

Kararehe Kino

Vertebrate Pest Research

Issue 14 / June 2009

Special Edition on 1080
Reduce.Refine.Replace



Landcare Research
Manaaki Whenua

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CORRECTIONS TO ISSUE 13

Pages 10 & 11

The acknowledgements for the article 'Mouse Population Irruption after Heavy Flowering of Snow Tussock' should have read:

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

Page 15 - The correct address for Sirtrack is Private Bag 1403, Havelock North, Hastings 4157

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Lead article

REDUCE

REFINE

REPLACE

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Moving forward with the complex issues of 1080

New Zealand's vertebrate pest challenge is that it has too many pests causing too much damage in too many places for the money available to resolve the problems. Conservationists, farmers, foresters and homeowners alike accept, with varying degrees of reluctance, that poisoning is often the only effective and affordable way to protect at least some kiwi, stop native forest collapse, reduce Tb, save pasture and exotic forest, and keep food stores clean. The immensity and diversity of New Zealand's pest problems require managers to use the most cost effective tools available provided they are adequately safe and humane. Balancing costs, benefits, and risks is a 'tightrope' managers must tread carefully to achieve the best possible outcomes for their stakeholders and for New Zealand. Nowhere is the balancing conundrum more obvious and controversial than with 1080 poisoning.

The debate around the economic, environmental, social and cultural benefits and costs of 1080 for pest management has

become highly polarised. Such complex policy and social issues, where the challenge confronted is unprecedented, where there is strong discord due to different values and priorities and where the issue has many tangled strands, are recognised as having no easy solution. The 1080 debate involves perceptions about a wide range of issues – different groups have different concerns about, for example, the toxin itself, its aerial delivery, non-target risks to indigenous species and hunting resources, environmental contamination, job creation, community willingness to pay for alternatives, consultation and involvement in decision making, and risks to Māori values. Successfully solving or at least managing the concerns about 1080 needs progress on two fronts: immediate action to address the most pressing issues and, ultimately, a reassessment of some of the traditional ways of working and solving problems with communities that hold strongly divergent views (see 'Taking the community with you' – Kararehe Kino Issue 5, December 2004).

At Landcare Research, our scientists are spearheading a broad-based programme of work to address some of these concerns. Much of this is done in close collaboration with the Department of Conservation, Animal Health Board and the regional councils who are at the front-line of control operations. Our approach, as described in this issue of Karerehe Kino, is based on a framework of reduce, refine, and replace – reduce the amounts of 1080 used without compromising control effectiveness; refine how 1080 is used to further minimise risks; and explore alternatives that might complement or replace 1080, such as alternative lethal and non-lethal methods.

Huge potential gains are predicted as a result of our research into simple new ways of applying aerial 1080 baits – by dropping baits in clusters or lines rather than broadcast application, the amounts of 1080 and bait used may be able to be reduced by more than 75% without compromising efficacy, and the more restricted placement of baits

lessens the risk of accidental contamination of waterways. This 'low-sow' approach may also cost less than half that of standard aerial poisoning, giving management agencies the flexibility to conduct control over more or bigger areas or to fund alternative options as part of an integrated approach. Current research aims to reduce aerial 1080 application even further by reducing sowing rates to 250 g per hectare and improving the cost-effectiveness of prefeeding.

Refining the use of 1080 applies new research knowledge of how possums respond to localised delivery of non-toxic prefeed and toxic bait. Knowing how frequently possums find and use localised sources of bait will enable management agencies to shift away from broadcast bait application to GPS-guided point-location application to avoid waterways, reduce the spatial distribution of baits, and reduce the total amount of bait applied. In effect, this will be like bait station application but delivered aerially. We have also, with funding from the AHB, assisted EPRO (a Taupo-based pest control company) to field test 1080 bait modified to pose less risk to non-target species, particularly deer where they are not considered a conservation or Tb threat. A series of tests of deer-repellent-coated 1080 cereal baits, the latest in an area with fallow deer, confirms deer deaths can be reduced routinely to under 10%, significantly less than in operations without repellent that have on at least one occasion killed more than half the deer.

To explore alternatives that might complement or replace 1080 we are taking both short- and long-term approaches. In some of the best controlled areas, where possums have almost been eliminated, we are using chew track cards (a new monitoring device) to find the few surviving possums and eliminate them using ground control methods. This provides an immediate new option to minimise the need for repeated aerial poisoning, the usual strategy for possum control in large areas of forest. Research into maximising the efficacy of alternative toxins for ground control has also demonstrated that possums and rats

that have survived control with an acute toxin, and which thus may be poison-shy, can be eliminated using a non-acute slow-acting toxin.

In the longer term, we are researching options to replace some use of 1080 for bovine Tb control with a Tb vaccine for possums. A recent field trial has demonstrated that a lipid-encapsulated version of the human BCG vaccine can give possums over 90% protection against infection by Tb. This new technology could be used to create buffers of vaccinated animals between Tb reservoirs and farmland, greatly slowing disease spread to livestock.

Our research into new toxins for rodents and stoats aims to address one of the main concerns about 1080 – its lack of specificity. These new toxins should affect only the target species: we expect the approaches we are taking to also be applicable to other pests.

Finally, we recognise some people in New Zealand and internationally are concerned about the ongoing extensive use of lethal control for management of animal pests. Our research on fertility control for possums (as part of the National Centre for Possum Biocontrol) and stoats aims to provide species-selective methods of birth control. These, like the Tb vaccine, will, where appropriate, replace or reduce toxin use.

This broad-based programme of research responds to the needs of management agencies for cost-effective and acceptable pest control while addressing the concerns and needs of the wider community. Given the role mammal pests continue to play in the decline of New Zealand's biodiversity, it is crucial that research continues to improve the efficacy of current control tools and strategies while striving to find new, more acceptable options. We believe there are huge efficiency gains possible in existing technologies that will provide immediate benefits and accommodate new technologies as they come on stream. This will provide both management agencies and communities with a wider range of pest

management options now and into the future. At the same time, fundamental issues remain that require open and frank debate – such as the use of lethal control, pest animal welfare, and the place of introduced species in New Zealand's fauna. It is important that we do not become fixated on single issues such as 1080 and ignore the pressing need to debate the wider strategic issues confronting New Zealand in protecting and restoring its biodiversity, and maintaining access to valuable international markets.



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A handwritten signature in dark ink that reads "Warren Parker". The signature is written in a cursive style with a horizontal line underneath the name.



REDUCE

Getting good kills with less 1080 – Molesworth 2008

Not so many years ago it was commonplace to use more 1080-loaded bait than was actually needed in operations against possums. For example, operations in the early 1990s to protect kōkako and their habitat sometimes used up to 18 kg of bait per hectare. This 'overkill' arose because back then managers had far less control of bait spacing and bait placement, and bait quality was more variable. Research by Dave Morgan and others has hugely improved bait quality and increased kills. This, combined with the advent of helicopters equipped with sowing buckets to deliver bait and GPS to guide flight paths, has resulted in typical sowing rates for toxic bait plummeting to 2–3 kg/ha.

However, researchers (particularly Graham Nugent and Bruce Warburton) have recently questioned whether even that is more than is necessary to get good kills (see Kararehe Kino Issue 11, 2007). In 2008, Graham and Ivor Yockney tested this over 28,000 ha of tussock land in eastern Molesworth Station – a huge and daunting step-up from earlier small field trials that indicated further reductions in sowing rates of bait were possible without any loss in effectiveness.

The area was divided into four blocks of 4000–9000 ha, and a digital terrain model that had been developed earlier to map predicted possum abundance across the station (see Kararehe Kino Issue 12, 2008) was used to divide each block into three zones: a zone predicted to have low numbers of possums (as indicated by a trap-catch rate of <5%), a zone with moderate numbers (5–10%), and a zone with high numbers (>10%). In each block, the zone with the lowest number of possums was



Grant Morris

Ivor Yockney setting a Chew Track Card for monitoring possum abundance on Molesworth Station.

left out of the control operation. In one pair of blocks only the zone with high numbers of possums was controlled (= low coverage), while in the other pair, zones with moderate or high numbers of possums were both controlled (= high coverage).

One of each pair of blocks was treated with the aerial baiting regime normally used over Molesworth, i.e. 2.5 kg/ha of 8-g 1080 cereal baits broadcast thinly in swaths of about 130 m wide. The other block in the pair was treated with 60% less of the same cereal bait (1.0 kg/ha) sown in clusters of 30–40 baits spaced about 30 m apart along the helicopter flight paths. This was achieved using a sowing bucket modified with a new gated paddle-wheel that is able to sow specific numbers of baits at the desired interval (*photo*). In addition to these four main blocks, a small block of about 500 ha was prefed with 1 kg/ha of non-toxic bait followed by the same clustered baiting.

Chew Track Cards (CTCs) (*for description see pages 18 & 19*) were used to monitor changes in the abundance of possums and standard

Residual Trap Catch Index (RTCI) trapping was used as a relative measure of how many possums survived the poisoning.

Good reductions in possum numbers were obtained with all three treatments. In the blocks where the zones with both moderate and high possum populations (high coverage) were controlled and where possum numbers were below 10%, there was a 100% reduction in CTC interference with cluster sowing and a 96% reduction with broadcast sowing. In the blocks where only the zone with high possum populations were controlled (low coverage), and where possum numbers were above 10%, reduction in CTC interference was 90% for cluster sowing and 89% for broadcast sowing. The trapping data also showed no difference in RTCI between cluster sowing (1.1%) and broadcast sowing (0.9%) for either treatment. No possums at all were trapped after control in the prefed cluster-sown block.

An analysis of the costs of bait and helicopter flying time (*Fig*) indicated that



The modified sowing bucket in use at Molesworth.

although cluster sowing slightly increased the amount of sowing time, this was greatly offset by lower bait costs and reduced flying time (60% in each case) to ferry bait from the loading zone. Expressed as a per-hectare rate for each block (including the parts not controlled), the bait and operational flying costs for the low-sowing-rate/low-coverage block were <\$4 per hectare compared with \$14 for the high-sowing-rate/high-coverage block.

The good kills achieved using clustered bait indicate that it is not necessary to spread bait evenly over the whole area targeted for possum control – most if not all possums will sooner or later find clusters of bait. Such kills also support the hypothesis that clustering bait enables possums to quickly find enough baits to receive a lethal dose of 1080. Despite some bait being broken up on impact with the rocky ground, sublethal poisoning is likely to be greatly reduced.

A key question that emerges from this study is whether it is necessary to have as many as 40 baits in each cluster. Graham and Ivor speculate that as few as 10 baits might suffice. This would mean that sowing rates as low as 0.25 kg/ha might be effective on Molesworth, reducing the cost and amount of bait used by as much as 90% compared with current practice there.

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

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Ivor Yockney, Jackie Whitford and Dave Morgan

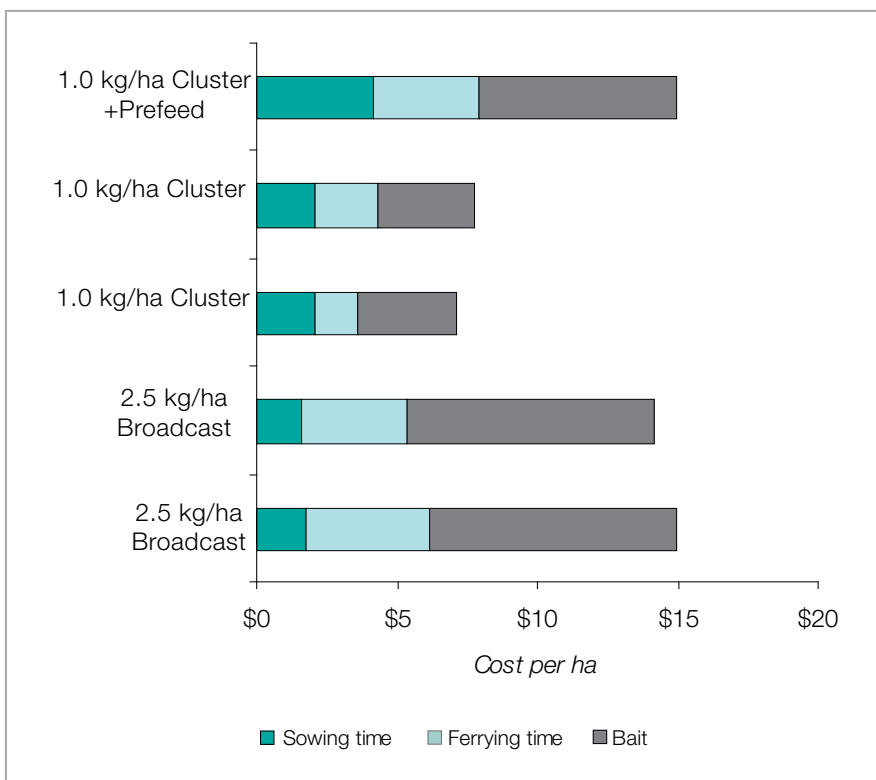


Fig. Estimates of the costs per hectare of bait and of helicopter time spent sowing and ferrying bait to the blocks (but excluding fixed costs such as planning and consents).



REDUCE



Dave Morgan

Getting good kills with even less 1080 – Landsborough 2009

practice on the West Coast: prefeed (1 kg of 6-g non-toxic baits/ha) was broadcast from a bait bucket using a high spinner-speed to distribute it as evenly as possible over the whole area, then 5 days later 3 kg/ha of 12-g toxic bait was similarly broadcast, with no particular effort made to align the prefeed and toxic-bait flight paths.

The second treatment was 'cluster-not-aligned' and was identical to the first treatment except that only 0.25 kg/ha of toxic bait was sown in clusters of 10–15 baits every 40–50 m along the flight path.

The third treatment was 'cluster-aligned'. It was identical to the second treatment, except that, as far as practicable, the same flight paths were used to sow both the prefeed and toxic bait with the prefeed being sown using a slow spinner that deposited most of it close to or under the flight path. The aim was to get the possums accustomed to searching the areas subsequently sown with clusters of toxic bait, while ignoring the strips without toxic bait.

Outcomes were monitored using a Tracking Tunnel Index (TTI) for rodents (1 night) and stoats (4–5 nights), and Chew Track Cards (CTC) for rodents and possums. Possum abundance was determined after control using the Residual Trap Catch Index (RTCI).

Stoat and rat TTI indices were low before control (8% and 5% respectively). No stoats were detected after control, but the data were too few to say whether any treatment reduced stoat activity. Likewise, there were no rats detected after control at any of the sites where they had been detected before control, but rats were detected at three new sites in one of the 'cluster-not-aligned' blocks.

The SowLow bucket modified with a gated paddle wheel mechanism for aerial delivery of bait in clusters as used in the Landsborough and Molesworth trials.

An aerial baiting trial on Molesworth Station in 2008 demonstrated that sowing 60% fewer 1080 baits in clusters was just as effective in controlling possums as widely broadcasting it at the usual rate of 2.5 kg/ha (see previous article). Grant Morriss and Graham Nugent have tried to improve on this by exploring whether cluster sowing is still effective when the sowing rate is further reduced to 0.25 kg/ha.

In early 2009, and with the help of Terry Farrell of the Department of Conservation,

the abundance of possums, rats, mice, and stoats were compared before and after an aerial baiting operation in the lower Landsborough Valley in South Westland. Six study blocks were selected, each 300–500 ha, and three different treatments applied to two each of the blocks. All involved sowing cereal bait (12-g Wanganui #7) along parallel flight paths spaced 100 m apart, from a helicopter travelling at about 110 km per hour.

The first treatment was 'broadcast-not-aligned' and represented current best

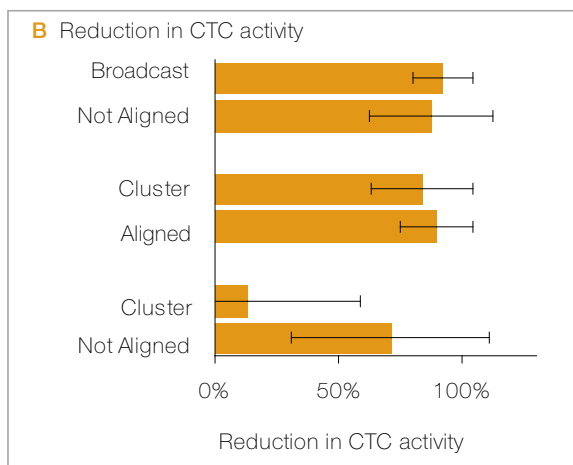
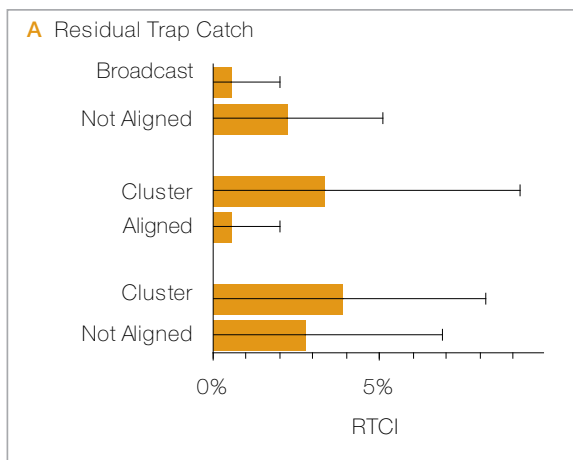
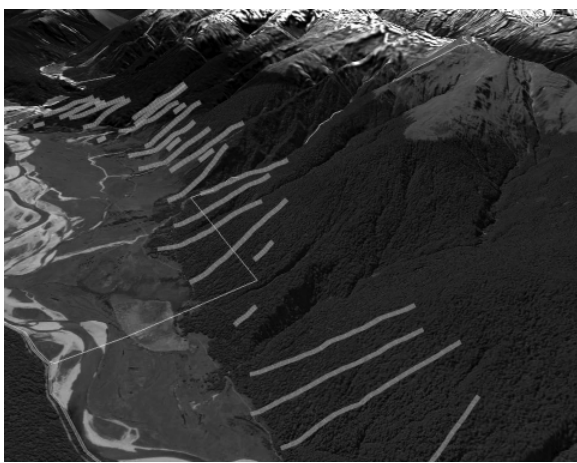


Fig. Means and 95% CI for (A) residual trap-catch rates (RTCI) of possums, by block and treatment, and (B) reductions in Chew Track Card (CTC) activity levels per transect.



Looking north over the operational area past the confluence of the Haast and Landsborough Rivers showing the Chew Track Card lines (longer lines) and the Residual Trap Catch Index lines.

The overall reductions in rat activity were estimated at 100% using TTIs and 84% using CTCs. Mouse activity levels were similar or higher after baiting, indicating few if any were killed.

Before control, possums were initially widespread in all blocks (31–89% CTC detections per transect). After control, RTCI values were all below 4% (Fig. A) and did not differ statistically between treatments. The average reductions overall in CTC activity per transect in the ‘cluster-aligned’ blocks (down by 87%) and in the ‘broadcast-not-aligned’ blocks (down by 90%) were similar (Fig. B), and matched the low numbers of possums trapped. In the ‘cluster-not-aligned’ blocks, possum activity was reduced by only 41%, which was consistent with the higher RTCIs recorded there.

The similar average kills and residual abundance of possums obtained under the ‘cluster-aligned’ and ‘broadcast-not-aligned’ (standard) treatments indicates the former technique has substantial promise, so Grant and Graham are looking to further refine the technique. They will now be testing whether still tighter clustering of bait (by flying lower and slower) and/or by having more but smaller baits in each cluster) will produce acceptable kills of possum and other mammalian pests without having to resort to higher sowing rates.

Overall, the results indicate that sowing small amounts of bait in clusters is reasonably effective in controlling possums, provided prefeeding is used to teach the possums where to look for patches of bait. By using 92% less toxic bait than normal sowing (i.e. 0.25 kg/ha instead of 3 kg/ha), this strategy opens up new possibilities, through increasing the affordability of more frequent repeat control that is needed to reduce the number of rats and stoats. Importantly, it requires only small straightforward changes in current practice so could be implemented quickly to provide major improvements in the scale and effectiveness of the pest control needed to protect critically threatened native species over much larger areas than now.

This work was done under contract to the Animal Health Board with operational support from the Department of Conservation.

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Graham Nugent

REFINE

Localised prefeeding alters possum foraging behaviour



Bruce Warburton

A possum with a newly fitted electronic tracking collar.

Prefeeding with non-toxic bait is used to encourage the target species to eat sufficient of a similar toxic bait to receive a lethal dose. Prefeed can be broadcast from the air, placed in bait stations, or placed in localised strips or piles on the ground. Typically pest managers then wait 1–2 weeks before applying the toxic bait. For the strategy to be successful when prefeed is restricted to limited areas within the control zone, targeted animals have to remember eating it (consumption memory) and where it was located (spatial memory). While it is likely that the benefits of prefeeding will diminish over time, consumption memory has been shown to

persist in possums for at least 1 month. This is important because inclement weather often increases the time between prefeeding and toxic baiting. However, it is unclear whether possums remember where prefeed was found after such delays and whether they continue searching for it until toxic bait becomes available.

Richard Clayton and Bruce Warburton recently investigated how prefeeding affected the time that possums spent foraging at or near prefeed sites, and how long any effect persisted once all prefeed was eaten. They put VHF radiotransmitter

collars on possums in the Orongorongo Valley and monitored them continuously using a specially designed contact logger system for 3 weeks before and 4 weeks after prefeeding. The logger system comprised a scanning-receiver/data-logger combination that monitored the presence of collared possums along a 350-m length of co-axial aerial, laid on the ground along a transect that was subsequently prefeed. The logger recorded the arrival and departure time of the collared possums that came into 'contact' with the aerial. The prefeed used was 6-g Wanganui #7 cereal baits placed in clusters of 15 baits at about 5-m spacing.

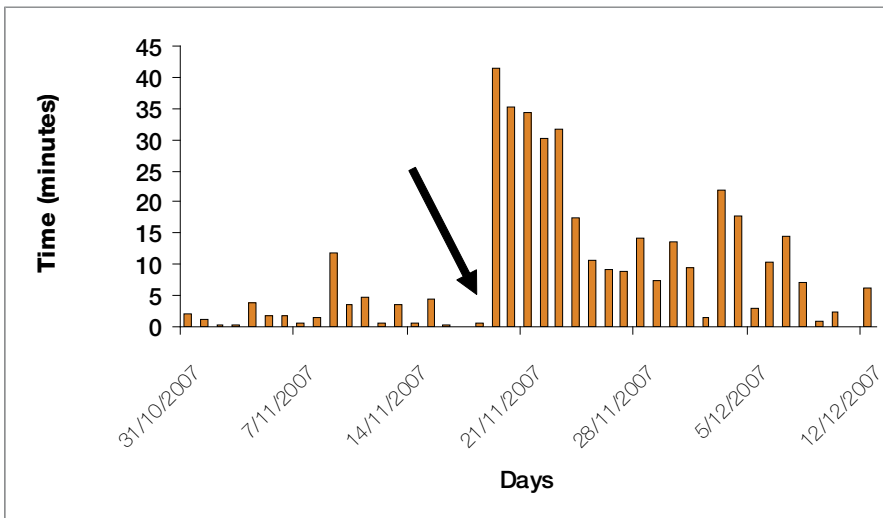


Fig. Mean time spent by 15 possums about a prefeed line before and after bait was applied (prefeed application denoted by arrow).



Bruce Warburton

VHF Tracking receiver and electronic tracking collar.

Fifteen possums were detected by the contact logger, and they exhibited a clear pattern of increased use about the prefeed line following baiting (Fig). These possums spent an average of 2.5 minutes per night within close proximity of the aerials before prefeeding, but this increased 17-fold to 43 minutes on the first night following prefeeding and then declined exponentially but slowly over the subsequent 3 weeks. By the 5th night, all prefeed had been eaten, yet possums continued to spend significantly more time on the bait line for a further 16 nights even though they were not rewarded for doing so.

The mean number of visits by possums to the prefeed line prior to its application was 0.3 per possum per night, but following prefeeding this increased to two visits per possum per night and then decreased exponentially over the following weeks. Possums returned to the bait line on average 76 minutes earlier on the second night after discovering the prefeed.

Prefeeding clearly encourages possums to look for bait where they had previously found it and influences both their spatial use and proportion of time spent on the ground. Prefeeding should therefore increase the

likelihood of possums quickly encountering newly sown toxic bait, especially when applied in the isolated strips or clusters that arise from either aerial trickle sowing or any form of ground-based poisoning. Richard and Bruce infer that a key benefit from prefeeding is that it encourages possums to actively look for, and more frequently encounter, a second toxic bait soon after they have eaten the first bait encountered. This reduces the chance of possums surviving due to sublethal poisoning where one bait encountered on its own does not deliver a lethal dose of toxin.

The team further concludes that prefeeding has a broader effect on possum foraging behaviour than just increasing their willingness to accept and eat toxic bait. Prefeeding clearly alters where they spend their time, and appears to teach them to search in places likely to be baited. This insight is now being used to design programmes that increase the efficiency of both poisoning and trapping operations by drawing possums to easily baited areas. For aerial baiting systems, this includes the possibility of applying the prefeed in only small parts (i.e. to < 80% of the landscape) to encourage possums onto those sites and consequently limiting the toxic bait to the same area. Such an approach might reduce concerns about 1080 poisoning by permitting a move away from broadcast sowing operations that are intuitively disliked by many, to much more localised baiting regimes.

This work was jointly funded the Foundation for Research, Science and Technology and the Animal Health Board.

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Richard Clayton and Graham Nugent



REFINE

A repellent to reduce deer by-kill from aerially sown 1080 bait

The unintended killing of deer during aerial 1080 operations targeting possums is controversial. While land managers sometimes see deer as pests because they may carry bovine Tb or browse native plants, hunters are opposed to any deer being poisoned and often argue against applications to apply 1080 aerially. The few possum control operations in which deer have been formally monitored indicate that the effect of 1080 on their populations is variable but can be substantial. In the most extreme example known, 54 fallow deer were found dead in 359 ha after an aerial poisoning operation in 2001 in the Blue Mountains Recreational Hunting Area, Otago. It was estimated that roughly two-thirds of the deer population (500–600) had been killed. It is suspected that fallow deer are more vulnerable to 1080 operations than red deer because they are smaller and need to eat fewer baits to be poisoned.

To address hunter concerns often raised at consent hearings for aerial 1080 poisoning, EPRO (a Taupo-based pest control company) commissioned Landcare Research to identify and test a deer repellent for use on 1080 baits for possums. Since 2001 a series of trials, funded by the Animal Health Board (AHB), has shown that experimental formulations of the repellent (EDR) on carrot and cereal baits were effective in reducing the by-kill of red deer, but still effective in killing possums. EPRO and AHB have now obtained registration of EDR carrot bait, and in 2009 sought and obtained registration for EDR cereal bait. For this registration, they required efficacy data for its commercial formulation. A repeat poisoning in 2008 of the same area of the Blue Mountains poisoned in 2001 provided an opportunity to obtain those data.

The operation was carried out over 6444 ha in June 2008. A helicopter sowed 2 kg/ha of non-toxic (prefeed) EDR-coated Wanganui #7 cinnamon-lured 12-g cereal baits, followed 21 days later by the sowing of the same baits loaded with 0.15% 1080.

Three weeks after poisoning, Grant Morriss and his team searched at least twice for animal sign along parallel transects (and at right angles to them in subsequent surveys) in four blocks of about 120 ha. They recorded deer faecal pellets (a proxy for pre-poison deer abundance) accrued on plots 100 m apart along the transects and any fresh deer tracks after poisoning (a proxy for post-poison deer abundance), the number of live deer seen, and the number of deer, pig, bird and possum carcasses found. During the first search, they placed large brown paper rubbish bags filled with leaf litter at intervals along the transects to mimic deer carcasses, and used the proportion of bags found in later searches as a measure of search efficiency.

In all, 6 fallow deer, 3 small pigs, 34 possums, 7 blackbirds, and 1 kererū carcass were found. All of the deer, pigs and blackbirds were found to contain 1080, but not the kererū (possums were not tested). The number of sacks found indicated that each search covered about a quarter of each block, and suggested that about 12 deer had been killed in the four blocks, which was thought to be less than 10% of the population.

During the searches, 33 live fallow deer and one live pig were seen, and fresh deer tracks were observed on 28% of the transect segments.

Possum numbers were low but variable, with faecal pellets deposited before control found on 7% (range 3–14%) of the plots searched after control. Operational monitoring indicated a very good possum kill, with no possums caught on 30 lines of 10 traps set for three fine nights. In addition, the Department of Conservation monitored possum interference rates on 32 lines of 10

Wax Tags®, and found it declined from 40% before control to 0% afterward. Both sets of data suggest strongly that the inclusion of EDR did not reduce bait acceptance by possums.

The Department of Conservation also conducted surveys of small mammals before and after baiting, using 16 lines of 10 tracking tunnels. Tracking declined from 22% to 0% for mice, from 2% to 0% for rats, and was 0% for stoats before and after control.

Based on these results, Grant and his team considered that a much lower percentage of the population of fallow deer in the Blue Mountains was killed in 2008 than in 2001, namely 10% vs 66%. As fallow are likely to be the most vulnerable of deer species to poisoning, cereal bait with repellent is likely to be more effective in protecting red deer populations. This refinement should help reduce opposition from many hunters to aerial 1080 operations undertaken in areas where deer are a highly valued hunting resource. However, managers are concerned about the increased cost of its use. Grant anticipates that economic concerns will reduce if ongoing research (*see page 6-9*) confirms that much lower sowing rates are effective, the cost of adding repellent to the smaller amount of bait used will be also lower. If so, using repellent bait could cost the same or less than current operations without repellent.

As a consequence of this and related work, the Environmental Risk Management Authority (ERMA) has now approved the use of EDR repellent on cereal baits.

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

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Graham Nugent

Control of bovine tuberculosis by vaccination

Graham Nugent



Developing vaccines and vaccination strategies to complement conventional control of bovine tuberculosis (Tb) in wildlife has been a key focus of our research in recent years. Dan Tompkins and Graham Nugent from Landcare Research, in collaboration with the Animal Health Board, Immune Solutions and AgResearch, have been field testing the human tuberculosis vaccine (bacille-Calmette-Guerin, or BCG) against possums, the primary wildlife reservoir of Tb in New Zealand.

BCG vaccine efficacy in possums

BCG has an extensive safety record in humans – over 3 billion doses have been administered over the last 80 years, mostly via injection. A major obstacle to effective BCG vaccination of wildlife is a practical means of delivering a stable vaccine to wild animals. Oral baiting is generally considered the only feasible means of delivering vaccines for large-scale disease management in wildlife. However, since BCG is a live attenuated bacterium, its deployment as an oral vaccine requires that it be protected from degradation in the stomach. To this end, an edible lipid matrix has been developed that allows BCG bacilli to be maintained

in a viable state, thus making it suitable as a vehicle for delivering the oral vaccine. Encouragingly, a 2-year field trial by Dan and colleagues in the Orongorongo Valley has shown recently that this oral vaccine offers significant protection against Tb. Twelve of seventy one (17%) control animals became infected with Tb (culture-confirmed), compared to only 1 of 51 (2%) vaccinated animals. This one infected vaccinated animal had only 1-mm lesions in the liver compared with obvious Tb lesions in the lungs and/or lymph nodes in the infected control animals.

These results equate to about 90% protection against natural Tb infection conferred by the vaccine to free-living possums – well above the theoretical threshold required for Tb eradication. Work is now underway at Landcare Research to fully characterise the duration of protection against Tb conferred by oral vaccination of possums in the wild.

Application strategies

Attention has now shifted to developing two application strategies that would maximise the benefit achieved from vaccine use – ‘dual-agent control’ and ‘vaccinated

buffers’. The dual-agent control strategy, being developed by Graham Nugent, involves the simultaneous aerial sowing of toxic baits and vaccine. With any surviving possums vaccinated against the disease, the high numbers of toxic baits required to ensure high levels of possum control could be reduced (*Fig. 1*), while conservation benefits arising from still relatively high possum control may be obtained. Work is now underway to (1) liaise with Amuri Helicopters to redesign our patented SowLow bucket for ultra-low sowing rates plus vaccine application, (2) develop a vaccine package that can be aerially sown, and (3) develop spatial and bioeconomic models to identify the optimal toxic bait/vaccine dual-sowing rate.

In contrast to dual-agent control, vaccinated buffers prevent the transmission of Tb from wildlife to livestock through the containment of Tb-infected possums in areas well away from farmland. A vaccinated buffer works by using a ‘social fence’ of resident immunised possums to block the transit of potentially infected possums from deep forest to farmland. Such buffers need to be as narrow as possible to keep the

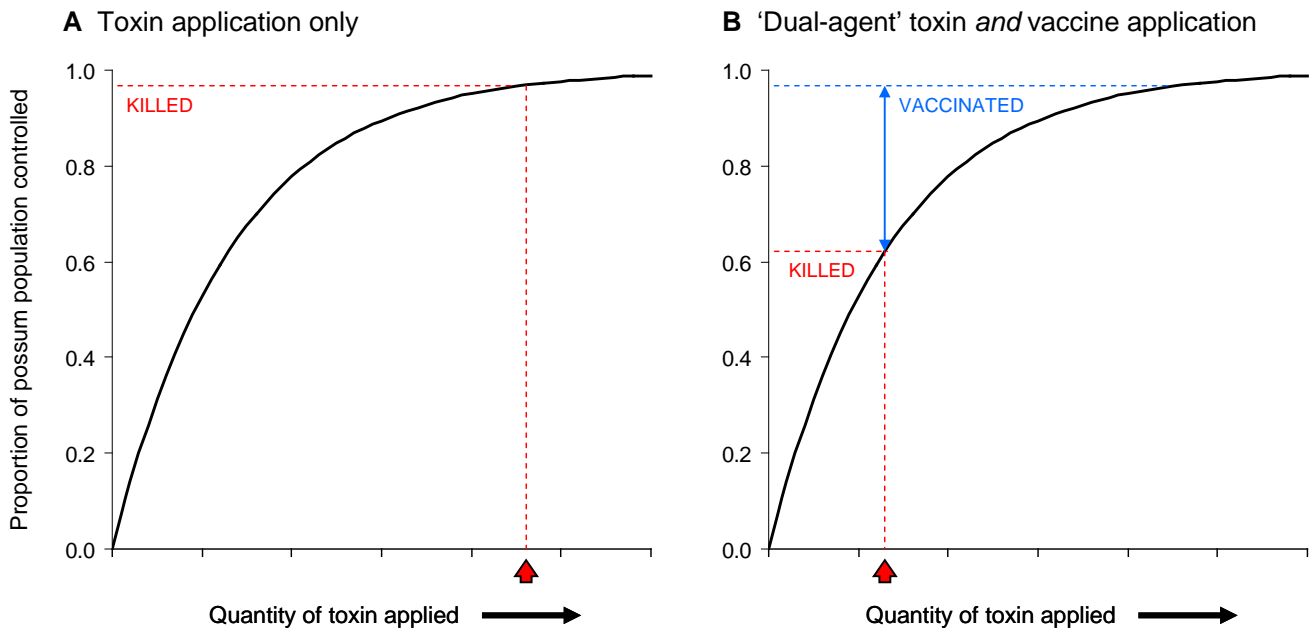


Fig. 1. Conceptual model for toxin application to possum populations showing how dual-agent control might reduce toxin use; (A) Tb management using toxic bait only, (B) the same level of Tb management achieved using dual-agent control – one-quarter the amount of bait plus vaccine.

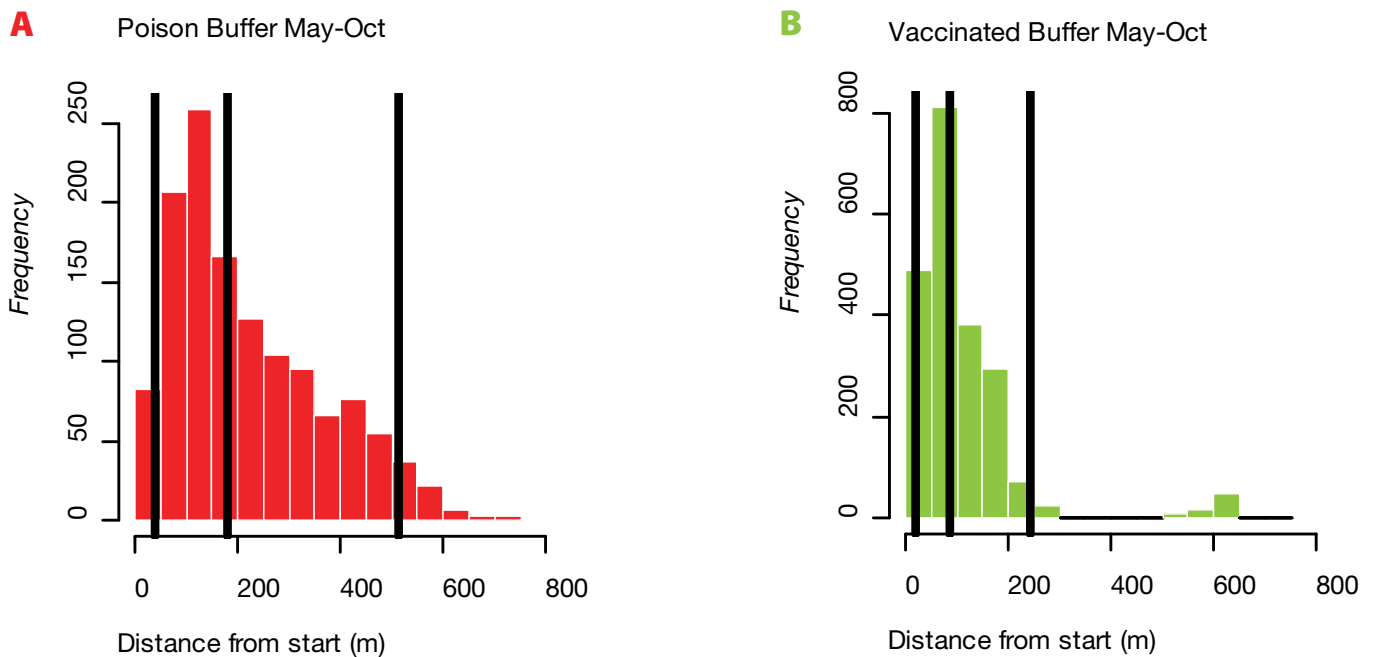


Fig. 2. Distances moved during winter from the location where each GPS-collared possum was initially trapped in (A) a poisoned buffer and (B) a simulated vaccinated buffer. The vertical lines are the 5%, 50% and 95% quantiles. The distributions of movements are significantly different ($P < 0.001$), in other words, possums move around less if they have 'vaccinated neighbours' in place.





Graham Nugent

Experimental oral vaccination of an adult cow using BCG in a lipid matrix, Clarence Reserve, February 2009.

protecting cattle against a natural challenge from an infected possum is not known. Furthermore, the main barrier to using BCG vaccine for controlling Tb in cattle is that the vaccine interferes with the diagnostic Tb skin test. Vaccination that did not cause skin test reactivity, yet still protected against infection, would greatly increase the potential utility of this tool as an alternative for reducing Tb in New Zealand cattle and deer herds. To this end, a 4-year programme of work by the team is now underway to (1) test whether BCG vaccination does indeed protect cattle from Tb transmitted from possums, (2) identify the duration of any protection conferred, and (3) investigate whether there is a vaccine dosage that provides protection but does not produce positive skin tests.

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

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**Andrea Byrom, Dean Anderson,
Roger Pech and Graham Nugent.**

costs of control to a minimum. However, there is a higher probability an infected animal will cross a narrow buffer than a wide buffer, and the risk will also increase over time as unvaccinated animals move into a vaccinated area. Hence, optimal buffer width will depend on an acceptable level of risk that an infected possum might cross the buffer.

To test this strategy, Andrea Byrom, Dean Anderson and Roger Pech recently compared possum reinvasion rates during a simulated 'vaccinated buffer' with the rate for an alternative 'poisoned buffer' in beech forest in the Kaimanawa Range. The movements of possums from an area with no possum control (simulating a vaccinated buffer) were compared with those from an uncontrolled area immediately adjacent to a strip 2.5–3 km wide where the population had been reduced to very low levels by 1080 baiting in September 2007 (a poisoned buffer). For the following summer (October to March), GPS collars

were used to monitor foraging movements of adult possums. Initial results indicate 95% of possum movements were markedly shorter for the simulated vaccinated buffer (≤ 243 m) than across the poisoned buffer (≤ 381 m; *Fig. 2*). A similar difference in winter movements was also observed, indicating that buffers for containing Tb in possums away from farmland can be significantly narrower if vaccination is used, compared with conventional control. However, comparison of vaccinated and poisoned buffers at other sites is needed to allow more robust advice for managers, together with the relative costs of using vaccine and toxic baits.

Potential vaccine for cattle

Looking ahead to future applications of this vaccine, Graham and the team are now field testing it for its application to cattle – an alternative or back-up Tb control strategy should an extensive vector control programme not be achievable. However, the efficacy of current vaccine formulations in



REPLACE

Hare and tortoise: Combining toxins for one-hit ground control of possums



Looking across the Kumara Reservoir towards the study area.

Aerially sowing 1080 baits to control possums is not permitted in some forested water-supply catchments. This leaves ground-based trapping or poisoning as the only practical alternatives. Getting a good kill of possums with trapping is expensive as it requires several visits to clear traps, whereas hand-laying toxic baits normally requires only one or two visits.

Toxins can be fast or slow acting. Fast-acting toxins, such as cyanide, kill possums quickly but because their effect is so rapid some possums become ill before eating a lethal dose, and survive to become wary of the bait used. Slow-acting toxins, such as anticoagulants and cholecalciferol, are less detectable by possums and are less likely to cause bait aversion. The practical downside with slow-acting toxins, when pest densities are high, is that large and expensive amounts of bait are required to ensure hungry animals leave some bait for less avid feeders.

To eliminate this downside, Graham Nugent and his colleagues looked at whether possum populations reduced with a fast-acting toxin could be eliminated effectively and affordably with immediate follow-up using a slow-acting toxin. Their trial was conducted in four contiguous forest blocks alongside the Kumara Reservoir in 2008. Two blocks were poisoned first with twice-prefred cyanide paste (Cyanara®) and then with 100 g of cholecalciferol (Decal® cereal pellets) placed in pots 20 m apart along bait lines 100 m apart, and two blocks received the same treatments on bait lines 200 m apart. Leghold trapping on Residual Trap Catch Index (RTCI) lines, radiotelemetry, and chew card interference on Chew Track Card Index (CTCI) lines were used to monitor the outcome.

The cyanide paste killed 79% of the radio-tagged possums, with no difference between blocks with 100- or 200-m line

spacings and very similar reductions in RTCI and CTCI (Table). Cholecalciferol pellets killed four of the five surviving radio-collared possums. No possums were subsequently trapped but chew cards detected some survivors at seven sites. For both methods combined, there was a 96% kill of radio-collared possums, a 100% reduction in RTCI, and a 90% reduction in CTCI activity. After baiting with cholecalciferol, CTCI detected two foci of possums on a single line in the blocks with lines spaced 100 m apart, compared with five foci in the blocks with lines spaced 200 m apart. The best overall reduction (97%) in possums was in one of the 100-m spaced blocks.

Of the 27 radio-tagged possums killed with cyanide, 22 (81%) were found beside baits along with 508 non-collared possums. Assuming the same mortality between collared and uncollared possums, this indicated that about 650 were killed across



Helen Lash

	100-m spacing	200-m spacing	All
Radio-collared possums			
% kill cyanide	80% (15)	79% (19)	79% (34)
% kill cholecalciferol	100% (1)	75% (4)	80% (5)
% kill both	100% (16)	96% (23)	98% (39)
Possom trapping (RTCI)			
% reduction cyanide	80%	81%	80%
% reduction cholecalciferol	100%	100%	100%
% reduction both	100%	100%	100%
Possom Chew Card (CTCI)			
% reduction cyanide	74%	79%	76%
% reduction cholecalciferol	91%	30%	60%
% reduction both	95%	86%	90%
Rat Chew Card (CTCI)			
% reduction cyanide	3%	increase	increase
% reduction cholecalciferol	91%	93%	93%
% reduction both	93%	88%	91%

Table. Reduction in possum and rat numbers after cyanide and cholecalciferol poisoning, for two bait-line spacings. The reductions in CTCI were calculated from Poisson-transformed data. Number of possums killed shown in brackets.

all four blocks. Allowing for 20% survival, the pre-control population appeared to average about 820 possums, a relatively low density (by West Coast standards) of c. 1.5 possums/ha.

Cyanide paste had no discernible effect on rat CTCIs, with interference recorded on almost every card in all blocks. In comparison, cholecalciferol pellets reduced rat interference levels by 91% overall and by up to 97% in one of the 100-m-spacing blocks.

Overall, these results indicate that using slow-acting toxins in a different bait immediately after an operation using a fast-acting toxin can be successful in mopping up surviving possums. The small non-significant difference in the total reductions of possums at the two line spacings indicate that possum survival in the 100-m blocks was unlikely to reflect a non-encounter with

baits, but rather that about 20% of possums survive an encounter with cyanide paste. Using an intermediate bait line spacing of 150 m rather than the 100-m and 200-m line spacings trialled appears unlikely to reduce the efficacy of possum or rat control in forest habitats.

The experimental control programme required six visits – two to prefeed the cyanide paste, two to lay and remove the cyanide, and two to lay and remove the cholecalciferol pellets. At an average spacing of 150 m between lines, this cost about \$75 per hectare, which could be reduced by perhaps a third if one prefeed and the bait removal visits were dropped. The cost of the prefeed and cyanide paste was minor but even at the low application rate of 300 g/ha the cholecalciferol bait cost \$6 per hectare. In comparison, an aerial 1080 operation a few months previously in the surrounding area cost \$36 per hectare.

Thus, in flat forest readily accessible from road edges, equivalent control can be achieved using ground-based methods, albeit at a substantially higher cost.

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

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REPLACE

Replacing repeat aerial 1080 baiting for possums by ground-based detection and mop-up



Grant Morris

Chew Track Cards, gathered in from the lines, showing the distinctive wavy edges caused by possums chewing on the baited cards.

Repeated aerial 1080 baiting at intervals of about 5 years is the common strategy for ongoing possum control in large areas of native forest. That is because the average annual cost (c. \$4–7/ha/year) is much lower than the cost of ground-based control. One reason that ground control is so expensive is because covering the whole area with traps and/or poison baits – in the absence of information about where possums are likely to be – is the only sensible strategy. However, aerial 1080 baiting has now become so efficient that, immediately after its use, there are often large areas free of possums that do not need follow-up control for a decade or more. If it was possible to identify such

gaps, the need to repeat 1080 baiting over the whole area would be reduced. Such a tactic would require an affordable large-scale ground-based system for mapping the distribution of possums after control.

To this end, Peter Sweetapple has developed a low-cost, highly sensitive device – the Chew Track Card (CTC). This is an interference device made of white plastic coreboard, set out on the base of trees throughout targeted possum habitat. Each CTC has peanut-butter-based baits pressed into the internal channels and a tracking ink pad (*Photo*). Possums and other small mammalian pests are detected by either

footprints or tooth impressions made as they attempt to extract the bait. The inclusion of bait and tracking ink potentially increases the sensitivity of CTCs to possums and other pests compared with existing non-palatable interference devices.

The efficiency of CTCs in detecting possums was highlighted by a comparison with leghold trapping conducted in the Hauhungaroa Range after aerial 1080 baiting in 2005. That operation reduced possum trap catch to an impressively low 0.05% over 15,000 trap nights, with just one possum detected for every 111 days of trapping effort. A CTC survey a few months later

deployed cards spaced at 50-m intervals along transects that systematically covered 16,000 ha of the poisoned area. This survey detected one or more possums for every 3.6 days of effort, a 30-fold improvement in detection efficiency. Subsequent fieldwork, also in the Hauhungaroa Range, suggests that CTCs about 50 m apart on transects 250 m apart detect over 80% of possums present.

CTCs are still in development and some problems remain. In particular, possum detection rates are lower when rats are abundant because they can remove all the bait. Nevertheless Peter and Graham Nugent are convinced that for some of the easier and more accessible forest, and more developed areas where aerial 1080 baiting is not feasible, CTCs are effective for identifying isolated groups of possums that survived aerial baiting and which can then be mopped up. The key question here is under what circumstances might detection surveys and targeted mop-up of possums be more cost effective than repeated 1080 baiting across the whole area? To answer this, Peter and Graham have been modelling costs of detection and mop-up operations under a range of initial possum densities and detection transect spacings, and comparing them with the cost of whole-area aerial baiting.

Assuming costs of \$36 per hectare for whole-area aerial baiting and \$41 per hectare for spot aeri ally baiting a 6-ha area around each site at which possums were detected by CTCs, their models predicted that whenever possum abundance was below about 3% trap catch (*Fig*), detection surveys with transects at 250-m intervals followed by spot baiting were more cost effective than whole-area aerial baiting. At very low possum densities, considerable cost savings are possible using a detection and mop-up strategy compared with blanket control. But at higher possum densities, possums occupy most of the available habitat so whole-area control operations are still necessary to reduce them to levels where there are gaps in their

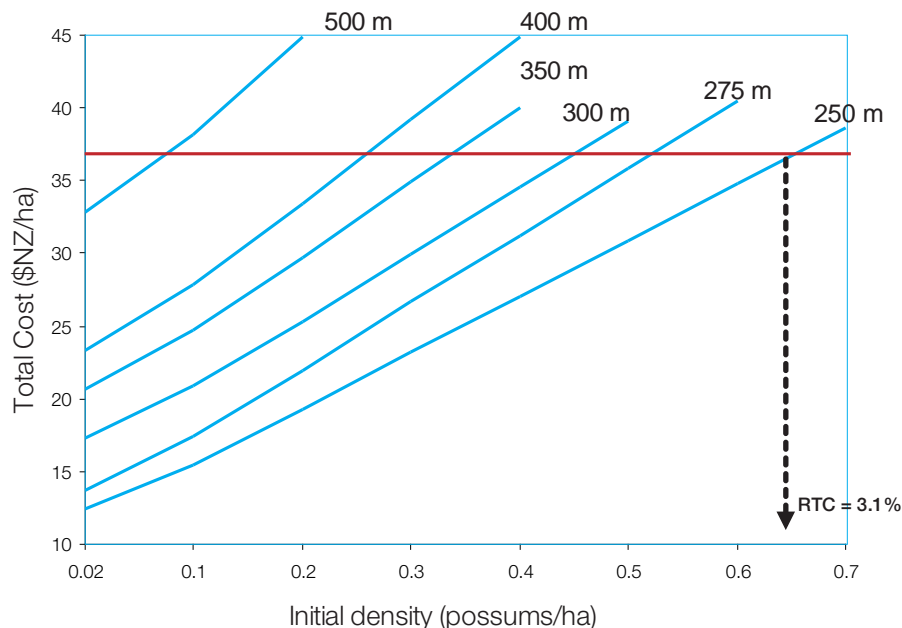


Fig. Costs of achieving a 95% reduction in possum abundance using whole-area aerial 1080 baiting (red line) and detection surveys at different transect spacings followed by spot aerial baiting (blue lines).

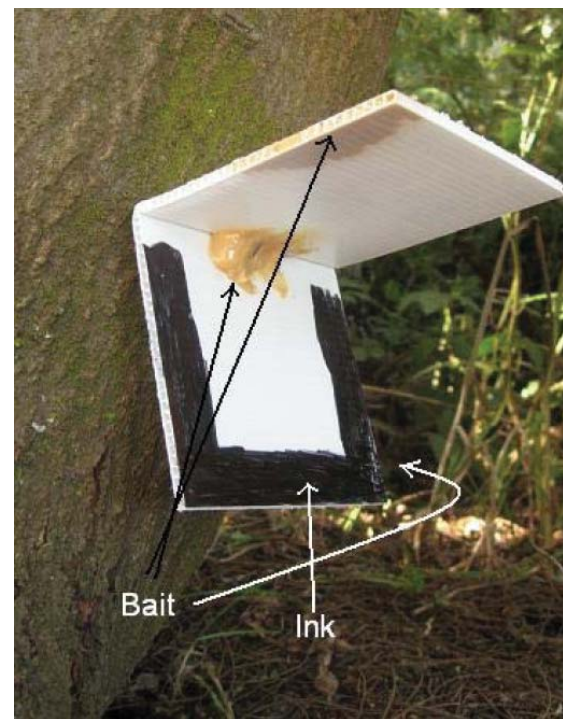
distribution. The predicted cost-benefits may, in future, be eroded if the cost of whole-area aerial baiting is greatly reduced as a result of reduced sowing rates and new sowing strategies (see pages 6-9 in this issue). However, if possum numbers can be somehow reduced to extremely low levels, the detection-and-mop-up strategy should enable managers to not only completely eliminate possums from an area but also confirm that they have been removed.

The strategy is currently being tested in the field, and other research is proposed to develop other cheaper mop-up strategies.

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

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A Chew Track Card nailed to the base of a tree trunk.

REPLACE

Vaccines to control possum fertility



Jane Arrow

Full term possum embryo at day 17 of pregnancy. Immunisation with the ZP2 vaccine prevents fertilisation and reduces the number of possum young born.

There is increasing interest in New Zealand and overseas in the use of non-lethal methods for control of vertebrate pests. Bait-delivered fertility control vaccines are being developed as humane and species-specific methods and as alternative tools to controlling possums with broad-spectrum toxins such as 1080. The main impact of such vaccines will be to slow the rate at which possum populations recover after conventional control. This would reduce the amount of toxin used and the frequency of

its application, as well as reduce the risk to non-target species and of environmental contamination.

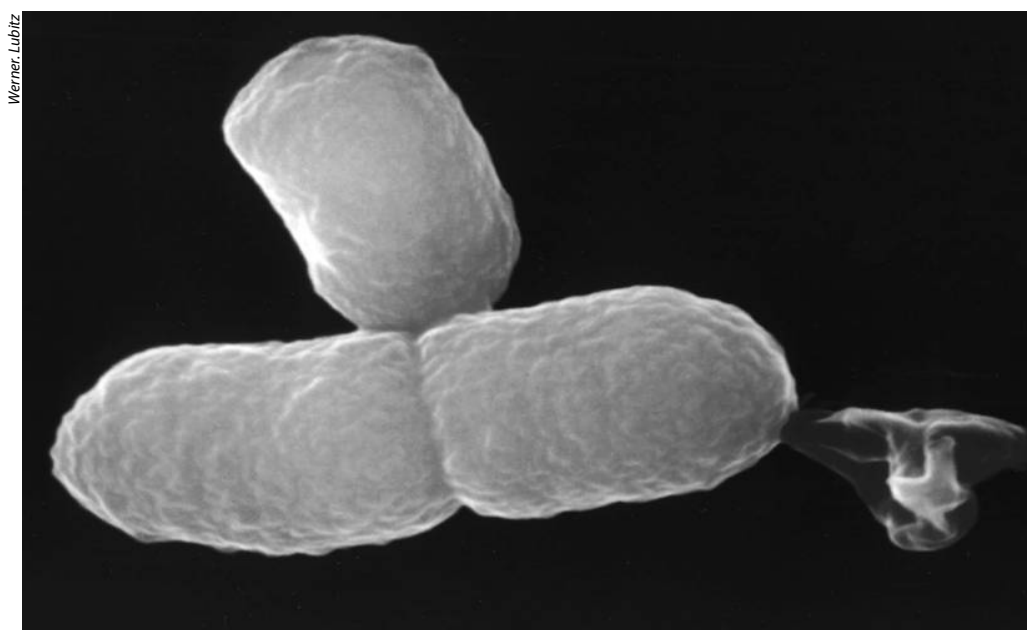
Landcare Research and collaborators at the National Research Centre for Possum Biocontrol are developing vaccines using target molecules from the possum's egg coat or zona pellucida (ZP). Possum ZP proteins are essential for successful reproduction and, importantly, distinctly different to those found in non-target

species such as birds and non-marsupial mammals. Female possums injected with possum ZP vaccines had 60–80% fewer embryos than untreated possums, a result of the vaccine interfering with the development of possum eggs in the ovary and preventing fertilisation. Vaccinating model non-target species (mouse and chicken) with the possum ZP proteins did not affect their fertility, which suggests that species-selective vaccines may be a real possibility.

The next important step is to develop an effective technique to vaccinate possums in the field. This is a real challenge as most human and animal vaccines are given by injection. Collaborators at the University of Vienna (Professor Werner Lubitz and his team) have modified a harmless strain of bacterium to produce the possum ZP2 protein within its cell wall. The bacteria are then killed and the cell contents expelled, leaving the empty non-living shell, called a 'bacterial ghost', containing the ZP2 (Photo). If possums are exposed to the ZP2-ghosts, their immune systems recognise the ghost as foreign and are tricked into developing antibodies against both the ZP2 protein and the bacteria, causing a contraceptive response.

To test the contraceptive action of 'ghosts', Janine Duckworth and her team immunised 20 female possums with ZP2-ghosts and 20 with ZP2-free (plain) ghosts either applied to the mucosal surface of the possum's eyes and nose to mimic delivery via an aerosol spray or given orally to mimic delivery via a bait. The possums were then allowed to breed naturally in small outdoor pens. Antibodies against possum ZP2 protein were detected in the blood of 85% of the animals treated by the eye/nose route and in 60% of orally dosed animals. For the control possums given plain ghosts, 94% of matings were fertile, whereas for possums treated with ZP2-ghosts, fertile matings dropped significantly to 64% for eye/nose-dosed animals and 68% for orally dosed animals. The number of offspring born following eye/nose vaccination was reduced by about 30% for 3 months, while the effects on orally treated females were shorter-lived. These results demonstrate that bacterial ghost vaccines delivered as an aerosol spray or as a bait are able to stimulate an immune response in possums and can interfere with the ability of female possums to breed successfully.

Following on from the positive outcome of this trial, the inter-agency team has been working to improve the intensity and longevity of the contraceptive immune



Bacterial ghost vaccines are made from the empty cell envelopes of bacteria formed when the bacterial cell lyses and the cell contents are expelled.

response of possums to the vaccines. Petra Lubitz at the University of Vienna has optimised the bacterial ghosts so that they now contain about 400 micrograms of ZP2 protein per milligram of ghost compared with only 6.7 micrograms of ZP2 protein per milligram of ghosts in the formulation used in the earlier trial. It is hoped this will increase the intensity and longevity of immune responses, creating greater and longer lasting infertility. Bacterial ghosts are also being formulated into enteric-coated granules by Professor Ian Tucker's group at the Otago University School of Pharmacy to protect the ghosts from degradation in the possum's intestinal tract and improve the effectiveness of oral delivery. Granules containing the bacterial ghosts are being coated with a pH-sensitive coating that remains intact in acidic conditions in the stomach but breaks down in the more neutral pH of the small intestine to release the vaccine for uptake by the immune cells.

If successful, bait-delivered fertility control will be a useful addition to the possum control toolbox. In addition to being a substitute for some conventional control operations using 1080-loaded baits, the ZP vaccine should be suitable for use in sensitive

ecological and cultural areas and by private individuals. The technology should also be adaptable to other key pest species, such as stoats, and the proven efficacy and species-specificity of possum ZP proteins could offer distinct advantages in the development of a transmissible approach to fertility control of possums.

This project was funded by the Foundation for Research, Science and Technology, the Animal Health Board, Landcare Research and the National Research Centre for Possum Biocontrol.

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Professor Werner Lubitz and Petra Lubitz



REPLACE

New technologies for stoat control



New technologies to control stoats are urgently required, as these pests are a major threat to native wildlife in New Zealand, and are implicated in the decline of many iconic bird species such as kiwi, blue duck, yellowhead and kākā. Currently stoat control relies heavily on labour-intensive trapping. Eggs poisoned with 1080 have been used in the past to kill stoats but there are no registered stoat-specific toxins. However, new toxins and fertility control agents that target the unique physiological and reproductive traits that may well be the stoats' Achilles heel' are under investigation by Landcare Research scientists.

Stoats occur widely and are highly effective predators that live life in the fast lane. They have a very rapid metabolism and generally live only 1–2 years. Intensive trapping can reduce stoat populations; however, they have a very high reproductive rate and an unusual breeding strategy that makes them

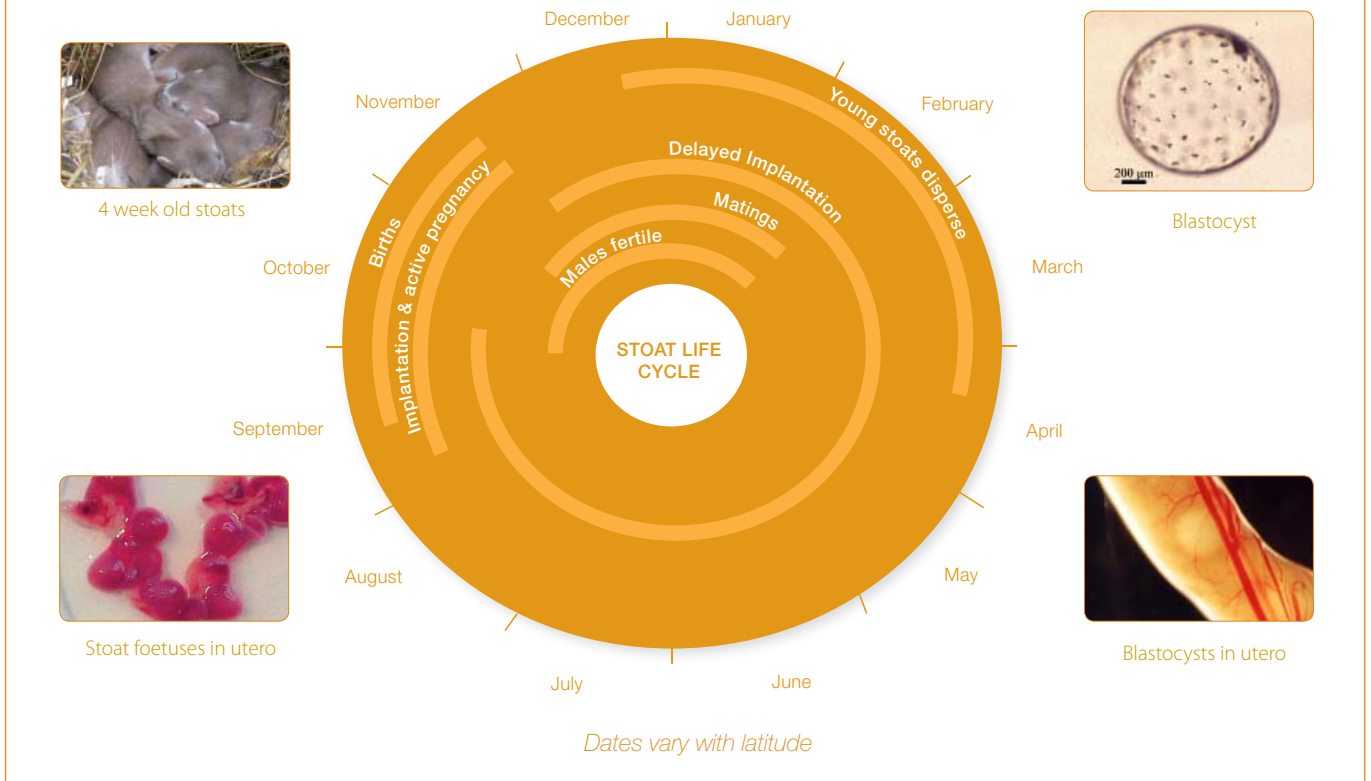
difficult to control (*Fig*). Female stoats can mate at only 3–5 weeks of age while still unweaned (before they open their eyes or have fur), and carry embryos in suspended animation for 9–10 months. In the following spring, if conditions are right, the embryos reactivate and 6–12 young are born 4 weeks later. Large litter sizes mean that stoat populations can grow rapidly when food is plentiful, and that a single pregnant female may potentially carry a viable breeding population of stoats to any island or patch of bush she colonises.

Landcare Research scientists have been targeting some of the unusual aspects of stoat physiology that may allow the development of novel, humane, and potentially species-specific methods for controlling their populations. Brian Hopkins leads one line of research that is developing a new species-selective toxin, i.e. one that is lethal to stoats but non-toxic to non-target

species. He has recently demonstrated 'proof of concept' in studies with captive stoats, with intravenous injection of the toxin killing them. When tested in endothelial cell lines in the laboratory, the toxin killed cells from stoats but did not affect the same cell type from non-target species such as dogs, cats, rats and mice. Brian is now seeking to synthesise the toxin cost-effectively and to optimise its structure, so that it is suitable for oral delivery in baits using technologies currently being developed elsewhere for the oral delivery of small proteins, peptides and vaccines.

Janine Duckworth leads a second research team that is seeking to disrupt the breeding cycle of stoats. Their large litter size, short lifespan and unusual breeding cycle make them excellent candidates for fertility control, and modelling studies by Nigel Barlow and Mandy Barron previously of AgResearch indicate that it could be as effective as

Seasonal life cycle of the stoat



trapping for suppressing stoat populations. Janine is investigating several aspects of their reproduction, including using a vaccine that targets the zona pellucida (the coat surrounding the egg) and prevents fertilisation. Injection with this vaccine halved the number of eggs produced by treated stoats (4.0 ± 1.3) compared with the number produced by control animals (8.3 ± 1.7). However, the window for disrupting fertilisation in stoats is very short (2–3 weeks) and further work is required to develop an effective bait for delivery of the vaccine.

Janine is also evaluating two other agents for their effectiveness in and palatability to stoats and their potential environmental and non-target impacts. Both are orally active chemicals that could be used over a longer part of the stoat's breeding cycle. The first is a toxin targeting hormones that support the embryo and that may disrupt embryonic development anytime during pregnancy.

The second is a chemosterilant that, in rats and mice, destroys eggs in their ovaries during early development. As the number of eggs in an ovary is set before birth, the chemosterilant causes premature ovarian failure (menopause) and sterility. It can be administered to adult females at any stage during their breeding cycle.

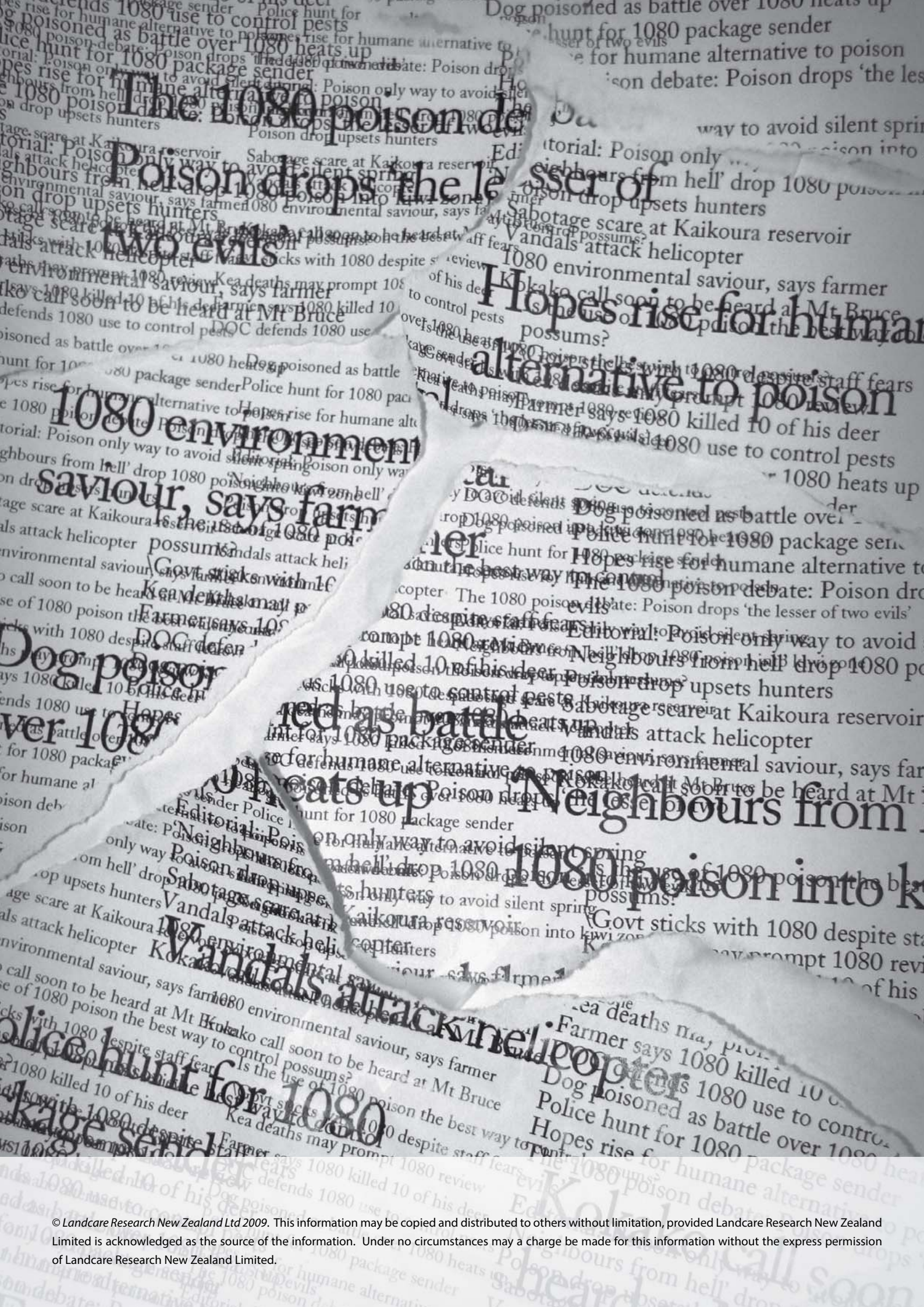
Effective species-selective methods for controlling stoats with reduced non-target effects and fewer adverse environmental impacts are likely to be a highly beneficial addition to the control toolbox to reduce levels of predation of valued native animals.

This work was supported by the Foundation for Research, Science and Technology, Landcare Research and the Department of Conservation.

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Brian Hopkins



The 1080 poison debate

Police hunt for 1080 package sender
Police hunt for 1080 package sender
Police hunt for 1080 package sender

Two evils

Editorial: Poison only way to avoid silent spring
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1080 environmental saviour, says farmer

Neighbours from hell' drop 1080 poison
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Dog poisoned as battle over 1080

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