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RESEARCH

Field palatability and degradation of a selection of feral cat bait matrices on Auckland Island

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Abstract: Primary poisoning is an important method to ensure the successful eradication of cats (*Felis catus*) from large islands. Poison bait options for feral cat eradications and landscape-scale control in New Zealand are limited at present. As part of the development of a toxic bait for cats that can be aerially distributed, a non-toxic palatability trial was undertaken on Auckland Island to compare three types of prototype meat-based bait and one currently registered fishmeal polymer pellet for their palatability to feral cats and non-target species. Degradation rates of baits over a range of environmental conditions were also estimated by taking photographs of baits at regular intervals and inferring degradation from visual appearance of baits over time. Fourteen individual cats were sighted on 144 occasions with all individuals consuming at least one bait type. Results show that the three prototype meat baits were significantly more palatable than the fishmeal polymer baits. No native non-target animals were observed consuming any of the baits during the trial. Fishmeal polymer baits degraded at a slower rate than the meat-based matrices. Palatability results for the meat-based matrices are encouraging. Further trials of a toxic meat-based bait will be required to assess efficacy in pursuit of a registered product for wider use.

Keywords: Auckland Island, baiting, cat bait, eradication, feral cat, invasive species, Orillion feral cat bait, palatability

Introduction

Feral cats (*Felis catus*) are recognised as a major threat to native biodiversity, particularly on islands where endemism and species richness tends to be a feature (Holmes et al. 2019). Removal of feral cats can eliminate predation pressure and allow a process of recovery for many species and island communities (Griffiths et al. 2019). Most eradications for species other than rodents require a sequence of different tools to account for individual behaviour (Fisher et al. 2015; Griffiths et al. 2015). On review, primary poisoning was used in 31% of island eradication operations targeting cats where the methods were documented (Campbell et al. 2011). On larger islands (>2000 ha) poisoning appears to be more critical due to the labour requirements of alternative tools such as trapping. For example, all successful cat eradications on islands larger than 2000 ha (with the exception of Santa Catalina, 3890 ha, and San Nicolas, 5896 ha) have used primary poisoning for knockdown (Parkes et al. 2014).

Leg-hold traps are frequently used as a primary method in cat eradications (Campbell et al. 2011), though they carry a risk of educating animals if an escape occurs (Fisher et al. 2015). For example, an escape extended the Raoul Island cat eradication by 10 months until the animal was eventually caught (Ambrose 2002). Registered toxicants and baits for feral cat eradications or even sustained control on a landscape-scale are limited. In both Australia and New Zealand, two toxicants are registered for the control of feral cats – sodium fluoroacetate (hereafter 1080) and para-aminopropiophenone (hereafter PAPP). In Australia, meat-based baits that can be deployed aerially are either implanted with PAPP in an encapsulated pellet (Curiosity®, Tréidlia Biovet, Sydney) or directly injected with 1080 solution (Eradicat®; Algar et al. 2020) and trials of these baits have shown relatively high consumption, efficacy and humaneness (Algar et al. 2020; Johnston et al. 2020). In New Zealand, there are two registered feral cat poison baits for ground application only: a fishmeal polymer pellet (Feral Cat Bait) containing 0.1% 1080 that is manufactured by Orillion (Whanganui), also known as 'ACP cat bait' (Morgan et al. 1996), and a paste containing PAPP (PredaSTOP™) developed by Connovation NZ Ltd (Auckland) that is used in freshly-made meat baits (Murphy et al. 2011). Large-scale feral cat management is rarely undertaken in New Zealand, which may be partly attributed to the limitations of these products. Perceived efficacy, regulatory controls and logistic difficulties contribute to their poor uptake by biodiversity managers, but the cost of ground-based operations at a landscape scale is probably the greatest barrier. To eradicate cats from large islands of New Zealand and carry out effective landscape-scale control on the mainland, there needs to be a toxic bait that can be aerially distributed. Given the scale and the proportion of inaccessible areas to ground operations, an aerially distributable

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poison bait is critical for the technical feasibility of a feral cat eradication on Auckland Island (45 891 ha; Horn et al. 2022).

The New Zealand Department of Conservation (DOC) are developing a poison bait for feral cats that could be deployed aerially within New Zealand. Registration of a new toxic bait in New Zealand follows a prescription regulated by the Environmental Protection Agency and the Ministry for Primary Industries. These authorities assess the risk of a new hazardous substance to protect the environment and the health and safety of people and the community. They are also concerned with efficacy to ensure its use warrants the risk of release. A non-toxic palatability trial was undertaken on Auckland Island to compare palatability to target and non-target species of the prototype meat bait matrices being developed and the currently registered fishmeal polymer bait. To further inform palatability and efficacy, the degradation of each bait matrix as well as the chemical degradation of 1080 in the toxic version of the fishmeal polymer bait was investigated.

Methods

Study site

The study site covered approximately 1300 ha in the vicinity of Deas Head at the north-eastern corner of Auckland Island (50.69°S, 166.08°E), which lies in the Southern Ocean, 465 km south of Bluff, New Zealand (Fig. 1). The study site rises gradually from sea level to around 400 m elevation and is made up of four major vegetation types. A coastal band of southern rātā (*Metrosideros umbellata*) forest is present around the coast, grading inland into a thick band of low, tight shrubland dominated by inaka (*Dracophyllum longifolium*), *Ozothamnus vauvilliersii* and *Myrsine divaricata*. Cushion herbfields occur on low-altitude terraces, interspersed with bands of shrubland and patches of tussock grassland. Alpine tussock grassland dominates above approximately 300 m elevation. The climate is wet, cool, and windy. The daily weather is characterised by long periods of wind and frequent rainfalls.

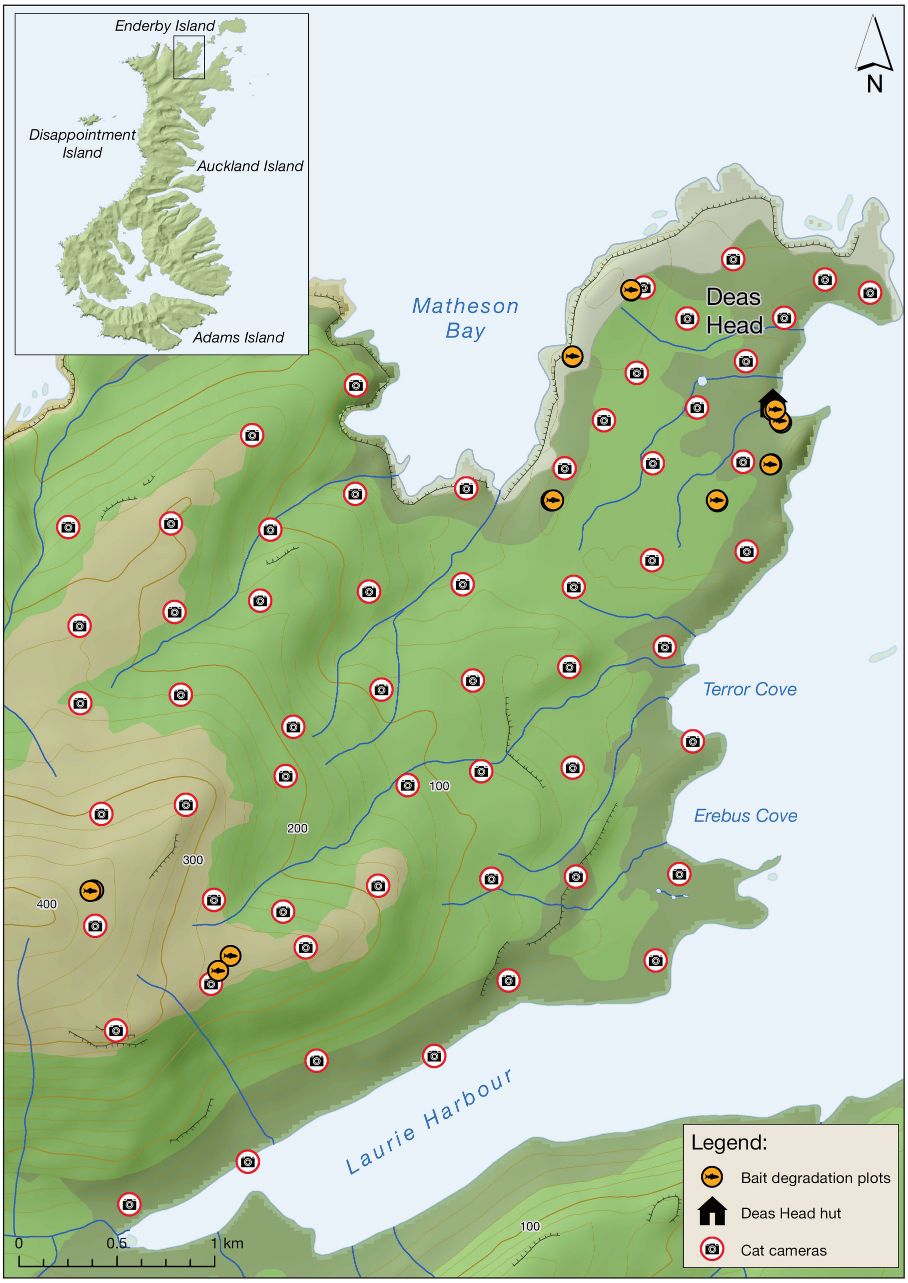

Figure 1. Camera grid and degradation plot locations across the study area, Deas Head, Auckland Island.

Table 1. Numbers of bait exposure incidents for each bait type in the three different habitats on Auckland Island. FM = non-toxic fishmeal polymer; CS = chicken sausage; GB = meat glue block; RS = rabbit sausage.

Habitat	Bait application 1				Bait application 2				Bait application 3				Total			
	FM	CS	GB	RS	FM	CS	GB	RS	FM	CS	GB	RS	FM	CS	GB	RS
Forest (n =17)	4	4	4	5	5	4	4	4	4	4	5	4	13	12	13	13
Scrub (n =18)	3	6	3	6	6	3	6	3	4	5	4	5	13	14	13	14
Tussock (n =13)	3	4	3	3	3	3	4	3	4	3	3	3	10	10	10	9
Total													36	36	36	36

Table 2. Bait degradation scores.

Score	Bait status
1	Fresh
2	Dry and crusty
3	Soft some mould
4	Mushy greater than 50% mould
5	Pile of mush greater than 50% mould
6	Disintegrating pile of mush
7	Gone or grain flakes

In August and September 2019, a camera grid was established at 500 m spacing (Fig. 1) to record cat and non-target species interactions with, and the palatability of, four different bait matrices. Previous work on cats at this site included GPS-collaring of six individuals, which were present during this trial and had unique marks on the collars to assist with individual identification (Rodriguez-Recio et al. 2022). A detectability assessment trial of feral cats with cameras has also been conducted previously, using a camera grid mostly replicated for this trial (Glen et al. 2022).

Palatability methodology

The palatability of four non-toxic bait matrices was investigated: chicken sausage (hereafter CS; semi-dried chicken mince +10% rice flour); rabbit sausage (hereafter RS; rabbit mince); meat glue block (hereafter GB; chicken mince +10% ProtiBondTG® EB3, a transglutaminase enzyme), with all three bait types weighing 18 g each; and fishmeal polymer pellet (hereafter FM; a non-toxic version of the Orillion feral cat bait) weighing 2 g.

Bait was presented at 48 sites in front of Bushnell Trophy-Cam Aggressor No-Glow infrared trail cameras (Bushnell Corporation, Kansas, USA) that were positioned in a grid approximately 500 m apart. Camera placement used a 'soft' grid i.e. field staff were given flexibility to choose sites within 100 m of the original point, to enhance cat detection. Game trails were considered ideal sites for detecting cats as evidenced in previous work by cat-detection dogs, leg-hold trapping, scat locations, GPS collars and cameras all indicating that cats use these trails frequently (Glen et al. 2022; Rodriguez-Recio et al. 2022).

Only one type of bait matrix per bait application was placed at each site. The camera grid was stratified by habitat type to ensure each bait matrix type had approximately even numbers of exposures in rātā, shrubland and tussock habitats as cat densities varied between these habitat types (Rodriguez-Recio et al. 2022). Meat baits (CS, RS and GB) and FM baits were placed in piles of three and nine respectively, approximately 3 m from the camera in the centre of its field of view. Three bait applications were carried out across the grid (Table 1) every 7–10 days between 20 August 2019 and 19 September 2019. Any old bait not consumed was removed at each re-bait and replaced with fresh bait. Bait matrix type at each camera site differed for each re-bait; each bait matrix type was exposed for 36 sampling periods across the grid and only two sites had a bait matrix type repeated during the trial.

After the sampling period, camera data were processed using a combination of a Microsoft PowerShell script and a Microsoft Access interface to streamline the process of identifying animals; images were automatically transferred into folders organised by species or false triggers. Animal interactions or encounters were categorised into 'consumption', 'interacting with bait but not eating' or 'not interacting with bait'. Also noted was the point during the trial period when the bait was 'gone' (either eaten or disappeared from frame without evidence of eating). Individual cats were identified by a combination of factors including coat markings or the presence of a collar. Identification was relatively straightforward as all but one individual sighted were tabbies with distinctive markings.

Degradation methodology

The visual appearance of the three non-toxic meat baits (CS, RS and GB) and the toxic version of the FM bait (containing 0.1% 1080) were used to assess degradation rates of the different bait matrices over time. Piles of bait (three baits for CS, RS and GB and 14 baits for FM) were put in a pest-proof cage at nine locations (Fig. 1). Plot locations were stratified by habitat type and altitude to assess the degradation rates over a range of environmental conditions.

Plots were visited and photographed on installation, then once a week for a period of approximately 5 weeks, then at 14 weeks after the end of the trial. Baits were given a score of 1–7 based on the level of decay (Table 2). Three samples of the toxic fishmeal pellets were taken from each plot (at installation and at 2 and 4 weeks) and to preserve the concentration of toxin baits were frozen at −20ºC until analysis (Booth et al. 1999). Samples were assayed by Maanaki Whenua Landcare Research Toxicology Laboratory, Lincoln, to determine concentration of 1080 toxicant.

Statistical analysis

A generalized linear mixed model (GLMM) was fitted to the palatability data to test the effect of fixed and a random variable on consumption. Consumption was binomially distributed with fixed variables including bait type and days since installation. With repeat measures from the same individuals, cat identity was included as a random effect.

A generalized linear model was fitted to the degradation data to test the fixed effects of days since install, cumulative rainfall and habitat on bait status.

Results

Palatability

There were 144 separate sightings of 14 individually identified cats, including all six previously collared individuals within the study site (cats collared for a home range and habitat study; Rodriguez-Recio et al. 2022). Of the 144 separate sightings there were only 85 occurrences of cats encountering bait (Table 3); in 59 cases the bait had already been consumed when the cat arrived at the camera site. There was a total of 50 bait consumption events (Table 3). Results show that the three meat baits (CS, RS and GB) were significantly more palatable than the FM baits even though the FM baits were interacted with around twice as much as the other baits (Fig. 2; Table 4). There was no significant difference in consumption between the three meat baits (CS, RS and GB). Cat identity ('cat_name') did not account for any of the variance seen in the data (Table 4) and resulted in no reduction in the residual variance present.

The number of days since deployment had no effect on bait consumption until about 7 days after deployment (Table 4; Fig. 3). Three encounters with chicken sausage after 7 days of deployment all resulted in no consumption, which is at odds with the very high rate of consumption of this bait within a 7-day period. Individual first encounter and first encounter for each specific bait matrix also had no significant effect on consumption.

Non-target species were seen on the trail cameras including the following native species: New Zealand sealion/whakahou (*Phocarctos hookeri*); bellbird/korimako (*Anthornis melanura*); yellow-eyed penguin/hoiho (*Megadyptes antipodes*); New Zealand pipit/pīhoihoi (*Anthus novaeseelandiae*); and tomtit/miromiro (*Petroica macrocephala*). No native animals were observed consuming any of the baits during the trial (Table 5). Feral pigs (*Sus scrofa*) and mice (*Mus musculus*) ate baits on multiple occasions (Table 5).

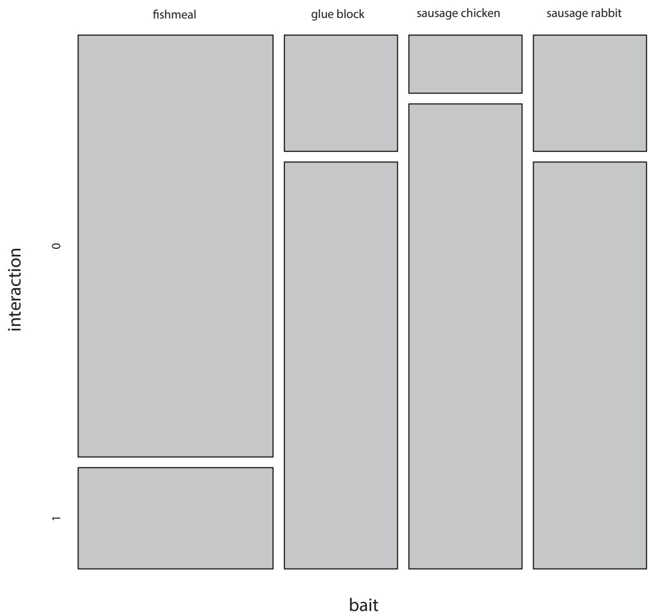

Figure 2. Proportion of feral cat interactions that resulted in consumption (1) and non-consumption (0) for each bait matrix type on Auckland Island during winter 2019.

Table 3. All bait matrices encountered and consumed by cats during the trial period. Numbers in bold in consumption column include likely consumption events, where the bait disappeared after a cat was seen on camera but there was no footage of it eating bait.

Bait type	Number of cat encounters where bait was present	Number of encounters where bait was present and was consumed (percentage consumed in brackets)	Number of individuals that consumed bait
Rabbit sausage	18	14 (78%) – **17 (94%)**	7
Chicken sausage	18	16 (89%)	8
Meat glue block	18	14 (78%) – **15 (83%)**	8
Non-toxic fishmeal	31	6 (19%)	4

Table 4. Results of coefficients included in the generalized linear mixed model on bait consumption of bait during trial on Auckland Island. The model included fixed and a random effect variable as shown in the table. p < 0.01 (***), p < 0.001 (**), p < 0.0001 (***).

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	−1.8307	0.6437	−2.844	0.004454 **
Bait: glue block	2.693	0.7332	3.673	0.000240 ***
Bait: sausage chicken	3.5377	0.8848	0.998	<0.00001 ***
Bait: sausage rabbit	2.7743	0.7451	3.723	0.000197 ***
Days since install	0.1122	0.1201	0.934	0.350316

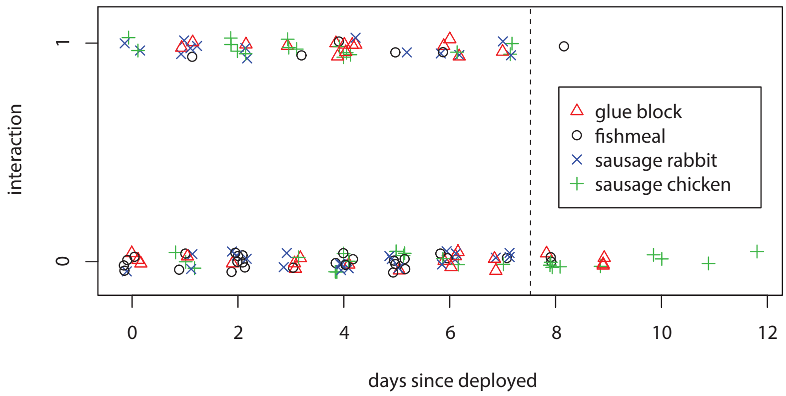

Figure 3. Feral cat interactions that resulted in consumption (1) and non-consumption (0) for each bait matrix type on Auckland Island during winter 2019. The vertical dashed line indicates 7 days where there is an apparent reduction in consumption, however, this reduction is not statistically significant.

Table 5. Non-target animals seen on camera that encountered bait during the non-toxic bait palatability trial on Auckland Island.

	Number of times seen on camera	Number of times interacting with bait	Number of times eating bait
New Zealand sealion/whakahou (*Phocarctos hookeri*)	26	3	0
Yellow-eyed penguin/hoiho (*Megadyptes antipodes*)	37	0	0
Tomtit/miromiro (*Petroica macrocephala*)	11	0	0
Bellbird/korimako (*Anthornis melanura*)	53	20	0
NZ pipit/pīhoihoi (*Anthus novaeseelandiae*)	5	1	0
Song thrush (*Turdus philomelos*)	2	0	0
Blackbird (*Turdus merula*)	50	0	0
Unknown bird (could not be identified from images/videos)	14	0	0

Degradation

FM degraded at a significantly slower rate than the meat-based matrices (CS, RS and GB; Tables 6 & 7). Unsurprisingly, cumulative time and rainfall significantly affected the degradation score (Table 7). In addition, habitat type affected degradation scores with baits degrading quicker in tussock habitat than shrub and rātā habitats.

After 5 weeks with a cumulative rainfall of 110.4 mm, 70% of samples had concentrations of 1080 below detectable levels and all baits tested were below detectable levels after 14 weeks (Table 8). The highest amount detected after 5 weeks of exposure was 0.0044 %wt.

Discussion

Palatability

The palatability trial has provided strong evidence of the preference for meat-based baits over fishmeal polymer of cats on Auckland Island, and given confidence that a palatable bait can be developed to target feral cats. Including cat identity in the model did not explain any of the variance present in the data. In hindsight this result is not surprising since there were only 14 individual cats detected within the study site with an average of 6.1 interactions per cat. This sample is a relatively small number of observations from which to gain any meaningful pattern.

Preliminary trials (as part of development) of different variants of the FM bait resulted in field and pen trial efficacy ranging from 20 to 100% (Eason et al. 1992; Coleman 1995; Morgan et al. 1996; Wickstrom et al. 1999). During winter 1991, a precursor to the bait was solely used on the successful eradication of feral cats from Matakohe Island (37 ha) Whangarei Harbour, New Zealand (Clapperton et al. 1992). In contrast toxic FM baits were used less successfully on Raoul Island, as part of the cat eradication following a brodifacoum broadcast application targeting rats (*Rattus* spp.) in 2002 (Ambrose 2002). On Raoul Island FM bait uptake was perceived low as evidenced by a cat seen in the area where bait had been for 18 days previous. Also, there were only two confirmed instances of cats eating the bait (both takes assumed lethal) and four individuals were subsequently captured with traps and dogs. Fishmeal polymer pellet bait is currently used in bait stations on Rakiura/Stewart Island but there is no formal result monitoring to inform its efficacy, which is perceived as low (Dowding 1995; P. Dobbins pers. comm. 2020).

The perception of mixed but generally low efficacy of FM bait is consistent with the consumption observed in this trial. FM baits were interacted with around twice as much as the other bait matrices because they were not being consumed and hence were encountered more often. Although significantly less consumed than the meat-based baits, there may still be limited application for the FM bait in targeting individuals that prefer fish baits (barracouta pieces) as observed on Auckland Island in February 2018 (Cox et al. 2019). Unfortunately, it is not possible to infer this preference from this trial as the two cats that only consumed fishmeal baits did not encounter any meat

Table 6. Mean ± SD degradation scores for each bait type on Auckland Island during winter 2019.

	Average degradation score for each bait type across all plots			
	Fishmeal	Chicken sausage	Rabbit sausage	Glue block
Install	1.00 (±0.00)	1.00 (±0.00)	1.00 (±0.00)	1.00 (±0.00)
Week 1	1.22 (±0.67)	1.56 (±0.67)	1.67 (±0.53)	1.44 (±1.50)
Week 2	2.33 (±0.50)	2.33 (±1.56)	3.33 (±0.71)	2.78 (±1.30)
Week 3	2.78 (±0.83)	3.44 (±1.27)	3.78 (±1.12)	3.22 (±1.22)
Week 4	3.33 (±0.50)	4.00 (±1.27)	4.33 (±1.12)	3.89 (±1.22)
Week 5	3.78 (±0.67)	4.56 (±1.24)	4.44 (±1.13)	4.44 (±1.33)
…	…	…	…	…
Week 14	**4.44 (±1.13)**	**5.44 (±0.88)**	**6.22 (±0.83)**	**6.11 (±0.60)**

Table 7. Results of coefficients included in the best generalized linear model on bait status during a degradation trial on Auckland Island. The model included variables as shown in the table. $p < 0.01$ (***), $p < 0.001$ (**), $p < 0.0001$ (***).

	Estimate	**Std. Error**	**t value**	**Pr(>|t|)**
(Intercept)	0.40273	0.22626	1.78	0.0766
Bait: glue block	0.38889	0.16512	2.355	0.0194 *
Bait: sausage chicken	0.40741	0.16512	2.467	0.0144 *
Bait: sausage rabbit	0.68519	0.16512	4.15	<0.001 ***
Days since install	0.16107	0.02609	6.174	<0.001 ***
Cumulative rainfall	−0.02263	0.01101	−2.056	0.0411 *
Habitat: forest	−0.07886	0.19242	−0.41	0.6823
Habitat: scrub	−0.07433	0.24778	−0.3	0.7645
Habitat: tussock	0.45281	0.21559	2.1	0.0369 *

Table 8. Toxicant concentration of toxic fishmeal polymer pellet (product should include 0.1% of pellet weight of Sodium fluoroacetate or 1080). Some measures were below method detection limits (<MDL). NA denotes samples not assayed.

Plot ID	**Vegetation type**	**1080 concentration (% weight)**			
		Day 0	Day 14	Day 32	Day 98
1	Forest	0.096	0.009	0.0044	<MDL
2	Forest	NA	0.010	<MDL	NA
3	Scrub	NA	<MDL	<MDL	<MDL
4	Coastal	NA	0.005	0.0003	NA
5	Tussock	NA	0.007	<MDL	<MDL
6	Forest	NA	0.012	0.0021	<MDL
7	Tussock	NA	0.002	<MDL	NA
8	Tussock	NA	0.004	<MDL	NA
9	Forest	0.098	0.001	<MDL	NA

baits. There were multiple cases of cats eating meat baits and refusing fishmeal but no instances where the reverse occurred.

The palatability trial was conducted during a period of high mouse numbers following a strong tussock masting event (Sagar et al. 2022). Many cat scats were encountered, the majority of which were full of mouse fur and bones. Despite the availability of alternative food, uptake of the meat-baits was very high so it is expected that delivery of toxic meat-based baits during the winter season, when it is expected that resources are particularly limited (Rodriguez-Recio et al. 2022), should result in a high knock-down of cats, assuming that palatability of the toxic bait matches the palatability of the non-toxic bait. Pen and field trials during development of the toxic bait will inform understanding of the palatability of the toxic bait.

Meat-based baits were for the most part chewed rather than swallowed whole and all three meat-baits were consumed entirely during each consumption event. It is proposed that baits will contain 4.5 mg of 1080 or 80 mg of PAPP, which are toxic loadings known to provide at least a lethal dose to feral cats (Eason & Frampton 1991; Murphy et al. 2011). FM was sniffed and when consumed often 'nibbled' so that it fell into crumbs. It was challenging to see in the camera footage how much fishmeal bait was eaten; it appears that at least two of the four individuals that consumed FM bait took enough to ingest a lethal dose of toxin had the baits been toxic (Eason &

Frampton 1991). No cat ate all the FM bait that was present.

There was no significant effect of first encounter negatively influencing consumption. Cats evidently seek out the meat baits once they have detected them; most animals were recorded returning to bait sites after they had consumed bait and actively searching. Anecdotally, some cats initially appeared to exhibit some neophobic behaviour particularly towards the FM bait; no cats ate fishmeal on their first bait encounter (it was only consumed after they had previously eaten one of the meat baits or had seen fishmeal before). These behaviours highlight the probable advantage of pre-feeding with a non-toxic bait before the toxic meat bait is deployed and warrants further investigation. Observation of pen and field trials during the development of the toxic bait will further inform the value of pre-feeding prior to delivery of the toxic bait.

If the baits had been toxic, assuming cameras detected all individuals and the toxin did not affect palatability, the trial would have resulted in a 100% knock-down of cats. However, if we consider the first baiting period only (i.e. mimicking a single bait application), of the 14 cats seen during the trial, only ten individuals encountered bait during the first baiting period and only seven consumed bait, reducing the knockdown rate to 50% of the total population. The four cats that did not encounter baits during the first baiting period may have been outside the treatment area during that time. Of the ten individuals that encountered baits, two of the three that did not consume bait encountered the fishmeal bait only; if they had encountered a meat-based bait, they may have consumed it given the observed higher palatability of the meat-based baits.

These results suggest that small piles of bait at 500 m (one site per 0.25 km^2) spacing are effective for targeting a high proportion of the cat population. There were multiple baiting periods in this trial so if only one application is planned for eradication/control activities then bait density and/or distribution should be considered to compensate for fewer baiting periods. An additional consideration for an aerial prescription is that the bait sites in this trial were chosen to maximise cat interactions, if bait was broadcast and randomly placed across the landscape, then the bait density should be increased to compensate for the less effective placement. Multiple studies in Australia have aerially distributed variants of a meat-based feral cat bait, and most apply baits at a rate of 50 baits per km^2 on flight lines between 500 and 1000 m apart (Algar et al. 2011; Johnston et al. 2012, 2014). This rate is significantly higher than used in this trial (~11 baits per km^2).

Individual cats were able to be individually identified during this trial. Distinctive markings particularly for tabbies, and to a lesser degree their size and shape were used to accurately distinguish between individuals. This identification was helpful to test for individual bait preferences and its effect on consumption. In addition, observations of individual behaviours could be made such as an assumed subdominant male repeatedly visiting bait sites immediately after an assumed dominant male. This assumed dominant individual consumed a significant amount of bait, taking the opportunity to encounter bait away from other cats. This observation is not a concern for future use, as if the bait was toxic the initial consumptions would have been lethal.

The fact that no native non-target animals consumed bait is encouraging and suggests that non-target impacts of toxic baits on Auckland Island may be low. Abundance of terrestrial birds on Auckland Island is low (Horn et al. 2022; R.L. Sagar unpubl. data) so additional research is needed for wider use in New Zealand. There was a limited amount of pig and mice interference (pigs consumed seven bait piles, mice consumed six); this consumption was spread across all bait types and had little effect on the trial results.

Degradation

The bait prescription needs to be designed to ensure every cat encounters a palatable bait. The rate of encounter can be increased by bait density, but consumption will be influenced by how quickly the baits degrade. It would be speculation to assess the period for baits to become unpalatable from their appearance in this study. However, zero consumption of the small sample of meat baits encountered by cats after 7 days suggests that meat baits are unpalatable after this period (Fig. 3). Based on this inference, bait density on Auckland Island needs to be high enough to ensure a strong likelihood of cats encountering bait within a 7-day period. Formal degradation studies of the toxic meat bait, including fate in the soil, will need to be completed as part of a registration process for the proposed PAPP bait but will also inform implications of toxicant degradation.

Presumably due to the integrated polymer, FM pellets held together the best and had the slowest degradation rate of all baits, with some remaining whole and looking relatively 'fresh' at the end of the trial when compared to the meat baits. 1080 is highly water soluble (Eason et al. 2011) and will leach out from bait even if the pellets are still intact.

During the Raoul Island eradication, all FM baits were supposedly removed from the field after a period of baiting, however, a monitoring dog died apparently from consuming a toxic FM pellet fragment and succumbing to 1080 poisoning (Ambrose 2002). On Auckland Island, it is highly likely dogs will be used as part of the mop up and validation phases of the eradication and the risk of 1080 poisoning if toxic FM baits are used needs to be mitigated. A higher resolution of degradation of this bait in relation to rainfall would be recommended to understand weather window restrictions to ensure efficacy.

Conclusion

The palatability trial has provided support for a pathway to develop a palatable meat-based vertebrate toxic agent for eradication and landscape-scale control of feral cats. This trial has also informed bait application density for Auckland Island to ensure high encounter rates by cats while bait is still palatable, however, this conclusion will require more investigation. No evidence of native non-target animals consuming baits is also encouraging. The efficacy of a toxic FM bait is likely to be less than a meat-based matrix though there may still be limited application for this bait in targeting individuals that prefer fish-based baits. Given the limited options for landscape-scale feral cat control in New Zealand, the development of a toxin that can be distributed aerially will be welcomed by biodiversity managers.

Author contributions

FSC and PMJ designed the study; FSC, PMJ and MSKC undertook fieldwork and analysed the data; and FSC and PMJ wrote the manuscript with input from MSKC and ECM.

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