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RISKS TO NON-TARGET SPECIES FROM USE OF A GEL BAIT FOR POSSUM CONTROL

Summary: The risks to non-target species of a newly developed bait containing either 0.15% 1080 or 0.6% cholecalciferol in a gel matrix were assessed. Very few of them ate gel bait. The safety of the gel bait is further enhanced by its placement in the purpose-designed bait station from which little spillage occurs, and which can be placed so that it is out of reach of most non-target animals. Comparative data show that non-target species are considerably less susceptible to cholecalciferol than to sodium monofluoroacetate (1080). Risks to non-target species could be further reduced by use of the cholecalciferol form of the bait.

Keywords: Baits; pest control; non-target species; risks; vertebrate pesticides.

Introduction

By comparison with other countries, New Zealand uses very large quantities of vertebrate pesticides with the dual aims of arresting the spread of bovine Tb and conserving vulnerable indigenous species and ecosystems. Annual usage of 1080 poison is many times greater than in Australia, which is perhaps the most similar country to New Zealand in terms of vertebrate pest problems and approaches to control. Furthermore, the use is increasing in New Zealand while declining in other countries (Parliamentary Commissioner for the Environment, (PCE) 1994). The greater use of vertebrate pesticides reflects the increasing area of New Zealand coming under possum control, now totalling around 3.7 million ha, or 13.6 % of the land mass (data combined from the Animal Health Board (1997), and Parkes, Baker and Ericksen, (1997)). Major successes in achieving the aims of possum control have been reported (e.g., Briden, 1998; Livingstone, 1998), but to sustain the benefits it will be necessary to continue using vertebrate pesticides for at least the next 5-10 years by which time it is expected that affordable, socially acceptable, and long-term biological control solutions will be available (e.g., Cowan, 1996). Even then, it is likely that conventional chemical control may be required to supplement biological control in a programme of integrated pest management (Coleman, 1993).

Pest control based on such heavy reliance of vertebrate pesticides is vulnerable, not only because of the high annual cost (*c.* $30 million), but also by increased awareness of potential risks of pesticide use worldwide. As pointed out by Williams (1994), market access for New Zealand agricultural produce could be threatened if food production methods failed to meet the increasingly stringent standards demanded by overseas consumers. Carefully managed ‘product stewardship’ is required to provide confidence in the safety of vertebrate pesticides, and this must be based on toxicological data related to public health and environmental effects, and strategies for minimising risk (Eason, Wickstrom and Gregory, 1997).

One environmental risk is the poisoning of non-target species. Examples of accidental poisoning have been documented for native birds, native bats, invertebrates including honey bees, deer, livestock, and domestic pets (data summarised in PCE, 1994). Research to date suggests that despite some deaths of individual animals, poisoning operations generally have no impact or, indirectly, a positive impact on populations of native birds (Spurr, 1990) and invertebrates (Spurr, 1994). Nevertheless, individual deaths are always undesirable even for common species and unacceptable for rarer species such as kaka (see Appendix 1 for scientific names of animals), populations of which may be unable to withstand such losses.

The risk of accidental poisoning can be simply expressed by:

Risk = Hazard x Exposure

The hazard for non-target species is determined by the susceptibility of species to the toxin delivered by the bait. This paper assesses the likely exposure of a number of non-target species to a new type of bait developed for control of possums, and which contains either 1080 or cholecalciferol (vitamin D_3). The likely exposure of non-target species to these hazardous materials was assessed, first, by conducting a pen trial to measure the amount of spillage that occurs when possums feed at gel bait stations, and second, by observing whether a range of non-target species would feed on freely available bait.

Methods

The bait

Gel bait for possum control (Kiwicare Corporation, Christchurch) comprises a green-dyed, translucent, solid gel containing sugars and an orange essence. This latter is favoured by possums and effectively masks the presence of toxins (Morgan, 1990). The bait is expected to become commercially available during 1999 in two formulations. The poison sodium monofluoroacetate (1080) will be incorporated in the bait, for use by licensed operators, at a concentration of 0.15%. Cholecalciferol, to which possums are particularly susceptible (Eason, 1991), will be incorporated in the bait at a concentration of 0.6% for use without the requirement of a licence. The gel matrix also contains 'Bitrex®' to deter accidental consumption by humans (Kaukeinen and Buckle, 1992), and preservatives and stabilisers to ensure that it has a shelf life of at least 1 year. It is manufactured in a purpose-designed bait station containing 500 g bait, and is ready for use when purchased.

The bait station is intended to be used in places not frequented by livestock and pets. It should be mounted above ground to minimise the likelihood of ground-feeding non-target wildlife encountering and feeding on the bait. It is preferable, however, that the gel bait is accessible to possums on the ground as bait stations placed in trees have proved less effective (R. Henderson, *unpubl. data*). Locating bait stations so that the lowest part of the opening is 35 cm above ground is therefore recommended as the optimum balance between targeting possums and avoiding non-target species. Nevertheless, it is possible that some large ground-dwelling non-target species may encounter the bait, and if bait is spilt by possums, smaller ground-dwellers such as invertebrates, reptiles, or native bats may be exposed to the toxin.

Spillage of bait from bait stations

Four possums maintained individually in outdoor pens measuring 5 x 5 m were each presented simultaneously with a gel bait station containing 300 g non-toxic gel, and a 'Kilmore' bait station (as commonly used in possum control) containing 300 g RS5 non-toxic pellet baits (Animal Control Products Ltd., Waimate). The bait stations were spaced about 2 m apart and were fitted to vertical fence posts such that the lowest part of the opening of each bait station was 35 cm above ground. This is a convenient height for possums to feed from bait stations while standing on the ground. Bait stations were reweighed after each 24-h period for 8 days and the amount of each bait type eaten or displaced was calculated. Baits and bait fragments that were spilled during each 24-h period were collected and weighed.

Palatability of gel bait to non-target species

The responses of 26 species of animals to gel bait were observed to assess palatability of the bait. Apple paste bait was also presented to these animals as a control treatment because apple paste has been used for many years as a possum bait. Native birds observed included fruit-eating and ground-feeding species. Honey bees were observed because they are known to feed on sugar-rich food and have previously been observed on apple paste baits used for possum control (Goodwin and Ten Houten, 1991). Ground-dwelling invertebrates and skinks were observed because such small animals may climb into bait stations or encounter spilt bait. Native short-tailed bats were observed because they have previously been considered at risk where carrot baits were aerially distributed since they are omnivorous and feed on the ground (Daniel and Williams, 1984). Species are discussed in order of perceived risk and conservation importance.

(a) Native birds

The responses of groups of captive fruit-eating birds to gel bait were observed at a zoo (Orana Park, Christchurch). Species, which were observed as groups of individuals, were kaka (n=3), brown kiwi (n=2), kea (n=6), weka (n=3), kereru (n=4), and kakariki (n=5). Gel bait (100 g) was presented in plastic dishes to each bird species on two days for 8 hr. On separate days the birds were also presented with 100 g of one of two varieties of apple paste bait, BB13 and BB16 (Animal Control Products Ltd., Wanganui). The daily order of presentation of pastes to birds was randomised and their normal diet was maintained throughout the trials. The weight of bait eaten by the groups of birds was recorded daily. Since baits were presented fully exposed rather than in bait stations a correction was applied for weight variation due to climate using measured changes in control samples of each bait type placed out of reach of the birds.

The responses of native birds (listed in Table 3 and Appendix 1) in the wild to gel baits were observed at a site on the edge of mixed beech (*Nothofagus* spp.) forest at Bullock Creek, Paparoa National Park. Gel bait and two types of apple paste bait, BB13 and BB16 (Animal Control Products Ltd., Wanganui), were placed in separate bowls (100 g per bowl) approximately 1 m apart on each of two tree-mounted platforms with fuchsia (*Fuchsia excorticata* J.R. et G. Forst.) flowers as an attractant, and in separate bowls placed 1 m apart at two sites on the ground. The bowls were observed for 2 h after dawn and 2 h before dusk each day for 7 days. Observations recorded were: 'approach' when birds moved within 3 m of a bait bowl, 'encounter' when birds investigated bait without feeding, and the time spent feeding on bait. The same baits were used throughout the study to simulate normal field presentation, but they were removed at night to prevent possums from eating them.

(b) Honey bees

Approximately 200 forager bees were trained to feed on sugar (sucrose) syrup at a table placed 20 m away from a hive. Gel bait, and BB13 apple paste bait known to be attractive to bees (Goodwin and Ten Houten, 1991), were presented to the bees by placing 2 g of each material separately in Petri dishes. Ten dishes of each bait type were placed randomly on the table with 10 cm separating dishes. The number of bees visiting the two bait types was compared by counting the number of bees at each type during 10-min sampling periods. Twelve sampling periods were used, distributed between 1000 and 1500 h during fine weather on one spring day.

(c) Invertebrates and skinks

Time-lapse video recording was used to monitor the response of common skinks, large-headed weta, giant land snails, and ground beetles to gel bait and BB13 apple paste. Six – 10 individuals of each species were housed together in glass tanks (0.72 x 0.38 x 0.38 m), and each animal was uniquely marked with white "correction" pen ink for identification. Tanks for weta, snails and beetles had a floor-lining of soil, leaf litter and sphagnum moss which was moistened using a spray bottle daily. Small logs with a hollow core provided shelter for weta, as recommended by Barrett (1991). Snails and beetles sought shelter in the leaf litter. Tanks for skinks had a floor-lining of fine, dry shingle, and stones and bark were provided as shelter. Animals were fed twice each week. Weta and beetles were provided with fresh native plant material and apple, and processed pet meat. Snails were fed with earthworms, and skinks with mealworms and mashed banana. Water was always freely available for all animals.

Approximately 10 g of bait was placed on plastic beaker lids. Gel and apple paste bait were presented separately and responses to each bait type were monitored for 2 overnight periods of 16 hr for each group of animals. For each species, the number of animals investigating bait (i.e., contact with bait), the number feeding, and the total time spent feeding were recorded.

(d) Short-tailed bats

Gel baits and BB13 apple paste baits weighing 100 g were presented to six individually marked short-tailed bats, maintained on behalf of the Department of Conservation at Wellington Zoo. Baits were presented separately in Petri dishes for the first 3 h of night during the normal feeding period for bats. Gel baits were presented on two nights and BB13 paste on one night. An aqueous solution of 5% honey, which was part of the bats' normal diet, was presented on two other nights as a positive control. Time spent feeding on baits or honey solution was monitored using video equipment and infrared illumination. The weight of bait or honey eaten was calculated at the end of the 3-h observation period.

All studies were conducted with the approval of the Landcare Research Animal Ethics Committee.

Results

Spillage of bait from bait stations

During the eight nights for which possums fed on baits, a total of 1560 g of pellets and 790 g of gel was eaten. Only 0.1 g of gel on average was spilt each night, compared with 3.3 g of pellets. No gel bait was spilt on five nights (Table 1). Expressed as a proportion of the amount of each bait type eaten, the overall mean weight of gel spilt was 0.4%, and this was significantly less than the 6.6% of RS5 pellets spilt (paired t-test = 5.09, $d.f.$=7, P=0.001).

Table 1: *Spillage of RS5 pellets and gel bait expressed as a percentage of the mean mass of each bait type eaten each day (and s.d.). For each bait type, n = 4 each day.*

Day	RS5 pellet	Gel bait
1	5.8 (5.5)	0.1 (0.2)
2	1.4 (2.5)	0
3	9.8 (12.1)	0
4	15.2 (13.0)	2.8 (4.9)
5	4.5 (3.9)	0.4 (0.4)
6	5.7 (4.3)	0
7	4.8 (8.4)	0
8	5.4 (5.2)	0

Exposure of non-target animals to gel bait

Few data were gained due to a general lack of interest in baits by non-target animals. This, in itself, is an important result. Considerably more observations would be required to produce data for all species for statistical analysis, particularly species that are relatively inactive or immobile such as snails and weta. However, the trends indicate that gel bait was generally less preferred than apple paste bait.

(a) Native birds

Of the six species observed at Orana Park, four ate appreciable quantities of apple paste, while kereru and kakariki ate only small amounts (Table 2). By contrast, kea was the only species to eat appreciable amounts of gel bait. A total of 87 g of the gel bait was eaten by the six kea over two days. Three weka ate a total of about 1 g of gel bait while 59 g of BB13 paste was eaten.

Of the 16 species observed in the field study area, five approached within 3 m of a bait bowl, altogether on 17 occasions (Table 3). However, none of these species, which included two flocks of silvereye, actually encountered or fed on the bait. Two of the 16 species, weka (a family of three individuals) and robin (three individuals), were observed interacting with baits. Weka interacted only with the baits that were presented on the ground while robin interacted with the baits on the platforms as well as those placed at ground level. Approximately 98% of the total time spent feeding on gel by birds was attributable to weka, which fed approximately equally on paste bait (47% of total feeding by all birds) and gel bait (51%). The small amount of feeding by robin was mainly on paste (1.5% of total feeding by all birds) rather than gel (0.5%).

(b) Honey bees

During the 120 10-min counts, 154 bees were counted on apple (BB13) paste and 12 on gel bait. The mean number of bees observed on dishes for each 10-min sampling period was significantly fewer for gel bait (mean=0.1) than for BB13 paste (mean=1.28) (t=13.4, $d.f.$=10, P<0.0001). Bees appeared to be feeding on the paste bait throughout most of the time spent on this bait type as the proboscis of most bees could be clearly seen penetrating the surface of the bait. Due to the firmer texture of the gel, bees were not able to penetrate the surface and it is likely that most of the time was spent investigating the bait and attempting, unsuccessfully, to feed on it.

Table 2: *Mean daily mass (g) of gel and two types of apple paste eaten per bird at Orana Park, Christchurch (and s.d.). Six native species of captive birds were presented with bait during two days.*

Species	No. of birds tested	BB13 paste	BB16 paste	Gel bait
Kaka	3	8.7 (5.2)	2.0 (1.3)	0.0
Brown kiwi	2	7.0 (7.8)	17.9 (21.2)	0.1 (0.1)
Weka	3	19.6 (15.1)	0.3 (0.4)	0.4 (0.5)
Kea	6	5.1 (2.1)	2.8 (3.2)	14.4 (12.6)
Kereru	4	0.5 (0.5)	1.0 (0.8)	0.0
Kakariki	5	1.3 (1.6)	0.0	0.0

Table 3: *The number of times birds of six species were seen near baits, encountered baits, and the total time spent feeding on bait by each species. Eleven other species (see Appendix 1) present at the study site were not seen closer than 3 m from the gel bait.*

Species	No. of occasions seen within 3 m (no encounter)	No. encounters with bait		Total time spent investigating or feeding on bait (min)	
		BB13	Gel	BB13	Gel
Bellbird	6	0	0	0	0
Fantail	1	0	0	0	0
Kereru	2	0	0	0	0
Silvereye	2 (flocks)	0	0	0	0
South Island robin	0	2	1	0.5	0.2
Tui	6	0	0	0	0
Weka	0	19	27	14.7	16.9

(c) Invertebrates and skinks

Some of the small non-target animals observed in laboratory tanks were seen feeding on baits. Snails (3 out of 8 observed) and weta (1 of 10) fed on gel bait, while snails (1 of 8), weta (2 of 10), and skinks (2 of 8) fed on BB13 paste (Table 4).

(d) Short-tailed bats

Short-tailed bats were observed visiting all food types. However, while they often fed on honey water and BB13 apple paste on all three nights when these foods were presented, they did not feed on gel bait on either of the two nights it was presented (Table 5).

Discussion

Few non-target animals are likely to be attracted by gel bait. Even when presented very conspicuously in the canopy and on the ground at a field site where 17 species of birds were seen, most birds ignored the bait. Nevertheless, some inquisitive ground-feeding bird species (weka, robin, and kea), and some invertebrate species (giant land snails) are likely to eat the bait if they encounter it, albeit probably in lower amounts than apple paste. Presenting the bait above ground would minimise exposure of ground-active non-target animals to risk, particularly as the study showed that negligible amounts of gel are spilt when possums feed at the stations. The attractiveness of the gel bait station itself has not been assessed and while there is no evidence that other types of bait stations attracted non-target wildlife, this should be investigated.

Paste bait has been used for more than 30 years by placing individual baits of approximately 15 g on upturned earth spits (which are later overturned to bury the bait). During this period there have been only a few reports of non-target species being killed after feeding on this bait type. Weka, silvereye, bellbird, and tui have been found dead after apple paste was laid (Spurr, *in press*). There have occasionally been instances of honey bees being killed after feeding on paste during early spring or late autumn when bees' normal foods may be in short supply (Goodwin and Ten Houten, 1991). As gel is less attractive than apple paste, non-target effects would be expected to be even fewer than these examples.

Flying or climbing invertebrates may encounter gel bait in bait stations. However, it is likely that the bait will only be palatable to nectivorous species which, like the honey bees studied, are generally unable to feed on a solid food. An additional safety measure for birds could be the inclusion of cinnamamide as a bird repellent (Spurr and Porter, 1998). Kea for example, appear likely to investigate and eat bait. Use of cinnamamide may be warranted where the species is present. This compound has been found effective at a concentration of 0.5% wt:wt (a concentration that is palatable to possums), deterring both kea from eating carrot baits and weka from eating cereal-based baits. It is, however, expensive, and it therefore should be used only after careful consideration of risk to birds.

It is expected that gel bait will be available with either 0.15% wt:wt 1080 or 0.6% wt:wt cholecalciferol. Cholecalciferol is considerably less

Table 4: *Feeding response of skinks, weta, snails, and ground beetles to gel and paste bait. Baits were presented to each group of animals for 2 overnight periods of 16 h. Animals were individually marked for identification.*

	Skink	Weta	Snail	Ground beetle
No. of animals in group	10	8	8	6
BB13 paste				
No. investigating	8	2	1	4
No. feeding	2	2	1	0
Total feeding time (min)	2.8	5.9	21.5	0
Gel				
No. investigating	2	5	3	0
No. feeding	0	1	3	0
Total feeding time (min)	0	0.3	39.4	0

Table 5: *Feeding responses of six short-tailed bats presented with gel and paste baits and honey water for 3 h on different nights. Results for all bats are combined.*

Food type	Number of visits	% of visits where feeding definitely occurred	% of visits where feeding possibly occurred	Amount of bait eaten (g)
Honey water	23	78	4	4.24
Gel bait	42	0	0	0.00
Honey water	51	65	14	8.01
BB13 paste	68	88	1.5	5.73
Gel bait	10	0	0	0.00

toxic to mammals and birds than 1080 (Haydock and Eason, 1997). For example, the LD_{50} values of 1080 in weka and mallard duck are 8.0 mg kg^{-1} and 5.0 mg kg^{-1}, respectively, while the LD_{50} value for cholecalciferol in mallard duck is >2000 mg kg^{-1} (weka data not available). A weka weighing 1 kg would therefore need to ingest 5.3 g bait containing 1080 or 333 g bait containing cholecalciferol (assuming weka have a similar susceptibility to cholecaciferol as duck) to receive an LD_{50} dose. Cholecalciferol therefore seems to pose a much lower risk to birds than 1080. Cholecalciferol also has the advantage of presenting a lower risk of secondary poisoning than 1080. No cats Eason, *et. al*. (1996) or dogs Wickstrom, Henderson and Eason (1997) died after being fed for 5 days on possums killed by cholecaciferol while 1080 residues in possum carcases collected in the field were potentially lethal to dogs for more than 75 days after poisoning (Meenken and Booth, 1997).

Use of 1080 gel by trained and licensed personnel is expected to occur in some situations, particularly where few vulnerable non-target species are present. However, to minimise the risk to non-target species, use of cholecalciferol gel baits is advisable. The bait is unattractive and unpalatable to many non-target species and it poses low risks of either primary or secondary poisoning for non-target animals. The public acceptability of possum control by poisoning will be enhanced by the use of such relatively safe products.

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Appendix 1: *Scientific names of animals referred to in the text. Bird species marked with an asterisk were observed at the field study site, but not within 3 m of gel bait. Species that did approach within 3 m of bait at the field site are shown in Table 4.*

Common name	Generic name
Giant land snail	*Powelliphanta hochstetteri hochstetteri*
Large-headed weta	*Hemideina crassidens*
Ground beetle	*Megadromus bullatus*
Honey bee	*Apis mellifera* L.
Common skink	*Leilopisma nigriplantare*
Possum	*Trichosurus vulpecula* Kerr
Short-tailed bat	*Mystacina tuberculata*
Bellbird[1]	*Anthoris melanura*
Brown kiwi	*Apteryx australis*
Fantail	*Rhipidura fuliginosa*
Fernbird*	*Bowdleria punctata*
Grey warbler*	*Gerygone igata*
Kaka	*Nestor meridionalis*
Kakariki*	*Cyanoramphus auriceps*
Kea	*Nestor notabilis*
Kereru*	*Hemiphaga novaeseelandiae*
Mallard duck*	*Anas platyrhynchos*
Morepork*	*Ninox novaeseelandiae*
Paradise shellduck*	*Tadorna variegata*
Pukeko*	*Porphyrio melanotus*
Redpoll*	*Carduelis flammea*
Silvereye	*Zosterops lateralis*
South Island robin	*Petroica australis*
House sparrow*	*Passer domesticus*
Spur-winged plover*	*Vanellus miles novaehollandiae*
Tui	*Prosthemadera novaeseelandiae*
Weka	*Gallirallus australis*

[1]Nomenclature of birds follows Turbott (1990)