He Kōrero Paihama
Possum Research News

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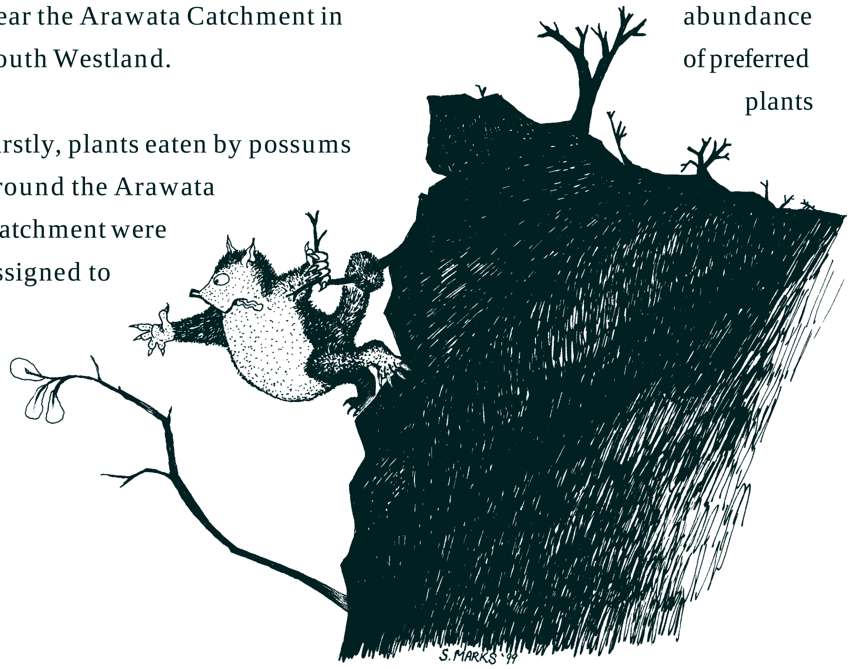
Possum Induced Ecosystem Degradation – the Possums' Perspective

Possums degrade indigenous ecosystems. Their selective browsing which causes death of some plants, contributes to forest decline. In turn, forest decline appears to adversely effect the resident possum population. These changes in forest health and possum ecology following possum colonisation were investigated recently by Peter Sweetapple, Wayne Fraser, and Phil Knightbridge at three sites with different periods of possum occupation (5–10, 20, and 30 years) of mixed beech forest in or near the Arawata Catchment in South Westland.

Firstly, plants eaten by possums around the Arawata Catchment were assigned to preference classes (Table 1) based on plants commonly eaten elsewhere in Westland. Possum diet changed with length of occupation of the study sites (Fig.1), with highly preferred plants being eaten most frequently at the site occupied for 5–10 years, and moderately preferred plants being eaten most frequently at the site occupied for 30 years. Peter and his colleagues assumed that the forest structure was similar at all three sites prior to possum colonisation. Hence, changes in the diet of possums reflect progressive reductions in both the vigour and abundance of preferred plants



over time. This interpretation is supported by direct measurements of the vegetation.

Possum plant food preferences probably reflect the nutritional value of each item of food so the shift in diet toward less favoured foods would appear to indicate a decline in the quality of food eaten by long established possum populations. This change was reflected in the demographic characteristics of the possum populations. At the site occupied for 30 years, possums were smaller, only 46% of captured adult females had bred that season, and only 4% produced pouch young in the spring. By comparison, at the site occupied for 5–10 years, 94% of adult females had bred that season and 53% produced pouch young in the spring. Not only is the ecosystem suffering as a result of long-term possum occupation, but the possums are suffering as well.

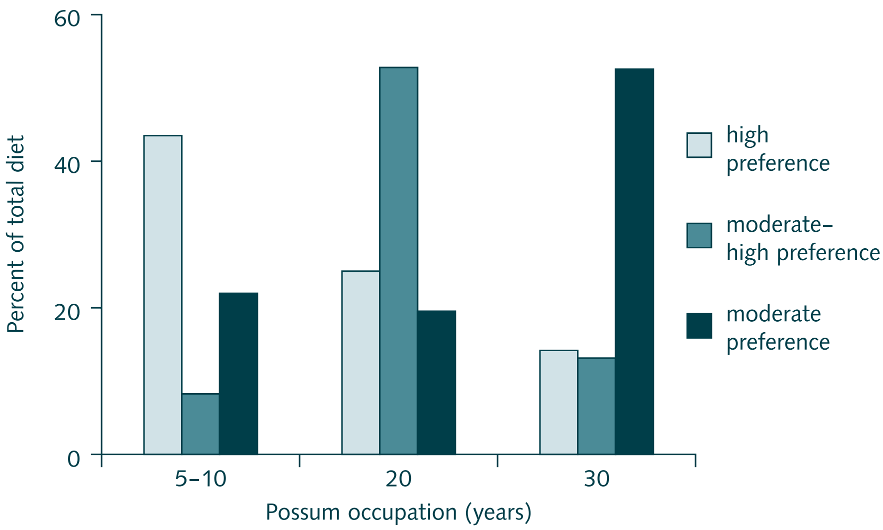


Fig. 1. Possum diet by food preference class at three sites with different lengths of possum occupation (n = 45 possums for each site).

Unless the possum population is significantly reduced, the condition of the ecosystem and the vigour of the possum population at the site occupied for 30 years is expected to continue declining for many years. Such long-term trends have been recorded in a study in the Orongorongo Valley. There, possum-induced changes in diet and forest structure still continue despite a possum occupancy of at least 80 years.

Table 1. Possum preferences for common diet components in South Westland

Preference class		
High	**Moderate-high**	**Moderate**
Mistletoe	Tree fuchsia	Kāmahi
Muehlenbeckia australis	*Pseudopanax simplex*	*Coprosma* species
Wineberry	Southern rātā	Kaikōmako
		Māhoe
		Ferns
		Ribbonwood

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

***Peter Sweetapple*, *Wayne Fraser* and *Phil Knightbridge* are ecologists working on the impacts of browsing mammals on native forests.**

Guest Editorial – Aspects of Possum Control Bioethics

My first experiences with possum control occurred about 45 years ago when, as a youngster in Australia, we killed them while spotlight shooting. Occasionally, we also had daylight possum hunts where we located nests in flimsy trees, shook the animals out and followed at ground level as they escaped through the tree tops. This was fun or sport to youngsters who did not question or otherwise seek to justify these actions.

Much has changed since then. The possum is now protected in Australia, although it understandably remains high on the "pest" hit list in New Zealand. We also have a hugely improved knowledge of ecological matters and of the behaviour and physiology of numerous animal species. This has sensitised us to the subtleties of animal-environment interactions and the capacity of all mammals, and many other animals, to suffer, leading us now to reflect more deeply on our motivation for killing "pest" animals, like possums, and the methods we use.

We are challenged to consider our responsibilities in at least two areas – the environment and animal welfare.

Environmental Responsibilities

As custodians of the environment we have a responsibility (where practicable): (1) to maintain an appropriate *ecological balance*, including protecting native species, especially endangered ones; (2) to maintain appropriate *species diversity*; and (3) to ensure environmental *sustainability*, i.e., its continuation in a healthful and flourishing way. We can justify these commitments in terms of the value we place on the environment and its characteristics because of its usefulness to us – its *instrumental value*. Alternatively, the impetus for us to exercise our custodial responsibility can arise from the perceived *intrinsic value* of the environment – the fact that it is there and has a value in its own right, quite independently of any value we might assign to it.

Animal Welfare Responsibilities

We have an ethical duty to minimise the suffering animals experience at our hands. In the context of possum control this translates into the following responsibilities: (1) to use the most humane pest control methods currently available which are practicable in each situation, and (2) to keep the humaneness of current methods under review, and through active research, to develop more humane methods. However, we have a further ethical responsibility, where it is practicable to exercise it – to maximise the benefits that can be derived from each animal's death in addition to the ecological ones, which led to it being killed in the first place. Thus, by-products such as meat, leather, fur and other derivatives from the dead animals' bodies should be utilised where practicable.

Balancing Responsibilities

The fact that we actively engage in possum control when we exercise our environmental responsibilities shows that we place a higher priority on minimising the harm possums can do than we place on the harm done to possums by our current control methods. The fact that we have good reasons for preserving and protecting the environment does not mitigate the harshness of this position from the possum's perspective. We can partially rescue ourselves from the apparently callous implications of that harshness if we actively, resolutely and vigorously strive to meet the first two animal welfare responsibilities noted above. But complete rescue in animal welfare terms will only be at hand when we have developed and use control methods that cause no suffering at all.

There are obvious ethical implications for the funding of work designed to rank the humaneness of current methods and to develop more humane methods. We must ensure that funding levels are sufficient to make progress rapidly!

David Mellor *is Director of the Animal Welfare Science and Bioethics Centre, AGMARDT Professor of Animal Welfare Science, and Professor of Applied Physiology and Bioethics at Massey University.*

Can Antifeedants Predict Browsing by Possums in New Zealand Forests?

Despite the presence of possums throughout most New Zealand forests, the damage they cause is far from uniform. Within forest stands, possum browsing is frequently concentrated on only a few trees, which may be heavily defoliated

Initial feeding interest when rātā foliage is first placed in the cage.

or killed, while neighbouring trees of the same species remain largely unaffected. At larger scales, forest communities and plant species such as fuchsia and the beech mistletoes may be anything from severely damaged (including local extinctions) to little affected. An understanding of the reasons for this variability is needed to prioritise the limited resources available for possum control and should large-scale eradication of possums continue to prove elusive, a longer-term requirement to produce indigenous plant species that are less susceptible to introduced mammalian browsers.

Traditional approaches to determining palatability which relate what an animal eats to known nutritional (e.g., nitrogen) or antifeedant (plant chemicals that are toxic or interfere with digestion) constituents in the foliage, have not proved good predictors of what animals eat in the wild. Recent Australian studies however, have successfully predicted the feeding patterns of several marsupials (including possums) based on concentrations of specific antifeedants present in the eucalypt leaves that make up the bulk of their diet. These studies have used a bioassay approach in which animal preferences, rather than human assumptions about what determines palatability, are used to guide the search for the chemicals that restrict feeding.

In this article Ian Payton and Caroline Thomson report on the first stage of a study to determine whether leaf chemistry can be used to predict the browsing patterns of possums in native forests. The research has involved a series of preference (bioassay) trials with captive possums, to determine the range of palatability in two preferred plant species, fuchsia (*Fuchsia excorticata*) and southern rātā (*Metrosideros umbellata*). Ian and Caroline then looked at how well consumption levels could be predicted from known nutritional and reputed antifeedant constituents in the foliage.

Possums were fed an ample supply of foliage from a different tree each night, and had the choice of either eating it or going hungry. This enabled differences in the eating habits of individual possums, and carryover effects (the possibility that what a possum eats tonight will influence what it eats tomorrow night) to be determined and corrected for. Consumption was measured by weighing the foliage at the beginning (before dusk) and end (after dawn) of the trial period. The weights were corrected for moisture loss and changes in basal metabolic rate associated with body size, and the results expressed as dry matter intake / kg body weight$^{-0.75}$.

In the fuchsia trials, animals ate between 4.9 and 10.7 g dry matter / kg body weight$^{-0.75}$. Foliage from two trees at Doughboy Creek (D1 & D2) was significantly more palatable ($P < 0.05$) than that of a tree at Camp Creek (C3) (Fig. 1), but

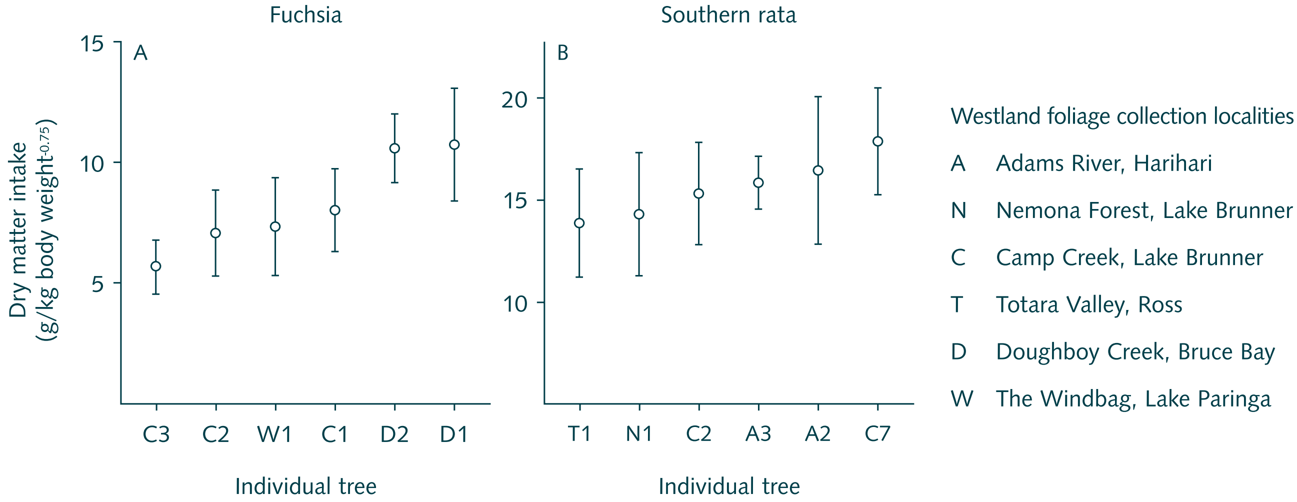


Fig. 1. Consumption of fuchsia and southern rātā by possums fed foliage from individual trees in two of the no-choice trials. Data are the means ± SE for 6 animals.

otherwise differences between trees were non-significant. A similar pattern emerged for southern rātā. Overnight consumption ranged from 10.1–17.9 g / kg$^{-0.75}$. Foliage from a tree at Camp Creek (C7) was significantly more palatable ($P < 0.05$) than that of trees from Totara Valley or Nemona Forest, but all other differences were not significant. Animals typically fed enthusiastically for 10–15 minutes after the fuchsia or rātā foliage was placed in the cage, but then showed little interest in it, and hungrily accepted alternative food the next morning.

When food intake was plotted against the nutritional (nitrogen, phosphorus) or antifeedant (total phenolics, condensed tannins) content of the foliage, no significant relationships emerged, with the curious exception that for fuchsia, animals appeared to prefer foliage with higher levels of total phenolics.

In both fuchsia and rātā trials, foliage intake was less than in recent Australian studies of eucalypt palatability to leaf-eating marsupials. Ian and Caroline also found considerably less variability between individual trees. The pattern of feeding by possums on the New Zealand plant species tested (initial enthusiasm followed by relative disinterest) parallels that of the Australian studies. This suggests (i) the presence of a deterrent agent, and (ii) that the sample trees did not include highly palatable individuals. For fuchsia at least, the relatively small quantity of foliage on a mature tree (probably not more than 10–15 night's feeding for a possum) may mean that highly palatable plants are browsed to death soon after possums colonize an area.

Ian is now using the same bioassay-guided approach to determine which plant extracts and chemicals restrict the amount of southern rātā and fuchsia foliage that possums will eat.

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

***Ian Payton** is a plant ecologist working on possum herbivory in native forests and **Caroline Thomson** is an animal ecologist.*

Bait Acceptance May Reflect the Availability of Natural Foods

Traditionally, aerial baiting to control possums has mainly been conducted in winter. At this time, possums are usually in relatively poor or declining condition, their favoured foods (fruit and new foliage) are generally in short supply, and pest managers believe that possums are most likely to accept baits. In addition, carrot (a highly palatable and widely used bait) is readily available in winter and in some regions, winter weather is the most settled and suitable for baiting. Over the last decade, however, the number of aerial control operations against possums has been increasing each year, particularly to stop the spread of bovine tuberculosis (Tb). Pest managers have had to spread the increased workload outside the traditional winter baiting season. While experience has shown that acceptably high levels of possum control (i.e., reductions exceeding 80%) could normally be expected in winter operations, few data were available to support aerial control at other times of the year. Two studies by Dave Morgan, Jim Coleman and Peter Sweetapple assessed the likely seasonal effectiveness of aerial control, particularly in relation to the changing availability of possums' favoured foods.

The first study, funded by the Department of Conservation, assessed seasonal bait acceptance by possums living deep in forests at three sites typifying the possum threat towards conservation values: Herekino Forest (Northland), Moki Forest (Taranaki), and the Cobb Valley (Nelson). Trials were conducted each season for 2 years.

The second study, funded by the Animal Health Board, concentrated on bait acceptance by possums over the Spring to early Autumn period on the forest / farm margin in the Waitaha Valley, Westland, a site typical of where possum-cattle Tb infection occurs. In all trials, blocks of up to 100 ha were aerially baited with non-toxic rhodamine-dyed cereal pellets at about 5 kg / ha. After one night of feeding, possums were trapped, killed and inspected for evidence of the dye. At the same time, the condition of each possum was assessed, and the availability of new leaves, fruit and flowers on forest plant species favoured by possums was measured.

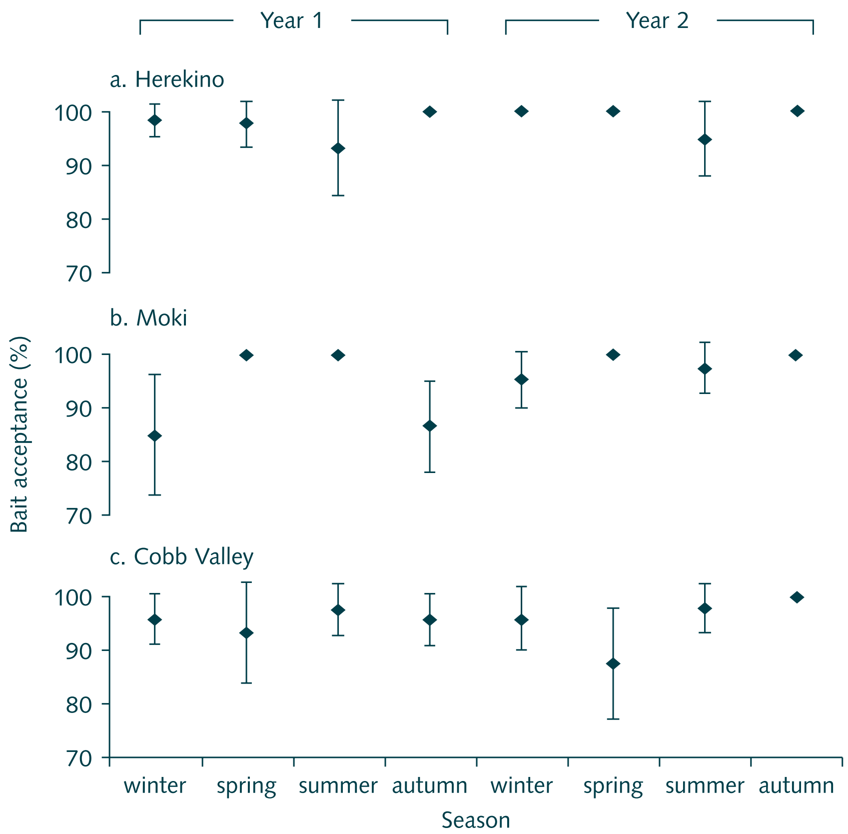


Fig. 1. The percentage of possums eating bait in each season over two years at (a) Herekino Forest, Northland, (b) Moki Forest, Taranaki, and (c) Cobb Valley, Nelson.

In the deep forest trials, there were high levels of bait acceptance (i.e., 85–100%) in all of the 24 trials conducted. Only three trials showed less than 90% bait acceptance (Fig. 1). Bait acceptance was similar in all three forests irrespective of whether fruit was available year round (Herekino Forest), sharply seasonal (Moki Forest), or very limited (Cobb Valley). Possums remained in moderate condition throughout the year at all sites, suggesting that they did not experience times of food shortage nor food abundance. In the forest-edge trials, bait acceptance was again similar throughout the trial (Fig. 2) but, on average, only 84% of possums ate the bait. This was less than the average of 94% recorded in the deep-forest trials.

The team's research confirmed that high levels of control can generally be expected in all seasons where possum populations in deep-forest are targeted. This supports the Department of Conservation's wish to conduct aerial baiting operations in 'non-traditional' seasons, especially before the late spring hatching of many native birds. However, every few years forest plants produce particularly abundant supplies of flowers and fruits. Such 'masting' did

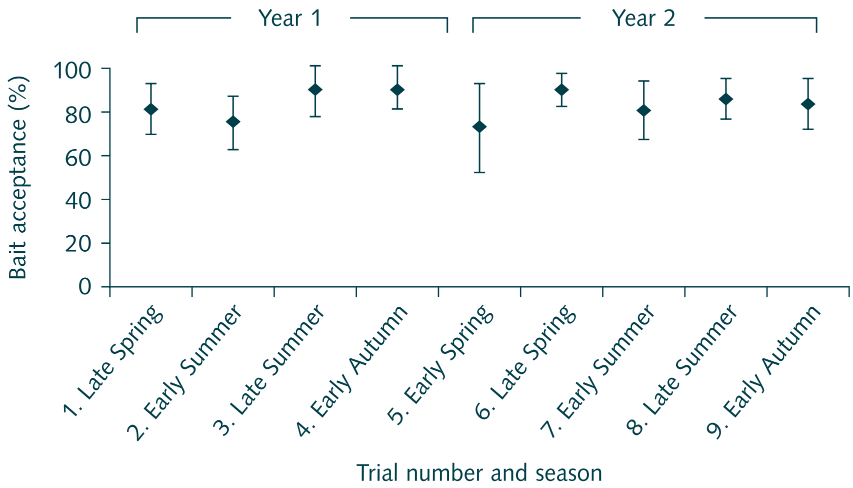


Fig 2. The percentage of possums living on the edge of the forest in the Waitaha Valley, Westland, eating baits during Spring – Autumn over two consecutive years.

not occur during this study. The influence of an abundance of preferred foods on the likely effectiveness of control remains untested. Hence, wherever possum-preferred plants are masting, prudent managers should conduct bait acceptance trials before scheduled aerial control operations.

Dave and his colleagues also showed that aerial baiting operations along the bush edge to control Tb are likely to be slightly less-effective than deep-forest operations – at least during Spring to Autumn. This difference appears to reflect the fact that possums living on forest margins eat pasture species which are high in nutrients relative to many forest species. Further trials are required in winter at the Waitaha Valley site to determine if the lower average kills recorded there are typical only of the warmer months.

This research was funded by the Department of Conservation and the Animal Health Board.

Dave Morgan *works on techniques and strategies for improved control of possums.* ***Jim Coleman*** *and* ***Peter Sweetapple*** *work on understanding the impacts of possums on natural ecosystems.*

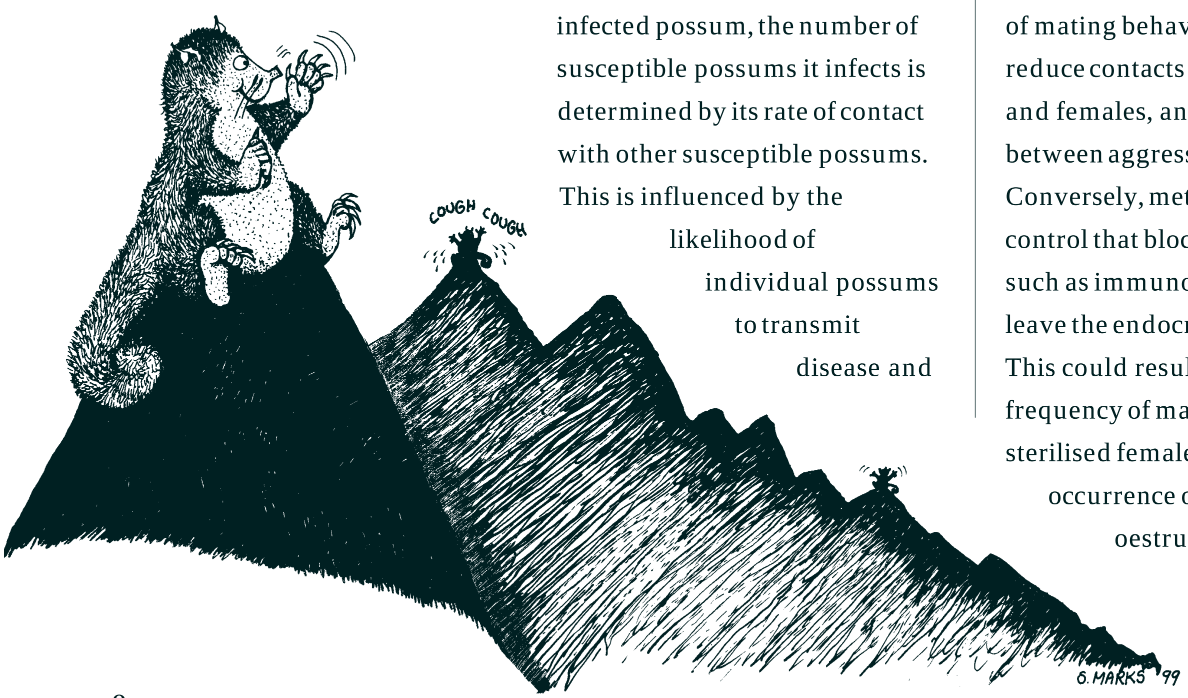
Do We Need to Suppress Population Density to Control Disease in Wildlife?

Reducing population density is the approach most frequently used to control disease in wild animals. In New Zealand, culling (conventional control by aerial or ground based poisoning or trapping) is the primary strategy for controlling bovine Tb infection in possum populations. Culling is predicted to reduce the prevalence of Tb infection, as some infected individuals are removed and contact between remaining possums is decreased. Peter Caley and Dave Ramsey have been considering this strategy and other approaches to the management of Tb in New Zealand.

As with most diseases, the ability of Tb to persist in possum populations is determined by the basic disease reproductive rate (R_o). This measures the number of new infections caused by a single infected individual in or introduced to a susceptible population. If R_o is < 1, the disease will die out and if R_o is > 1, the disease will persist (or establish). R_o is about 1.8 for Tb infection in possums. This means that each tuberculous possum is likely to infect about 2 other possums in its lifetime.

Obviously, to eradicate Tb infection from possum populations, R_o must be reduced to below one. However, culling of possums is not the only way of reducing R_o. Rather than targeting abundance, management could target the actual mechanisms of disease transmission as an alternative to targeting the pest. For any Tb-infected possum, the number of susceptible possums it infects is determined by its rate of contact with other susceptible possums. This is influenced by the likelihood of individual possums to transmit disease and the number of susceptible possums available. Possums may infect each other during contact such as mating, fighting, and den-sharing. The period of time a possum remains infectious is also important in determining how many other possums it has the opportunity to infect. This is influenced by natural and Tb-induced mortality rates.

Fertility control has been proposed as an alternative to culling for reducing the abundance of possums and for controlling Tb. Fertility control for possums can be achieved by interfering with reproduction in several ways. One proposed method targets the production of sex steroid hormones, leading to infertility. Blocking sex steroid release may result in behavioural changes including the inhibition of mating behaviour. This would reduce contacts between males and females, and possibly also between aggressive males. Conversely, methods of fertility control that block fertilisation, such as immunocontraception, leave the endocrine system intact. This could result in the increased frequency of mating contacts for sterilised females due to the occurrence of additional oestrus (heat) cycles. Whilst increased



contact could enhance transmission of a biocontrol vector, it might also increase the transmission rate of Tb among sterilised possums and thus, reduce the estimated threshold for persistence of Tb. Therefore, the implications of methods of fertility control for the rate of Tb transmission need to be examined as well as effects on abundance.

Possums are predominantly solitary animals, and social interactions are largely restricted to the breeding season. Tb requires close contact for transmission and mating is one activity considered to play a significant role. If this is so, then clearly, if the frequency of mating contacts is reduced, then the rate of disease transmission and hence R_o is also reduced. The amount by which R_o is reduced depends on what proportion of the population no longer participate in mating, and what contribution mating makes to disease transmission (Fig. 1). If, for example, mating makes up 75% of disease transmission, sterilising more than 60% of possums and inhibiting them from mating, will eliminate Tb. As the contribution of mating to Tb transmission decreases, the reductions that can be achieved through fertility control diminishes, to the point that if only 50% of transmission is due to mating, it is nearly impossible to eliminate Tb by targeting mating contacts alone.

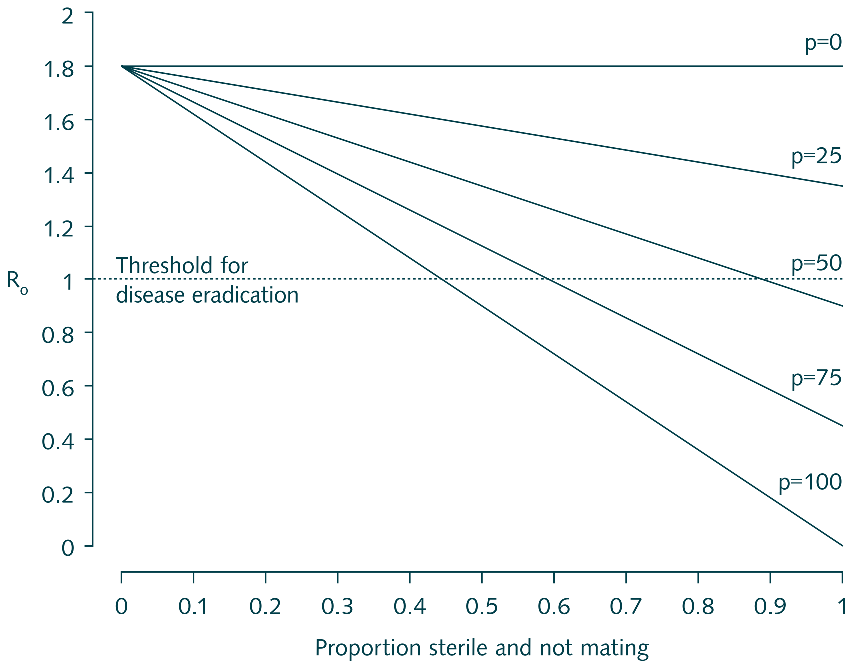


Fig. 1. Relationship between the basic reproductive rate of Bovine Tb infection in possums (R_o) and the proportion of possums sterilised and not participating in mating, for varying levels of p, where p is the % contribution of mating to disease transmission.

The obvious advantage of fertility control in reducing contact rates over conventional control of possums is that density need not be reduced, although a reduction in density will further reduce R_o. For conventional control to be effective, it must be followed up by regular maintenance control to prevent the population from recovering. However, maintaining a certain level of sterility in a population theoretically should be easier, as the population would not be increasing at its maximum rate or be subject to as much immigration as a population reduced significantly by conventional control. Research into fertility control of possums by Dave Ramsey has shown that sterilised females have lower mortality rates than unsterilised females. This would result in a reduced turnover of the sterile fraction of the population, and make it easier to maintain the level of sterility in the population.

Peter and Dave have illustrated that a reduction in density is theoretically not necessary to eradicate Tb in possums. Targeting transmission mechanisms rather than density could achieve similar results. One step in the process is to quantify the relative contribution of mating to bovine Tb transmission. Studies are currently underway to achieve this.

This article was funded by the Foundation for Research, Science and Technology, MAF Policy, and the Animal Health Board.

***Peter Caley** and **Dave Ramsey** work on strategies for the management of disease in wild animals.*

How Humane is Brodifacoum to Possums?

There is a growing public awareness of animal welfare issues and the importance of humane pest control. Kate Littin and Cheryl O'Connor recently completed some preliminary studies on the humaneness of brodifacoum (a second generation anticoagulant poison) to possums. This work, part of a collaborative effort between Landcare Research and Massey University, ranks the humaneness of five possum poisons: cyanide, 1080, cholecalciferol, phosphorus, and brodifacoum. The type, duration and intensity of any suffering by possums is being estimated from their behaviour, physiology, and pathology from the time of poisoning until death.

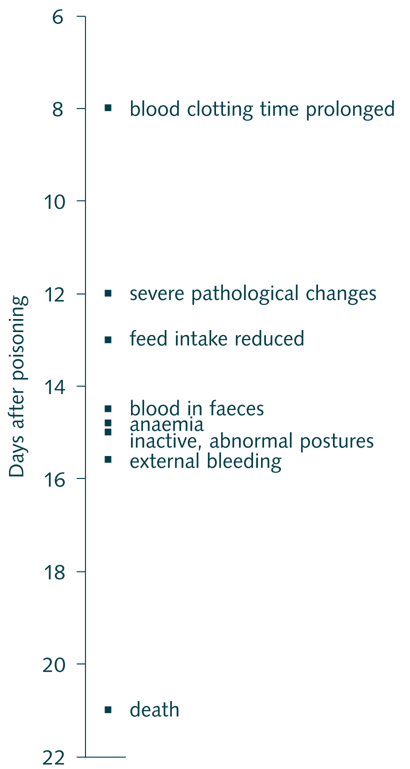


Fig. 1. Principle changes seen over time in possums given a lethal dose of brodifacoum.

Brodifacoum is used extensively in New Zealand and overseas as a rodenticide. It is now used widely in New Zealand as a possum toxin in two cereal pellet baits (Talon® and Pestoff®). Brodifacoum acts by disrupting the formation of clotting factors dependent on vitamin K, and leads to extensive haemorrhaging and death from heart failure.

Kate and Cheryl dosed 18 caged possums with a lethal amount of brodifacoum and then observed them regularly for behavioural changes (Fig. 1). They found that at 13 days, most possums reduced their food intake. Soon after (15 days on average), possums became inactive and exhibited abnormal body positions, then prolonged crouching and lying. At an average of 15 days (range 13–18 days), most also became anaemic, and blood appeared in their faeces (range 11–19). At 16 days (range 12–21), bleeding occurred from their nose, eyes, ears, mouth, and any skin lacerations present. Shivering, tremors, head pressing, diarrhoea, abnormal breathing, dehydration, incoordination, and fur erection were also seen in some possums.

They died on average 21 days after dosing (range 15–45).

Kate and Cheryl bled and autopsied another 36 possums at various stages after poisoning, and found that their packed cell volume (an indicator of dehydration) did not change. This was probably because possums lost blood slowly and compensated for its loss. Blood clotting times increased after eight days, and haemorrhages appeared after a similar time. Moderate pathological changes were seen in euthanased possums after eight days, and severe changes after 12 days. These included moderate to severe haemorrhages in the skin, testes, within and between skeletal muscles, internal organs, joint cavities, lymph nodes, brain, and the walls of the stomach, intestine, bladder, and airways. Pooled blood was found throughout all body cavities.

The nature, site and severity of the pathological changes seen in possums following poisoning were variable and unpredictable. Brodifacoum may have caused sickness, lethargy, discomfort, or pain. The abnormal behaviours and postures seen typically represent lethargy and pain in other animals, and similar anticoagulant-induced haemorrhages cause pain in humans. This suggests that possums given brodifacoum may experience pain and distress for at least one week, depending on the site and severity of internal haemorrhages. Compared to other commonly used shorter acting toxins, brodifacoum poses greater concerns for possum welfare because of the duration and unpredictability of its effects.

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

Kate Littin *and* ***Cheryl O'Connor*** *are working on the behaviour and welfare of possums exposed to common control techniques.*

Contacts and Addresses

Researchers whose articles appear in this issue of *He Kōrero Paihama - Possum Research News* can be contacted at the following addresses:

Jim Coleman
Wayne Fraser
Kate Littin
Dave Morgan
Cheryl O'Connor
Ian Payton
Peter Sweetapple
Caroline Thomson
Landcare Research
PO Box 69
Lincoln
ph: +64 3 325 6700
fax: +64 3 325 2418

Peter Caley
Dave Ramsey
Landcare Research
Private Bag 11052
Palmerston North
ph: +64 6 356 7154
fax: +64 6 355 9230

Phil Knightbridge
Department of Conservation
Private Bag 701, Hokitika
ph: +64 3 755 8301
fax: +64 3 755 8425

David Mellor
Director
Animal Welfare Science and Bioethics Centre
Massey University
Private Bag 11222
Palmerston North
ph: +64 6 350 4807
fax: +64 6 350 5657

A Selection of Recent Possum-Related Publications

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Landcare Research
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