Research on Vertebrate Pesticides and Traps: Do Wild Animals Benefit?

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Summary — New Zealand has a range of carnivorous and herbivorous mammals that were originally introduced for recreational, financial, aesthetic and biocontrol reasons, but which now pose significant threats to conservation and animal health values. Research is undertaken to develop new tools and strategies to manage these pests. Captive trials that are carried out include those to determine the toxicity of poisons, the efficacy of fertility control agents, and welfare impacts of poisons and traps. Field trials are undertaken to test the efficacy of poisons and traps, and large-scale management trials carried out to optimise control strategies. Although this research is aimed at managing animals, including killing them, we believe that there are benefits to both individual animals and animal populations that far exceed any cost of harm to individuals that are managed (often killed). We suggest that there are three levels of beneficiaries: the individuals of the pest species that are killed, the individuals in the surviving population, and the individuals and populations of other species. We provide examples of how wild animals can benefit from vertebrate pesticide and trap research.

Key words: *animal welfare, pest control, traps, vertebrate pesticides*.

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Introduction

Up until the early 1700s, New Zealand evolved in the absence of any land mammals, aside from three species of bats and a Polynesian rat (kiore), introduced in about 900AD. However, a rich bird and invertebrate fauna did evolve. The absence of terrestrial mammals did not appeal to early European colonists, who, over a 100-year period, introduced many exotic species for recreation, to establish a fur industry, as a cheap food source, and then as predators, to control some of the previously released species. Unfortunately, many of these introduced species became pests, either threatening conservation values or becoming vectors of livestock diseases, such as bovine tuberculosis (TB).

As a consequence of this early acclimatisation culture, New Zealand now has a significant vertebrate pest problem, and several government agencies spend considerable funds managing brushtail possums (*Trichosurus vulpecula*), ferrets (*Mustela furo*), stoats (*Mustela erminea*), feral cats (*Felis catus*), rabbits (*Oryctolagus cuniculus*), hares (*Lepus europaeus*), rats (*Rattus norvegicus, Rattus rattus* and *Rattus exulans*) and mice (*Mus musculus*), as well as some localised populations of larger vertebrates such as goats, deer, thar, chamois and pigs. Just for possums alone, about $NZ 50 million is spent annually, resulting in a conservative estimate of about 5 million possums killed each year.

Underpinning this management is a large range of research projects, using captive animals or free-ranging wild animals in field trials. Before any of this research can proceed, all animal-research projects must receive approval from institutional Animal Ethics Committees (AECs). Since 1996 there have been about 3000 to 5500 possums used each year in experiments (1). In New Zealand, total animal use numbers are reported along with a scale of severity of suffering, and as an example, of the 4440 possums used in experiments in 2000, 26% were classified as "no suffering", 61% as "little suffering", 13% as "moderate suffering", and none as "severe" or "very severe suffering".

Although it is necessary when applying for AEC approval to consider the Three Rs, it is also necessary to provide a rationale for the AEC committee, whose members approve the planned use of animals. This is usually done by assessing the "ethical cost" to the experimental animals (i.e. pain and suffering) in relation to the end benefits of the study (i.e. biodiversity conservation and control of zoonoses). However, these benefits are often not direct or immediate, and will often be difficult for these people to recognise. In this paper, we argue that such pest animal-based research leads to benefits for both the individual pest animals, the residual populations, and to populations of other non-target species.

Discussion

Animal use in animal-based vertebrate pest research

The vertebrate pest research carried out by Landcare Research (New Zealand's major environmental research organisation) is aimed at developing more sustainable, environmentally and publicly acceptable, humane and cost-effective mitigation of pest animal impacts. In New Zealand, most effort is expended on managing the brushtail possum, which has a significant impact both on the indigenous flora and on livestock health as the major wildlife vector of bovine TB, and the introduced predators (stoats, ferrets, rats and feral cats), which pose significant risks to many of New Zealand's endemic bird species. Additional species are also used in research trials because they are either non-target species for which information such as poison residue concentrations are required (e.g. sheep), or are considered appropriate experimental models (e.g. mice). Additionally, other species can be inadvertently included in research when they are caught as non-target bycatch in field experiments (e.g. hedgehogs; Table 1).

Animals are used in experiments ranging from low-grade manipulations such as behavioural observations and field studies that cause very little suffering, to more intrusive studies such as laparoscopic artificial insemination (AI), through to trials with potentially severe effects, such as toxicity testing of vertebrate pesticides (Table 2).

Table 1: The range of vertebrate species and numbers used by Landcare Research during 2000–2001

Species	Used	Killed
Possum	2460	1527
Ferret	288	38
Stoat	16	5
Feral cat	77	0
Rabbit	89	83
Hedgehog	190	0
Rat	22	20
Mouse	364	363
Sheep	50	46
Pig	17	17
Introduced birds	22	0

Landcare Research Animal Ethics Committee 2000: summary of animal usage in research (Landcare Research, unpublished data).

Benefits to animals from animal-based research

We have classified the potential benefits to wild animals (pests and non-pests) from vertebrate pest research carried out in New Zealand into three categories. The first includes the benefits to the primary individuals that the manipulation is aimed at by reducing the welfare compromise of that manipulation. The second is at the intra-population level in which the survivors of any manipulation benefit, and the third is at the inter-population level in which individuals of other species benefit.

Benefits to primary individuals

Research has been carried out over a number of years to increase the effectiveness and to minimise any adverse welfare impacts of vertebrate pest control methods. When using vertebrate pesticides, welfare benefits can accrue from ensuring that all individuals exposed to the pesticides receive a lethal dose, and that the lethal dose kills as quickly and humanely as possible.

Morgan (2) concluded that possums survive poison operations primarily because animals either encounter sublethal baits, or they only eat a sublethal quantity of bait because of neophobia (including taste or olfactory aversion). When a significant proportion of a population are sublethally poisoned (*c.* 15%), there are significant welfare concerns as well as efficacy concerns (2). In

Table 2: Examples of manipulations carried out on vertebrate pests and their grading

Manipulation	Possible grading
Non-toxic bait trials	O
Blood sampling under anaesthesia	A
Cardiac puncture — fluothane or ketamine	A or B
Laparoscopic AI	B
Oral gavage	A
Pesticide trials (e.g. efficacy testing)	A to X
Field trials with foothold traps	C
Tracking using radio-collars	A or B
Field trials of pesticides	A to X

Pesticide manipulation grades range from A to X because each pesticide has a different welfare impact.

O = no or very low welfare compromise;
A = low welfare compromise;
B = moderate welfare compromise;
C = high welfare compromise;
X = very high welfare compromise.

response to these concerns, several studies have been carried out to maximise the kill achieved, and therefore, to minimise the incidence of sublethal poisoning. For example, Batcheler (3) examined the quality of carrot bait used for rabbits and possums, and showed that bait quality was often very poor, with many baits being less than optimal for killing the target species. The optimum carrot bait weight for rabbits is 2–5g, but the average weight measured from one operation was 0.31g, with only 2.8% of baits exceeding 2g. The same cutting process followed by a screening process produced baits with mean weights of 2.9g, with 46–62% of bait exceeding 2g. Powlesland *et al.* (4) found that 55% of New Zealand robins were killed during a possum-control operation when carrot baits were unscreened, but only about 9% when screened. Because of the non-target risk posed by unscreened carrot bait, all carrot bait used today must be screened before sowing.

Similarly, Henderson & Frampton (5) showed that baits with low palatability resulted in > 35% of possums being sublethally poisoned, and others that eat only small bait fragments having protracted times to death. However, research on bait quality and toxic loading led to findings that significant improvement in kills could be obtained by using baits with 0.15% 1080, adding cinnamon as a poison mask, and using prefeed. Additionally, Frampton *et al.* (6) reported that, using data from a series of possum-control operations, the percentage of animals sublethally dosed by one bait ranged from 23% to 77%. However, when bait specifications were modified to exclude baits smaller than 4g, the percentage of sublethally dosed possums was reduced to 19–66%. Further modification (i.e. baits > 4g and using pesticide concentrations [1080] of 0.15%) resulted in the percentage of sublethally dosed possums being reduced to 0–8%. Clearly, there are significant welfare benefits to be gained by integrating high quality assurance (QA) standards into control operations.

Improved welfare for the target pest animals can also be achieved if the most humane vertebrate pesticides are used. Studies have been completed describing the welfare impacts of the vertebrate pesticides used in New Zealand (7, 8), and a recommended protocol for assessing the relative humaneness of vertebrate pesticides has been developed (9). Although a significant issue, there has been little progress in developing pesticides that are "welfare friendly". However, some attempts have been made to mitigate adverse affects by, for example, incorporation of analgesics (10). Additionally, some vertebrate pesticides, such as strychnine and scilliroside, are not used because of their perceived inhumaneness. In contrast, pesticides such as sodium and potassium cyanide are favoured because of their rapid action and minimal welfare compromise (11).

The other major control tools used to manage vertebrate pests in New Zealand are traps, and these can also cause significant pain and distress to captured animals. A research programme has been carried out in New Zealand to assess both restraining traps, such as foothold traps, and kill traps (12–15). This research, using testing procedures developed as part of an ISO trap standard (16, 17), has enabled foothold traps used for trapping possums to be ranked on the basis of the frequency and extent of injuries caused to the target species (Table 3). This research underpins the planned prohibition in New Zealand of a range of foothold traps including all longspring and double-coil spring traps larger than No. 1s (e.g. Lanes-Ace gin traps and Victor No. 1.5 traps), except those with SoftCatch modifications (e.g. Victor No. 1.5 SoftCatch traps).

Kill traps have also been assessed against the specifications that target animals must be rendered unconscious within 3 minutes (18), and results indicate that most kill traps currently in use fail the test (Table 4). As a result of this research, it was recommended that these traps should also be prohibited or restricted, and that more effective traps should be found.

Table 3: Percentage of cumulative injury scores assigned to limbs of possums caught in five different foothold traps

		Injury scores					
Trap type	**n**	**0–5**	**10–35**	**40–55**	**60–95**	**100–200**	**205–300**
Lanes-Ace	78	9	62	5	9	12	4
Victor No. 1.5 unpadded	74	23	58	1	1	8	8
Victor No. 1.5 SoftCatch	82	77	16	2	0	5	0
Victor No. 1 unpadded	72	36	51	4	7	1	0
Victor No. 1 SoftCatch	63	89	10	2	0	0	0

A score of 5 includes slight oedema, and scores of 200+ include compound fractures (from 13).

n = the number of possums sampled.

Intra-population benefits

Most vertebrate pest management in New Zealand is based on a strategy of initially achieving a significant reduction in population numbers and then attempting to maintain the population below some threshold at which the impact of the pest is mitigated (19, 20). The frequency at which such "maintenance" control is applied depends on how low the required threshold is and the potential growth rate of the population once control pressure is removed. For many managed pest populations in New Zealand, maintenance control is carried out annually. However, if the frequency of application can be reduced, there are potentially significant benefits to be gained in terms of a reduction in the number of animals subjected to vertebrate pesticides and traps.

One option for reducing the frequency of control is to slow the breeding rate of pest populations. Research is being carried out to develop non-lethal methods for managing vertebrate pest populations, with a major focus on fertility control (21, 22). Although this research is at a very early stage, computer modelling, supported by field trials of surgically sterilised possums, suggests that the frequency of maintenance control could be reduced from intervals of 1–2 years to as much as 30 years if 80% of females are sterilised and immigration is limited (Figure 1; 23, 24). If such an approach were applied, even with only 50% sterility, to a typical control area of 10,000ha, the number of possums having to be killed over a 20-year period would reduce ten-fold from about 200,000 to 20,000.

Inter-population benefits

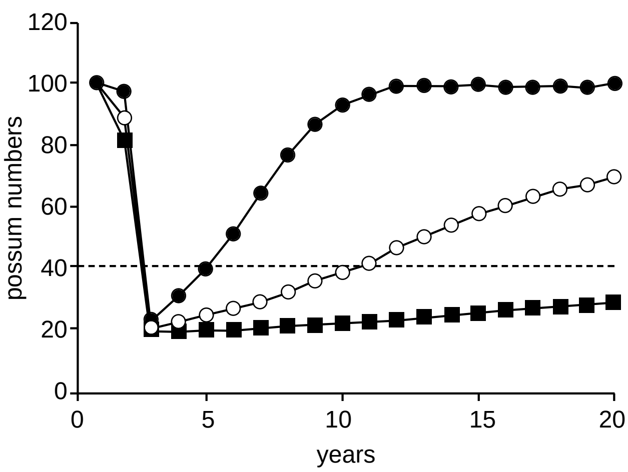
In New Zealand, vertebrate pests are often killed because of their impact as predators on endangered bird species. Consequently, animal-based research that increases the effectiveness of control operations can have a significant benefit for the animal species that the control operation is attempting to protect. For example, the aerial application of 1080 poison baits is often used to control populations of possums and rats (*R. rattus*), so that bird species such as the New Zealand robin (*Petroica australis*) may benefit. Powlesland *et al.* (4) reported that fledgling success for robins in an area before control was 0.4 fledglings per pair, but increased to 3.8 per pair following control, and the number of birds present increased by 132%.

Table 4: Species and kill traps tested for meeting the 3-minute requirement to loss of brain stem reflex (unconsciousness)

Species	Trap model	Pass	Fail
Possum	Timms	?[a]	?
	Conibear 160		✗
	BMI 160	✓	
	LDL 101	✓	
	Warrior	✓	
Ferret	Timms		✗
	Timms tunnel		✗
	Tunnel		✗
	SAF		✗
Stoat	Fenn Mk IV		✗
	Fenn Mk VI		✗
	Victor Snapback		✗
Feral cat	Conibear 220		✗
	BMI 160		✗
	Allan conibear	✓	
Rat (Norway)	Victor Snapback	✓	
	Rat Zapper		✗

[a] *The results from this trap are marginal because of a possum that escaped uninjured.*

Figure 1: Results from a stochastic population model run for 20 years where simulated populations had either 0%, 50% or 80% of females sterilised, followed by a conventional control operation where 80% of the population was killed



● = *control;* ○ = *50% sterility;* ■ = *80% sterility.*

Density-dependent compensation operated through both recruitment and adult survival. Each point is the mean of 100 simulations. Dashed line denotes 40% of carrying capacity (K), the approximate threshold for eradication of TB (from 24).

Similarly, for kukupa (*Hemiphaga novaeseelandiae*, a large native pigeon) at one site, nesting success increased from 0% before possum and rat control was carried out to 100% after 2 years of control (25), and at another island site, kukupa numbers increased six-fold after possum control (26). Benefits of possum control have also been recorded for kokako (*Callaeas cinerea wilsoni*), a rare endemic wattle bird, which has been declining in numbers over recent years on mainland New Zealand. Intensive rat and possum control increased the percentage of adult pairs that successfully fledged chicks from about 25% to 92%. Adult territorial birds in the same area increased from about 50 to more than 80 over a 6-year period (27).

Mohua (*Mohua ochrocephala*) is another endangered hole-nesting species that suffers periodic population crashes due to stoat predation. Trapping of stoats during the breeding season can significantly improve the nesting success of this species, with the number of nests successfully fledging young increasing from 36% in untrapped areas to 80% in trapped areas (28).

Following many possum control operations, the availability of foliage and especially fruit increases dramatically, and although the evidence is somewhat tenuous at this stage, it is suggested that this increased availability may have significant benefits for populations of some bird species that are food-limited and that may compete with possums for food (H. Robertson, personal communication).

Discussion and Conclusions

Introduced mammals have considerable adverse impact on New Zealand's flora and fauna, as well as on livestock health. Research is therefore carried out to develop more cost-effective and sustainable methods to control these pests and mitigate their impacts. The justification for using animals for research has been questioned for many years, and several authors have attempted to rationalise the use of animals in research and to justify vertebrate pest control *per se* (29–32). In New Zealand, all animal-based researchers must obtain approval from an independent AEC before commencing a project, and these approvals require some justification of the work by providing information on the potential benefits of the research. Although this process is often achieved with broad and often vague benefits being provided (e.g. to develop more cost-effective protection of an endangered species), and weighed against equally vague costs to welfare, this situation has arisen because it is often difficult or impossible to quantify the benefits prior to commencing the research. Cost–benefit decisions become even more difficult when the benefits might be to non-sentient organisms (i.e. flora). Marks (32) and Warburton & Choquenot (33) have attempted to provide alternative approaches for addressing these dilemmas.

However, we believe that there is more than enough evidence that the benefits in terms of animal welfare far outweigh any costs, solely in terms of the number of animals on either side of the equation. For example, in New Zealand, there are about 5000 animals used annually in vertebrate pest control-related research, with the majority of these animals being in manipulation classes of low to moderate welfare compromise. For possums alone, given there is about $NZ 50 million spent annually on their control, covering some 5.5 million hectares, improvements in traps and vertebrate pesticides and the minimisation of sublethal dosing is expected to benefit many hundreds of thousands of animals. Additionally, the benefits to the species that suffer from the predation impacts of introduced predators is not limited to the improved welfare (survival) of the individuals, but extends to the species as a whole by preventing extinctions.

Furthermore, although not recognised yet, the potential welfare benefits of fertility control are considerable and, along with ongoing research on improving conventional control, will ensure that pest and non-pest animals will continue to benefit from animal-based research into improved pest control methods.

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