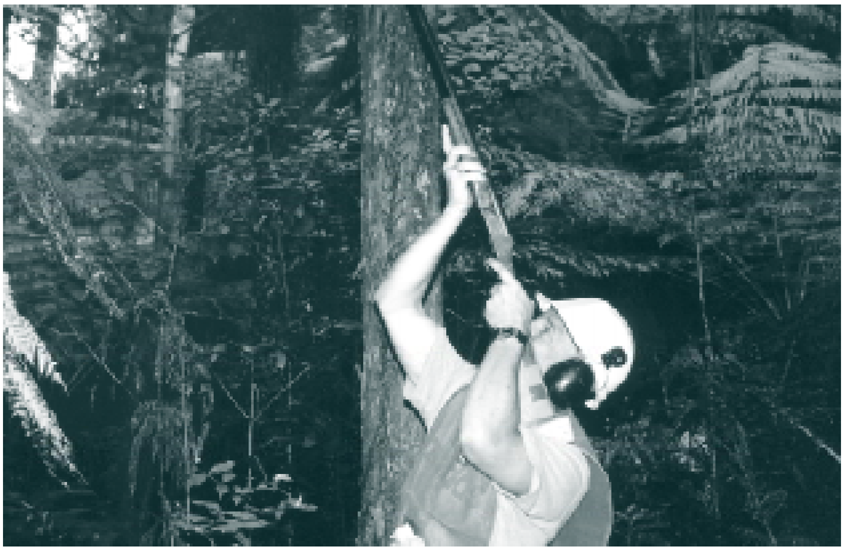


Fig. 1. Relationship between northern rātā leaf nitrogen and total phenolics. Different symbols represent different sites.

All five populations had at least some individuals with leaf nitrogen levels less than 0.9% (Fig. 1); in two populations all trees were in this category. This must be unusual for a supposedly important possum food source. Also, unhealthy northern rātā had significantly higher leaf nitrogen levels than healthy northern rātā (Fig. 2). Levels of other leaf nutrients (e.g., phosphorus, potassium) were generally normal for tree species.

The levels of phenolic compounds in northern rātā leaves were similar to overseas measurements from trees in temperate and tropical forests, but low in comparison to trees in Australian eucalypt forests. Interestingly, phenol levels were highest in leaves with low nitrogen levels and lowest in leaves with high nitrogen (Fig. 1), suggesting anti-herbivore compounds in leaves can vary with site fertility – an observation that concurs with the Australian findings.

Although analyses of further northern rātā populations are desirable, these results suggest that many surviving northern rātā trees produce leaves not particularly attractive to possums. Whether leaf nutrient levels remain constant between seasons, between trees of different ages, or on trees resprouting after partial defoliation by browsing is unknown. However, the study does indicate that the foliage of northern rātā growing on infertile soils is less attractive to possums than those growing on more fertile soils. Such a relationship may provide a basis for prioritising possum control between areas.



Sneaking up on an unsuspecting M.robusta

Funding for this work was provided by the Foundation for Research, Science and Technology.

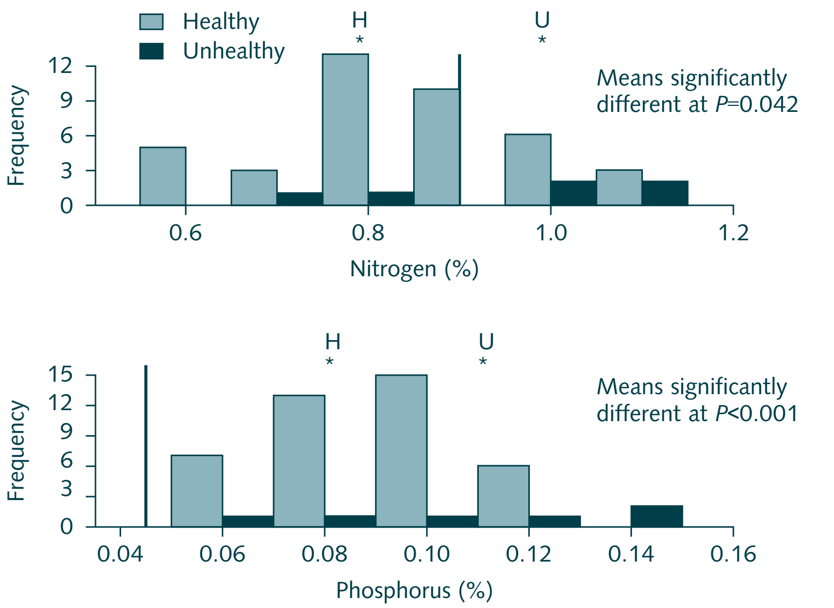
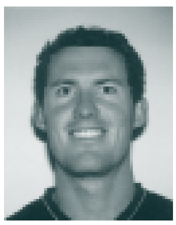


Fig. 2. Frequency distributions of leaf nitrogen and phosphorus of healthy (H) and unhealthy (U) northern rātā. Vertical lines represent approximate threshold levels above which foliage contributes to favourable folivore habitat in Australia. Asterisks represent mean nitrogen and phosphorus levels of healthy and unhealthy groups.

***Bruce Burns** is a forest ecologist who works in the Ecosystems North team of Landcare Research based at Hamilton.*

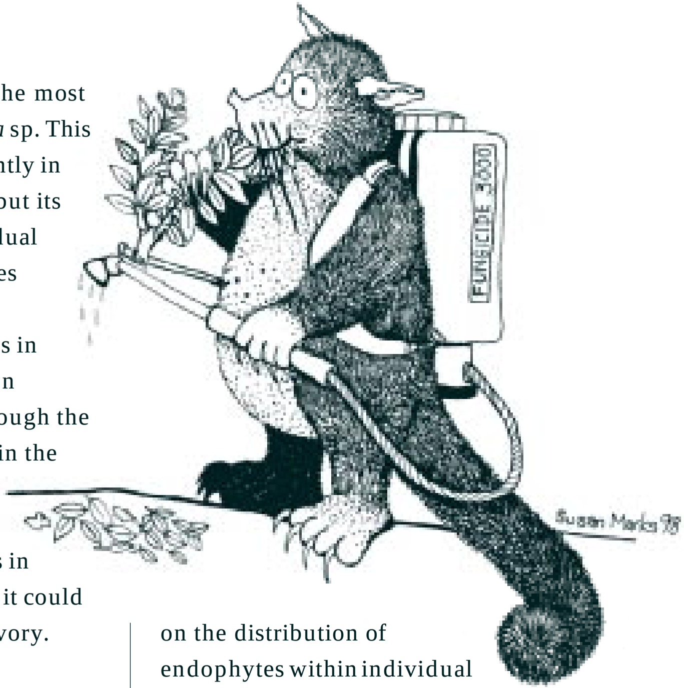


***Patrick Whaley** is a Conservation Officer with the Department of Conservation, based at Whangarei. **Malcolm Douglas** works at the Hands-On computer training centre at Hamilton.*

Do Fungi Influence Leaf Palatability to Browsing Possums?

Endophytic fungi, present within the symptomless, healthy leaves of all trees can help protect their hosts against attack by fungal pathogens or insect pests. This protection is related to the production of toxic metabolites by the fungus alone, or as a result of a fungus-host interaction. Endophytic fungi can also produce substances toxic to mammals. Individual tree species have a small number of dominant leaf endophytes that are generally specific to a single host. For a particular host species, the distribution of individual endophytes is patchy within leaves, within trees, between trees and between sites. The effect of this may be to transform leaves, trees or stands of trees into mosaics of substrates favourable and unfavourable to herbivores.

Peter Johnston and Maureen Fletcher have been amongst the first to study the leaf endophytes of New Zealand's trees. They identified a small set of dominant leaf endophytes in mānuka (*Leptospermum scoparium*), the most frequent being a *Phyllosticta* sp. This fungus was found consistently in natural stands of mānuka, but its distribution between individual trees was patchy. Some trees had close to 100% of their leaves infected, while others in the same stand had infection levels of less than 5%. Although the reason for such patchiness in the distribution of endophytes is not understood, if it also occurs in trees palatable to possums, it could influence patterns of herbivory.



To test this in a pilot trial, Peter and Maureen investigated the leaf endophytes of pōhutukawa (*Metrosideros excelsa*), comparing endophyte populations in trees known to have been heavily browsed by possums with those in adjacent trees not browsed by possums. Preliminary experiments at a site near Auckland City provided base data on the distribution of endophytes within individual pōhutukawa leaves and trees, so allowing sampling methods to be devised for measuring possible between-tree differences (Fig. 1). The upper and the lower sides of pōhutukawa leaves were found to have distinct endophyte populations. The fungi on the lower side were mostly generalists, commonly isolated as endophytes from other host species, as well as being common on dead and dying plant tissue and bark. Isolations from the upper side were dominated by only three species of fungi, all probably specific to pōhutukawa.

Coastal pōhutukawa browsed by possums

With the assistance of Lisa Forester and Ray Pierce from the Department of Conservation, Peter and Maureen sampled leaves from pōhutukawa on Bream Head. Previous monitoring of possum browsing damage at this site allowed two trees that had been heavily browsed, and two that had been lightly browsed, to be selected. From each of the four trees, a total of 160 leaf pieces were sampled from the

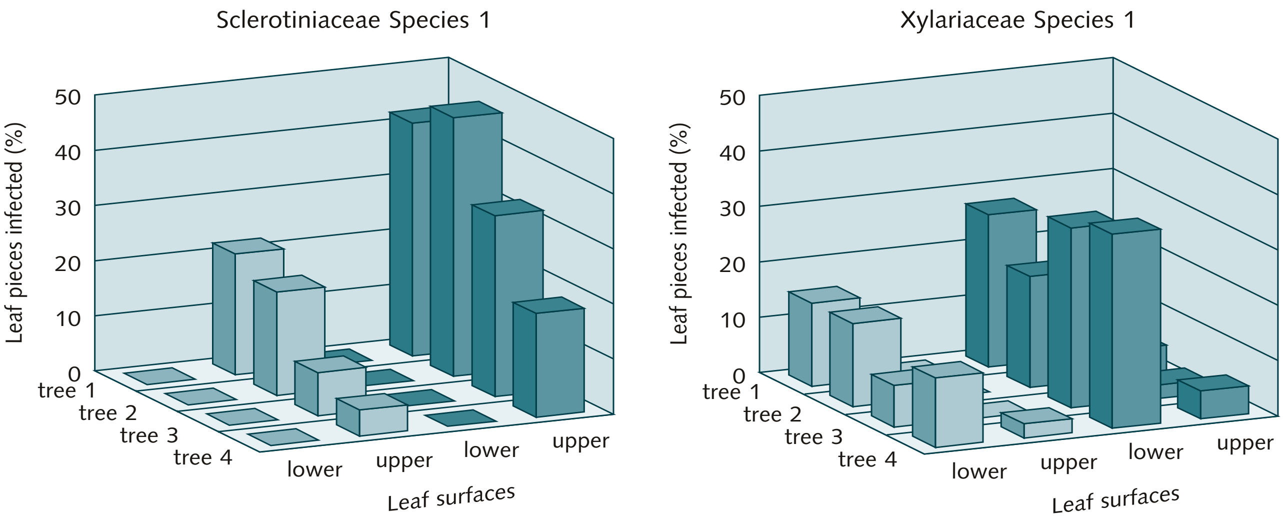


Fig. 1. Between-tree and within-tree variation in the frequency of the most common fungal endophyte from the upper (Sclerotiniaceae species 1), and lower (Xylariaceae species 1) side of pōhutukawa leaves sampled from a site near Auckland City. The dark boxes are data from leaves taken from near the base of the tree, the light boxes from leaves taken from the canopy.

upper surface of 40 leaves. No consistent patterns of difference were noted between the trees in relation to browsing damage, except that overall levels of infection appeared to be higher in the less browsed trees (Table 1).

Despite there being no dramatic differences in endophyte populations recorded between browsed and unbrowsed trees at Bream Head, other evidence suggests this research may be worth continuing. Leaves from a single unbrowsed pōhutukawa tree near New Plymouth showed a similar range of endophytes to those at other sites, but the most frequent was a *Phomopsis* sp. This was present at the other sites sampled albeit at very low levels. Many *Phomopsis* spp. produce potent mammalian toxins. The tree near New Plymouth was originally one of three adjacent trees, two of which had been killed by heavy possum browsing. The heightened level of *Phomopsis* infection may be significant in terms of possum browsing, or it may simply represent regional or site differences in endophyte population levels. Further sampling is needed from stands where adjacent trees are browsed with different intensities. Given that endophytic fungi occur in the leaves of all trees, such a study need not be confined to pōhutukawa.

This work was funded by Landcare Research.

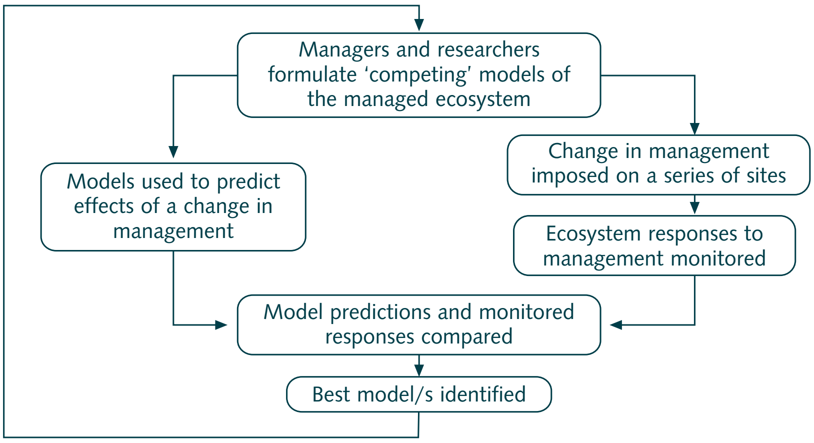
Table 1. Proportion (%) of pieces from the upper leaf surface infected by the three most common fungal endophytes isolated at Bream Head, and the proportion of leaf pieces from which no fungi were isolated. Four pōhutukawa trees were sampled, two with a history of low and two with a history of high browsing damage.

	low browsing damage		**high browsing damage**	
fungus	tree 1	tree 2	tree 1	tree 2
Sclerotiniaceae sp. 1	15	49	20	9
Sclerotiniaceae sp. 2	3	8	4	16
Phyllosticta sp.	14	3	3	1
Nothing isolated	34	30	55	68


Peter Johnston *and* ***Maureen Fletcher*** *are in Landcare Research's Insect and Microbial Systematics team, based at Mt Albert.*

Adaptive Management - What is it, and can it be used in Possum Research?

Adaptive management is a term that seems to crop up more and more regularly in discussions about how to improve the management of our natural resources. Adaptive management simply means that by monitoring the effectiveness of changes to a management process, improvements can be made. This general principle has recently been developed to encompass many of the intricacies of traditional experimental design, including the need for replication and non-treated controls.



A diagram of an adaptive management programme. The programme leads to a continuous refinement of understanding about how management influences the ecosystem, by linking modelling and monitoring as integral parts of the management process.

The use of mathematical models as an integral part of adaptive management has also been promoted. The alternative views that managers have about how an ecosystem functions are represented as a series of 'competing' mathematical models. These models are used to make predictions about how an ecosystem will respond to a change in management. By comparing these predictions with the field results, the most accurate model can be identified. When viewed in this way, the 'competing' models used in adaptive management experiments become the equivalent of the hypotheses that are tested in more traditional scientific studies.

Adaptive management and possum research

Opinions vary about how possums and vegetation interact and about how native forests will respond to different possum control strategies. Data currently available cannot unequivocally demonstrate which experts' opinion are right and which are wrong. The lack of consensus concerning how forests respond to various forms of possum control is perhaps best illustrated by the broad range of variation in maintenance possum control used in conservation areas. Some mainland islands are controlled annually or even continuously, while in other areas control is undertaken every 8 or even 10 years. Factors such as control technique, the potential for bait shyness, likely rates of re-invasion, and the susceptibility of local vegetation to possum-induced changes will complicate the issue. Research into the response of possum populations and the condition of forests to the imposition of different possum management strategies has the potential to improve the effectiveness of possum control. If this work is conducted in a formal adaptive management framework, employing adequate replication of management "treatments" in order to distinguish between competing models of the managed ecosystem, it will also provide important guidance to where the results of more focused studies will most directly improve possum management.

John Parkes and David Choquenot from Landcare Research (in collaboration with the Department of Conservation (DoC)) are undertaking a large-scale adaptive management programme that will use different possum management strategies and a rigorous monitoring schedule to test competing models of how the control-possum-vegetation complex works. Using "what-if" scenarios based on existing population models, DoC staff will identify "best bets" for optimal possum management. The logic underlying their choices will be formalised into a series of competing models that will be used to predict how characteristics of the possum populations and vegetation should respond to the different management regimes imposed. These regimes will then be replicated across a series of DoC possum management areas so that detailed monitoring can be used to test the accuracy of the predictions made by the competing models. Using the most accurate subset of these models, options for possum management can be refined, a new series of competing models formulated, and the adaptive management process can continue. As such, there is no real end point to an adaptive management programme of this type. What starts out as a structured investigation of the effectiveness of competing management strategies evolves naturally into an ongoing management process in which the outcomes of control are continuously monitored and fed-back via modelling, information, and training systems to further refine management strategies. In this way, adaptive management, in combination with more focused studies of interaction between possums and vegetation, can move possum management onto a trajectory of progressive improvement.

This work is being funded by the Department of Conservation, who are also providing the management expertise and commitment that is necessary for an adaptive management programme to succeed.


***David Choquenot** and **John Parkes** are animal ecologists in the Pest Impact and Management team of Landcare Research based at Lincoln. They work on the identification of strategies that optimise the cost of pest control relative to its benefits.*

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A Selection of Recent Possum-Related Publications

Caley, P. 1998: Broad-scale possum and ferret correlates of macroscopic *Mycobacterium bovis* infection in feral ferret populations. *New Zealand veterinary journal* 46: 157-162

Coleman, J.D.; Nugent, G.; Fraser, K.W. 1998: Optimal buffer widths for the control of bovine Tb in possums, deer, and cattle on forest / pasture margins: trends in Tb prevalences following control. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 407-411

Day, T.D.; O'Connor, C.E.; Mathews, L.R. 1998: Effect of social behaviour of brushtail possums on potential biocontrol strategies. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 221-226.

Fraser, K.W.; Knightbridge, P.I.; Fitzgerald, H.; Coleman, J.D.; Nugent, G. 1998: Optimal buffer widths for the control of brushtail possums: rates and patterns of population recovery. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 401- 406.

Glazier, A.M.; Molinia, F.C. 1998: Improved method of superovulation in monovulatory brushtail possums (*Trichosurus vulpecula*) using pregnant mares' serum gonadotrophin-luteinizing hormone. *Journal of reproduction and fertility* 113: 191-195

Gregory, N.G.; Milne, L.M.; Rhodes, A.T.; Littin, K.E.; Wickstrom, M.; Eason, C.T. 1998: Effect of potassium cyanide on behaviour and time to death in possums. *New Zealand veterinary journal* 46: 60-64.

Molinia, F.C.; Gibson, R.J.; Brown, A.M.; Glazier, A.M.; Rodger, J.C. 1998: Successful fertilization after superovulation and laparoscopic intrauterine insemination of the brushtail possum, *Trichosurus vulpecula* and tammar wallaby, *Macropus eugenii*. *Journal of reproduction and fertility* 113: 9-17.

Morgan, D.R. 1998: Community participation in research to improve efficiency of ground-based possum control. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 93-97.

Nugent, G.; Whitford, J; Coleman, J.D.; Fraser, K.W. 1998: Effect of possum (*Trichosurus vulpecula*) control on the prevalence of bovine tuberculosis in wild deer *in* Proceedings of the ARC-Onderstepoort OIE International Congress. Onderstepoort Veterinary Institute, Onderstepoort, South Africa. Pp. 462-466.

O'Connor, C.E.; Day, T.D.; Mathews, L.R. 1998: Do slow acting toxins induce bait shyness in possums? Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 331-336.

Thomas, M.D. 1998: Optimising the use of bait stations to control possums in New Zealand native forests. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury, Western Australia. Pp. 337-340.

Warburton, B. 1998: Evaluation of escape rates by possums captured in Victor No.1 Soft Catch traps. *New Zealand journal of zoology* 25: 99-103.

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