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RESEARCH

Trials with non-toxic baits for stoats and feral cats

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Abstract: Stoats and feral cats are key predators of some of New Zealand's most threatened fauna and landscape-scale control tools are urgently needed. A ready-made meat bait is being developed for use in both aerial and ground-based control operations. As part of the development, two trials with non-toxic versions of the bait were undertaken: one targeting stoats in Fiordland in spring 2020 and the other targeting feral cats in the Mackenzie Basin in winter 2021. The trials aimed to assess the palatability of baits to both target and non-target species. Stoats and feral cats ate both rabbit and chicken sausage baits. The only native species found to eat baits during the stoat trial was the South Island robin. No consumption of baits by native species was observed during the feral cat trial. These trials have provided confidence that stoats and feral cats can find baits that are hand-laid at a relatively low density. Adding a toxin which has an odour and taste may affect palatability, so field trials will be required to test toxic versions of the baits.

Keywords: bait palatability, bait trial, *Felis catus*, feral cat, *Mustela erminea*, non-targets, non-toxic, stoat

Introduction

New Zealand wildlife evolved in the absence of mammalian predators and their introduction has been responsible for many extinctions and declines (Parkes & Murphy 2003, Innes et al. 2010). Stoats (*Mustela erminea*) were introduced in the 1880s in a failed attempt to control rabbits (*Oryctolagus cuniculus*) and since then have become widespread throughout the mainland from sea level to well above the treeline (Smith et al. 2007; Murphy et al. 2019). Domestic cats (*Felis catus*) were introduced nearly 100 years before stoats, arriving with the early European explorers from 1769, and later formed feral populations (Gillies & van Heezik 2021). Feral cats can also be found in a wide range of terrestrial habitats, from sea level to 3000 m (Gillies & van Heezik 2021). Both stoats and feral cats pose a major threat to New Zealand's native fauna and must be controlled if endemic species such as kiwi (*Apteryx* spp.), kakī (*Himantopus novaezelandiae*), short-tailed bat (*Mystacina tuberculata*), and grand and Otago skinks (*Oligosoma grande, O. otagense*) are to survive on the mainland (McLennan et al. 1996; Dowding & Murphy 2001; Reardon et al. 2012; Scrimgeour et al. 2012).

Effective control techniques for both stoats and feral cats are currently limited. Stoats are mainly controlled through kill-trapping and secondary poisoning from aerial 1080 operations for rats (*Rattus* spp.) and brushtail possums (*Trichosurus vulpecula*) (Murphy et al. 1999; Brown et al. 2015). Feral cats are also mainly controlled by trapping and can be secondarily poisoned during 1080 operations (Gillies & Pierce 1999; Alterio 2000). A fishmeal bait surface-coated with 1080 has been registered for use by the Department of Conservation (https://pestoff.co.nz/products/1146-1080-feral-cat-bait/) to target feral cats, but its effectiveness is uncertain (Cox et al. In Press). The toxin para-aminopropiophenone (PAPP) is registered for use in a paste (PredaSTOP™), for application in hand-made minced meat baits for the control of stoats and feral cats (Dilks et al. 2011; Eason et al. 2014). Uptake of PredaSTOP™ has been low however, due to hand-made baits being labour-intensive and messy to make. These baits also need to be used in bait stations, which stoats and feral cats may avoid.

Additional techniques for the control of both species are needed. In particular, we need tools that can be deployed at a large scale, or in areas with difficult access (Murphy et al. 2019; Kemp et al. 2022). Ready-made baits that could be hand-laid or delivered aerially and that are attractive to stoats and feral cats would be a valuable addition to current tools. Sausage baits have been shown to be palatable to both stoats (Brown et al. 2012) and feral cats (Algar et al. 2020; Cox et al. In Press).

The objective of this study was to hand-lay non-toxic sausage baits in the field to see whether stoats and feral cats found and ate them. We also wanted to know which non-target species could potentially be at risk from eating toxic versions of the baits.

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Methods

Two trials were undertaken to test our non-toxic baits. The first targeted stoats in the Borland Valley, Fiordland National Park, and the second targeted feral cats in the Mackenzie Basin, Canterbury.

The Borland site covered c. 1000 ha within the lower Borland Valley. This area generally has high stoat numbers and low rodent numbers, with mustelid tracking indices regularly between 60 and 100%, and rodent tracking indices often at 0% (Department of Conservation, Te Anau, unpubl. data). The vegetation in the area is predominantly mountain beech (*Fuscospora cliffortioides*) and silver beech (*Lophozonia menziesii*).

The Mackenzie Basin site covered c. 1100 ha in the Pukaki River Valley. Habitat types in the area included grasslands, dry riverbed, and shrubland with scattered exotic conifers.

In both trials, 50 bait sites were allocated on a c. 500 × 500 m loose grid, resulting in a bait density of c. 1 bait per 25 ha. The Borland grid was roughly square, but the Mackenzie grid was long and relatively narrow (c. 9.5 × 1.0–1.5 km), with bait sites either side of the river. Trail cameras (Browning Dark Ops 6HD-940, Prometheus Group Birmingham, Alabama; Bushnell Aggressors, Bushnell Outdoor Products, Cody Overland Park, USA) were focussed on each bait and set to record 30-second videos. A 'soft' grid placement method was used, meaning that the bait and camera site could be selected from within a 50 m radius from the pre-determined point. Sausage baits containing rabbit (100% rabbit mince) or chicken (90% semi-dried chicken mince + 10% rice flour) were dyed green and alternated on the grid. Baits weighed 10 g for the stoat trial and 18 g for the cat trial. On day 1, a single bait was placed on the ground in front of a trail camera at each bait location. Baits had been frozen but were thawed on the day of placement.

The stoat trial ran for 20 days from 25 November–15 December 2020, with bait being checked and replaced with the same bait type 8–9 days after deployment. The cat trial ran for 25 days from 3 June–28 June 2021, with bait being checked and replaced with the same bait type 12 days after deployment. Camera data were retrieved, and batteries changed if required when baits were replaced. At the end of the trials, any remaining baits were removed.

In the Borland stoat trial, baits were placed directly on the ground mostly under forest canopy in predominately damp/wet conditions. In the Mackenzie cat trial, almost all baits had no vegetation overhead and were exposed to the sun, wind, snow and frosts. Most of the baits in the Mackenzie were placed on small rocks c. 4 cm off the ground to make the bait easily visible on the trail camera.

Camera footage was reviewed, and the following were recorded: (1) bait present, absent, or unsure; (2) animal present identified; (3) animal behaviour described. An animal detected more than once on the same camera within a 10-minute period was classed as a single detection.

Results

Borland stoat trial

Stoats were detected on video a total of 301 times and encountered a bait (i.e. a bait was present) on 58 (19%) of those occasions. Stoats either ate or took the bait away on 55 (95%) of the 58 encounters (Table 1). Except for three instances, stoats took baits on their first encounter. In two of these instances, stoats triggered the camera by running through the frame, and at both locations a stoat returned later and ate or took away the bait. On only one occasion did a stoat sniff the bait and leave without eating or taking it away. This bait was later taken away by a Eurasian blackbird (*Turdus merula*). Of the 55 baits eaten or taken away by stoats, 11 (20%) were eaten immediately in front of the camera, and 44 (80%) were taken out of shot. Of the 11 baits consumed on camera, three had been present for 2 days, four for 3 days and four for 5 days.

Stoats ate or took 22 baits between 2 and 7 days after the baits were first deployed, and 33 baits between 1 and 6 days after re-baiting. Visits by stoats to bait sites after a stoat had previously eaten or taken a bait increased almost three-fold, from 64 times to 179 times after re-baiting. In two instances after re-baiting, baits were taken within 3 and 31 minutes of being placed. All bait at sites where stoats were detected had been removed after 7 days, so it is not known whether stoats would have taken older baits.

Of the 55 baits eaten or taken away by stoats, 25 (45%) were chicken and 30 (55%) were rabbit. Of the 11 baits eaten

Table 1. Species recorded on trail cameras and their interactions with baits during the Borland Valley non-toxic stoat-bait trial, November–December 2020.

Species	Bait encounters	Ate or took bait	Sniffed/ mouthed only	Ignored
Possum (*Trichosurus vulpecula*)	115	2	49	64
Stoat (*Mustela erminea*)	58	55	1	2
Deer (*Cervus elaphus*)	6	0	1	5
Hedgehog (*Erinaceus europaeus*)	5	2	3	0
Cat (*Felis catus*)	2	1	0	1
Pig (*Sus scrofa*)	1	0	1	0
Blackbird (*Turdus merula*)	95	11	15	69
Chaffinch (*Fringilla coelebs*)	77	0	0	77
Songthrush (*Turdus philomelos*)	57	8	5	44
SI robin (*Petroica australis*)	19	5	8	6
Dunnock (*Prunella modulari*)	4	0	0	4
Bellbird (*Anthornis melanura*)	1	0	0	1
Rifleman (*Acanthisitta chloris*)	1	0	0	1
Tomtit (*Petroica macrocephala*)	1	0	0	1

on camera, nine (82%) were chicken and two (18%) were rabbit baits. Baits taken out of view of the camera may have been cached and not eaten.

Borland non-target interactions

A total of 14 non-target species were recorded on cameras while a bait was present. Four were native bird species, four were introduced bird species, and six were non-target mammalian pest species (Table 1). The only native bird that interacted with baits was the South Island robin (*Petroica australis*) (Table 1). Robins pecked small amounts of meat from the outside edges of the bait and ate maggots off the bait.

No rats (*Rattus* spp.) were detected. Only one mouse (*Mus musculus*) was recorded but the bait had already been removed so there was no opportunity for interaction.

Mackenzie cat trial

Cats were detected on video 58 times during the trial and encountered a bait on 37 (64%) of those occasions. Of the 37 encounters, baits were eaten on camera on 23 (62%) of the occasions (Table 2). Unlike stoats, cats did not take baits out of view of the camera.

Individual cats could be identified by distinctive coat patterns and other distinguishing features such as ear notches. Most cat detections were of two individuals, with 39 (67%) of the detections being of Cat A, which ate at least 18 (78%) of the baits. Cat B contributed 9 (16%) of the detections and ate at least four (17%) of the baits. Cat A was detected on 23 of the 50 cameras covering the length of the grid and Cat B on five of the 50 cameras in the middle of the grid but there was no overlap in the cameras they were detected on. Of the 10 cat detections (spread throughout the grid) where an identification could not be made, baits were encountered 4 times (11% of total cat bait encounters), but on only one occasion was the bait eaten. The three uneaten baits were 1, 2, and 3 days old.

The age of consumed baits ranged widely between 1 and 12 days. Of the baits consumed by cats, 12 (52%) were chicken, and 11 (48%) were rabbit. Ten baits were initially eaten (four rabbit, six chicken) and 13 baits (seven rabbit, six chicken) after re-baiting. In all but one interaction cats ate the entire bait, and in most instances, consumed the bait whole with just a few chews. In most encounters cats sniffed or licked the bait first. Several times cats licked the ground or rock where the bait had been after consuming it. It was possible to assess the cat's eating behaviour in 20 cases; the mean time taken to consume a bait was 25.1 secs with a range of 6–120 secs.

Mackenzie non-target interactions

A total of 21 non-target species were recorded on the cameras including two native birds, nine introduced birds, and 10 non-target mammalian pest species (Table 2). Neither of the native species, swamp harrier (*Circus approximans*) and New Zealand pipit (*Anthus novaeseelandiae*), were seen to interact with baits during this trial (Table 2). Other than cats, European hedgehogs (*Erinaceus europaeus*) and a ferret (*Mustela furo*) were the only species observed eating a bait. Hedgehogs consumed five (50%) of the 10 baits encountered (two chicken and three rabbit, Table 2), all of which had been in place for no more than 5 days.

Bait longevity

Many of the baits in the Borland stoat trial started to lose their form and become visibly soft with maggots, sometimes within a few hours. In comparison, in the Mackenzie cat trial where baits where subject to much colder and drier conditions, it was clearly visible on several videos that the baits had become solid and rigid within a day or two. Although most of the baits consumed by cats in the Mackenzie appeared to be semi-dried and hard, they nevertheless retained their palatability.

Discussion

Both rabbit and chicken non-toxic sausage baits appeared to be palatable to stoats and feral cats in this trial. Fresh rabbit meat is known to be attractive to both species (Keedwell & Brown 2001; Pierce et al. 2007) and rabbit sausages were attractive to stoats in pen trials (Brown et al. 2012). Chicken

Table 2. Species recorded on trail cameras and their interactions with baits during the Mackenzie Basin non-toxic cat-bait trial, June 2021.

Species	Bait encounters	Ate or took bait	Sniffed/ mouthed only	Ignored
Lagomorph (Leporidae)	237	0	13	224
Possum (*Trichosurus vulpecula*)	70	0	22	48
Cat (*Felis catus*)	37	23	6	8
Wallaby (*Macropus rufogriseus*)	25	0	7	18
Mouse (*Mus musculus*)	17	0	6	11
Hedgehog (*Erinaceus europaeus*)	10	5	1	4
Stoat (*Mustela erminea*)	2	0	0	2
Ferret (*Mustela furo*)	1	1	0	0
Rat (*Rattus* spp.)	1	0	0	1
Deer (*Cervus elaphus*)	1	0	0	1
Small passerine*	33	0	0	33
Blackbird (*Turdus merula*)	7	0	2	5
Songthrush (*Turdus philomelos*)	7	0	0	7
Magpie (*Gymnorhina tibicen*)	4	0	0	4
Swamp harrier (*Circus approximans*)	3	0	0	3

*includes NZ pipit (*Anthus novaeseelandiae*)

mince is often used in a maintenance diet for captive stoats (Brown et al. 2012).

Stoats

Individual stoats could not be identified but, due to their large home ranges (Murphy & Dowding 1994; Smith et al. 2007), it is assumed that individuals were probably eating/taking multiple baits. The high rate of bait take indicates that the baiting density used during this trial might result in a good knock-down of stoat numbers, although trials with toxic baits are needed to confirm this.

Neophobia was not observed, with stoats exhibiting little hesitation when interacting with baits. Stoat visitation to a location increased after the bait had been taken, indicating learned behaviour. Stoats were seen on many occasions to scent mark bait locations, which they do to mark new objects in their home range (Erlinge et al. 1982). These behaviours suggest that pre-feeding with a non-toxic bait, especially during a ground-based operation where bait locations can be accurately repeated, could increase the speed at which stoats find toxic baits.

Cats

The number of cats in the Mackenzie site was small and our results were dominated by two individuals, so it is not possible to draw any significant conclusions regarding cat bait preferences or interactions. However, the two cats readily consumed both chicken and rabbit baits and at a wide range of age/time since placed. A similar trial undertaken on Auckland Island found that the chicken and rabbit sausage baits were more palatable than a fishmeal polymer cat bait (Cox et al. In Press). A slight preference for chicken over rabbit baits was found during a trial in Rakiura National Park, but again, sample size of cats was small (Glen et al. In Press).

Non-target interactions

The most likely competitors for meat-based baits are omnivorous opportunistic species such as rodents, hedgehogs, and possums. Although these species ate few baits during our Borland and Mackenzie trials, on Rakiura possums ate 8% and rats 41% of baits encountered (Glen et al. In Press). This has the potential to significantly reduce the amount of bait available for target species.

The only native species found to interact with baits during the Borland trial was the South Island robin. As robins pecked only small amounts of meat, it is not clear whether they would eat enough of a toxic bait to obtain a lethal dose.

No native species consumed baits in the Mackenzie cat trial, which was surprising as harriers were present and are known to scavenge (Keedwell & Brown 2001). No native species were seen consuming rabbit or chicken baits in trials on Auckland Island or Rakiura (Cox et al. In Press; Glen et al. In Press). Kiwi (*Apteryx australis lawyri*) on Rakiura were the only birds that interacted with baits. Birds sniffed, touched, or picked baits up in their bill, but did not consume any.

Management implications

The non-toxic trials have provided confidence that stoats and feral cats can find baits that are hand-laid at a relatively low density. There was also very little consumption of baits by non-target species, which was encouraging. Future trials should investigate the addition of a toxin to the baits, as that could affect palatability and efficacy.

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Data availability

The data from this article are available from the authors.

Author contributions

JR and EM designed the study. JR led the field trial and analysed the results. JR, PW and EM wrote the manuscript.

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