Baits and baiting strategies for multi-species pest control and feral cats

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Part 1. Development of multi-species baiting

D.R. Morgan, J. Innes, C. Ryan

Abstract

Multi-species pest control could offer a means of making control more sustainable, both economically (by reducing costs) and ecologically (by avoiding unwanted consequences of single-species control). A 2-year study investigated its feasibility and effectiveness. Initial trials focused on the response of captive possums, cats, rats, and mice to different bait types that had been stored together. Palatability of RS5 possum bait, ACP cat bait, and Talon 20p rodent bait was generally unaffected after baits had been stored together for 2–6 weeks, irrespective of whether baits were presented alone (as in aerial sowing) or as a mixture (bait stations). Talon consumption by mice was significantly reduced by mixing baits. Cats ate less cat bait when the mixture was presented in a bait station, but this was probably because of difficulty in removing the cat baits, which were smaller than possum and rodent baits. Green glitter was more effective than red or blue for use as a bait marker to determine whether cats are killed by primary (the bait) or secondary (poisoned carcasses) poisoning. A field trial to test efficacy of multi-species control was unsuccessful. The possum population was unaffected, radio-collared cats did not remain in the trial area, and ferrets were too scarce. However, rats were successfully controlled (98% reduction). Suggestions are made for improving the likelihood of success in further field trials of multi-species control.

1. Introduction

Manaaki Whenua – Landcare Research, Lincoln, initiated the development of multi-species pest control for Science and Research Division, Department of Conservation. Studies were conducted during July 1993–June 1994 against captive animals at the Landcare Research animal facility, Rangiora, and during July–December 1994 in a field trial at Rotoehu Forest.

2. Background

Pest control strategies based on the control of individual pest species are inefficient if several pest species frequent the same area. Furthermore, single-species control may have ecologically destabilising effects. For example, reduction of rats, rabbits, or possums may induce prey-switching by predators (Murphy & Bradfield 1992), thereby increasing the risk to native birds, reptiles, and invertebrates. By controlling several pest species simultaneously, multi-species control may result in improved economic and ecological sustainability of control (Morgan 1993).

Since a number of pellet bait types are available for the control of several of New Zealand's major mammalian pests, it may be possible to simultaneously target groups of pest species with a mixture of bait types.

Inclusion of different coloured glitter biomarkers in toxic baits may provide a means of determining whether pests are killed by a specific type of bait when a mixture is provided in multi-species control. This is particularly important where predators are targeted as they may also be killed through secondary poisoning by feeding on contaminated carcasses of rodents or possums.

3. Objectives

- To determine palatability of mixed non-toxic baits to cats, possums, rats, and mice.
- To assess the efficacy of mixed toxic baits for control of these species.
- To assess palatability and persistence of a glitter biomarker in cats.
- To test the efficacy of a multi-species aerial control operation against possums, rats, mice, cats and ferrets.

4. Methods

Trials of bait palatability and efficacy and glitter as a bait marker were undertaken at our animal research facility at Rangiora. Three bait types were used in all trials:

- RS5 cereal pellets manufactured by Animal Control Products Ltd (Wanganui), nominal mean weight 3 g.
- Talon 20p cereal pellets manufactured by ICI Ltd (Richmond), nominal mean weight 3 g.
- Cat bait fishmeal pellets manufactured by Salmon Services Ltd (Christchurch) (surface coated at Landcare Research with 1% alanine and 0.1% actinidia), nominal size 8 mm.

4.1 PALATABILITY TRIALS

Four species were used in bait palatability trials:

- Cats – six adults and six immature (6–8 months old) cats comprising five males, four females, and three of unknown sex). Eight had been born in captivity at the Landcare Research animal facility, but four feral cats had been live-trapped around Rotorua and Stewart Island 1–2 years before the trials.
- Possums – 20 adult possums (16 males, 4 females), live-trapped 2–24 months before the trials.
- Black rats – 13 adult and six immature rats, caught in forest areas or rural buildings 1–4 weeks before the trials.
- Mice – 20 adult mice, caught around rural buildings 1–4 weeks before the trials.

All animals were maintained at the Landcare Research facility using appropriate husbandry.

The effect on palatability of storing baits in a mixture was assessed by mixing equal quantities of the three bait types in plastic bags and storing the mixture for 2–6 weeks with the bags sealed. The three bait types were also stored separately in sealed plastic bags for the same period for use as a control treatment. Such a period of storage may be necessary where control operations are delayed due to bad weather.

Baits were presented to the four species in three treatments:

1. Mixed/separate – equal quantities of previously-mixed baits, sorted into three separate trays (to simulate the dispersion achieved by aerial sowing).
2. Separate/separate – equal quantities of non-mixed bait, in three separate trays (as a control).
3. Mixed/mixed – equal quantities of the previously-mixed baits, mixed in one tray (to simulate use of bait in bait stations).

Rats and mice were divided into two groups, half of which received treatments on successive nights in the sequence 1, 2, 3, the other half in the sequence 2, 1, 3. Trays measured 20 cm × 10 cm × 4 cm for cats and possums, and 8 cm diameter × 4 cm deep for rodents.

The amount of bait presented reflected the expected consumption by each species:

- Possums (caged individuals) – 80 g each bait type (240 g total) available for 1 night.
- Cats (penned groups of four) – 130 g each bait type (390 g total) available for 1 night.
- Rats (caged individuals) – 30 g each bait type (90 g total) available over 2 nights.
- Mice (caged individuals) – 20 g each bait type (60 g total) available over 3 nights.

All animals were provided with only one-quarter of normal food rations during the trials to approximate the level of hunger that might be expected among feral animals encountering baits. Possums were fed a mixture of fruit, vegetable and supplementary feed pellets (Sanders & Co. Ltd., Ohoka); cats were fed rabbit meat; and rodents were fed standard laboratory chow and carrot.

Uneaten baits and bait fragments were reweighed after feeding to determine consumption.

Bait consumption by each species for treatments 1 and 2, and 3 and 2, were compared by paired t-tests. Consumption by bait type for each species was tested by ANOVA. The effect of trial sequence for rats and mice was tested by a univariate repeated measures analysis.

4.2 EFFICACY OF CONTROL USING MIXED TOXIC BAITS

The efficacy (i.e., % kill achieved) of mixed toxic baits was assessed in outdoor pens (possums and cats) and cages (rats and mice) simulating aerial control or bait stations. Baits were used with toxins at concentrations as follows:

- RS5 – 0.15% 1080 (confirmed as 0.15% by laboratory assay)
- Cat bait – 0.1% 1080 (confirmed as 0.09% by laboratory assay)
- Talon 20p – 0.002% brodifacoum

For the aerial sowing simulation, half the animals were individually presented with a randomly distributed bait mixture of four pellets of each type for 2 nights (possums and cats; 1.5 m spacing between baits), or three pellets of each type for 7 nights (rats and mice; 15–30 cm spacing between baits).

For the bait station simulation, the remaining animals were presented with 80 g of each bait type mixed in bait stations (possums and cats), or 20/30 g of each bait type in small trays (mice/rats respectively). These animals were monitored for up to 8 days.

Possum bait stations were the "Kilmore" type. For cats, bait stations were made from 2-l round ice cream containers held on their side by stapling through the base to a vertical wooden stake. Trays used for rodents were the same as those used in palatability trials.

Mortality of the animals was assessed daily for 8 days, and bait consumption was measured.

4.3 GLITTER BIOMARKER TRIALS

Possums were used for an initial dose-response trial of the palatability and persistence of metal glitter (Draw Art Supplies, Auckland) as a bait marker. Three concentrations of glitter, 1%, 2%, and 4%, were incorporated into RS5 pellets. At each dose level, 10 individually caged possums received 10 g of glitter-treated bait overnight. The amount eaten was recorded, and faeces were checked each day for the presence ("obvious" or "just visible") of glitter until none was seen.

After this preliminary trial, palatability trials comparing glitter bait and standard baits were completed for all four species. Possums received 150 g of each treatment overnight, cats 100 g overnight, rats 30 g available over 2 nights, and mice 20 g available over 3 nights. Bait consumption by bait type was compared by paired t-tests.

Finally, three cats were individually caged to test the persistence of glitter in faeces. Each cat was fed its normal ration of raw mince mixed with 5 g of glitter-treated bait (average bait take in the efficacy trials). Faeces were checked daily for presence of glitter (as above) until none was seen. This was repeated for red, green, and blue glitter with different cats.

4.4 FIELD TRIAL OF EFFICACY OF MULTI-SPECIES BAITING

A trial was conducted in collaboration with DoC, Bay of Plenty, at Rotoehu Forest as part of the Department's pest management in this area. An aerial control operation on 27 October 1994 simultaneously targeted possums, cats, ferrets, and rats, and was expected to be particularly beneficial for the protection of kokako.

Animal Control Products Ltd (Wanganui) No.7 baits with 0.15% 1080 (confirmed as 0.18% by assay) were used to control possums and rodents. This bait is similar to the RS5 bait we used in our pen trials, both bait types being comprised of the same cereal base, green dye, and cinnamon mask. Fishmeal-based baits (Animal Control Products Ltd, Wanganui) with 0.1% 1080 (0.09% by assay) were used for controlling cats. Cat baits incorporated metallic green glitter (2%) as a bait marker to enable determination of death by consumption of cat bait (glitter present in gut) or possum bait (glitter absent). Preliminary trials conducted in conjunction with DoC staff at Mount Bruce National Wildlife Reserve confirmed that kokako are highly unlikely to eat cat bait (Appendix 10.1). The control operation did not target ferrets with a specific bait, but ferrets were monitored as a possible by-catch.

Random samples (300 g) of both bait types were collected from 10 separate bags (25 kg) of each bait type used in the operation. Samples were checked by laboratory assay for 1080 content.

A mixture containing 8 kg/ha of No.7 and 2 kg/ha of cat baits was aerially distributed over the study site by GPS-guided helicopter, ensuring complete coverage. Sowing machinary was calibrated to give the correct sowing rate.

Efficacy of the multi-species control operation against cats and ferrets was assessed by radio-telemetry monitoring of a sample of captured and released animals. Before the control operation, we attached loop-aerial transmitters (Sirtrack NZ Ltd) to nine cats and one ferret caught in cage-traps in the 740 ha area of Rotoehu forest scheduled for pest control. To increase sample size, a further four cats were captured in the nearby area Kaituna Reserve and translocated, with DoC permisssion, to the Rotoehu study site. Preliminary tests revealed that the transmission range of the loop-aerial transmitters was sufficient (150–250 m in heavy forest during ground searching) to enable relocation of collared animals. During 11–25 September, the study area was traversed along transects 200 m apart, and using a Telonics receiver, eight of the 13 cats and the ferret were relocated in the study area. Two cats and the ferret were reported killed, and one cat reported alive outside the study area during 21 September–25 October. Two cats were not relocated before the poisoning operation (27 October).

After the control operation the study area was thoroughly searched for cats by radio tracking on the ground and from the air. Ground searches were made on 8 days during 28 October–14 November mainly during the daytime, but with some night searching. Three searches were made from aircraft using both hand-held and externally mounted receiver aerials.

The reduction in possums was monitored by reduction in trap catch from 10 groups of traps separated by 200–250 m. Traps were not lured, but were set above ground at the end of a wooden ramp to exclude ground-feeding birds. Within each group, traps were set 10 m apart for 3 nights (i.e., 300 trap-nights) before and after poisoning. Trapped possums were killed. Trap lines after the operation were located at least 200 m away from pre-poison trap lines to ensure that the kill estimate did not include a measure of the pre-poison trap-catch.

The impact of the poisoning operation on the rat population was monitored using tracking rates on 100 tracking tunnels, baited with peanut butter, and set for 1 night before and 1 night immediately after poisoning.

All cage, pen and field studies were conducted with approval from the Landcare Research Animal Ethics Committee.

5. Results

5.1 PALATABILITY TRIALS

Consumption of the different bait types varied significantly for all four species (Fig. 1; $p \leq 0.001$ for all species). The preferred baits were:

- cat bait for cats
- RS5 and Talon 20p for possums and rats
- Talon 20p for mice.

Storage of baits in a mixture followed by presentation alone (i.e., to mimic aerial sowing) did not alter palatability of the baits for cats, possums, or rats ($p>0.4$, $p>0.5$ and $p>0.5$, respectively). However, storage in a mixture reduced Talon 20p consumption by mice by 23% ($p = 0.015$). Consumption of RS5 and cat baits by mice was not affected ($p>0.4$).

Storage and subsequent presentation of baits in a mixture (i.e., as in bait stations) reduced consumption of Talon bait by mice by 14% ($p = 0.05$); of cat bait by mice by 33% ($p = 0.02$); and of cat bait by cats by 57% ($p = 0.04$).

Order of presentation of the three treatments for rats and mice did not appear to influence these results ($p>0.1$).

5.2 EFFICACY TRIALS

All animals were killed in the simulated control operations, except for one rat in the bait station treatment, and two cats and one possum in the aerial treatment (Table 1). Death was usually rapid in all four species (Table 1).

Bait preferences were similar to those seen in the non-toxic palatability trial (see Fig. 1)

5.3 GLITTER BIOMARKER TRIALS

Mean consumption of glitter baits by possums was similar for all three dose levels. Persistence was highly variable between individuals (Table 2). The 2% level gave the most consistent results, with glitter found in the faeces of all possums that ate glitter bait. At the other two levels, some of the individuals that ate glitter bait had no glitter found in their faeces. The 2% level was chosen for use in further palatability trials with other species.

Inclusion of glitter did not affect the palatability of baits to possums ($p>0.3$), or rats ($p>0.6$). Consumption of standard cat bait by cats was 76% less than that of glitter bait ($p=0.002$). Glitter reduced the consumption of bait by mice by 57% ($p=0.001$).

Glitter persisted in cat faeces for 2–7 days. Green glitter proved to the most persistent, blue glitter did not show up quite as well, and red glitter did not show up at all.

5.4 FIELD TRIAL OF EFFICACY OF MULTI-SPECIES BAITING

One dead cat was relocated 5 days after the control operation. Inspection of its stomach contents revealed green glitter, indicating that it had eaten cat bait. Two other cats were relocated alive outside, but close to the boundary of the study area. One cat was captured at a poultry farm just outside the study area 5 months after the operation, and another was shot at approximately the same time inside the study area. It is possible that these cats may have been in the area at the time of poisoning. Since three cats were known to have been removed from the study area before the operation, this left five cats unaccounted for after the operation.

The operation had negligible impact on the possum population. Before the operation, the trap-catch was 35.7 possums/100 trap nights, and after the operation it was 35.1 possums/100 trap nights.

The rat population, in contrast, was greatly reduced. Although 52 of the tracking tunnels recorded rat movement before the operation, only one showed rat tracks after, indicating a reduction of 98%.

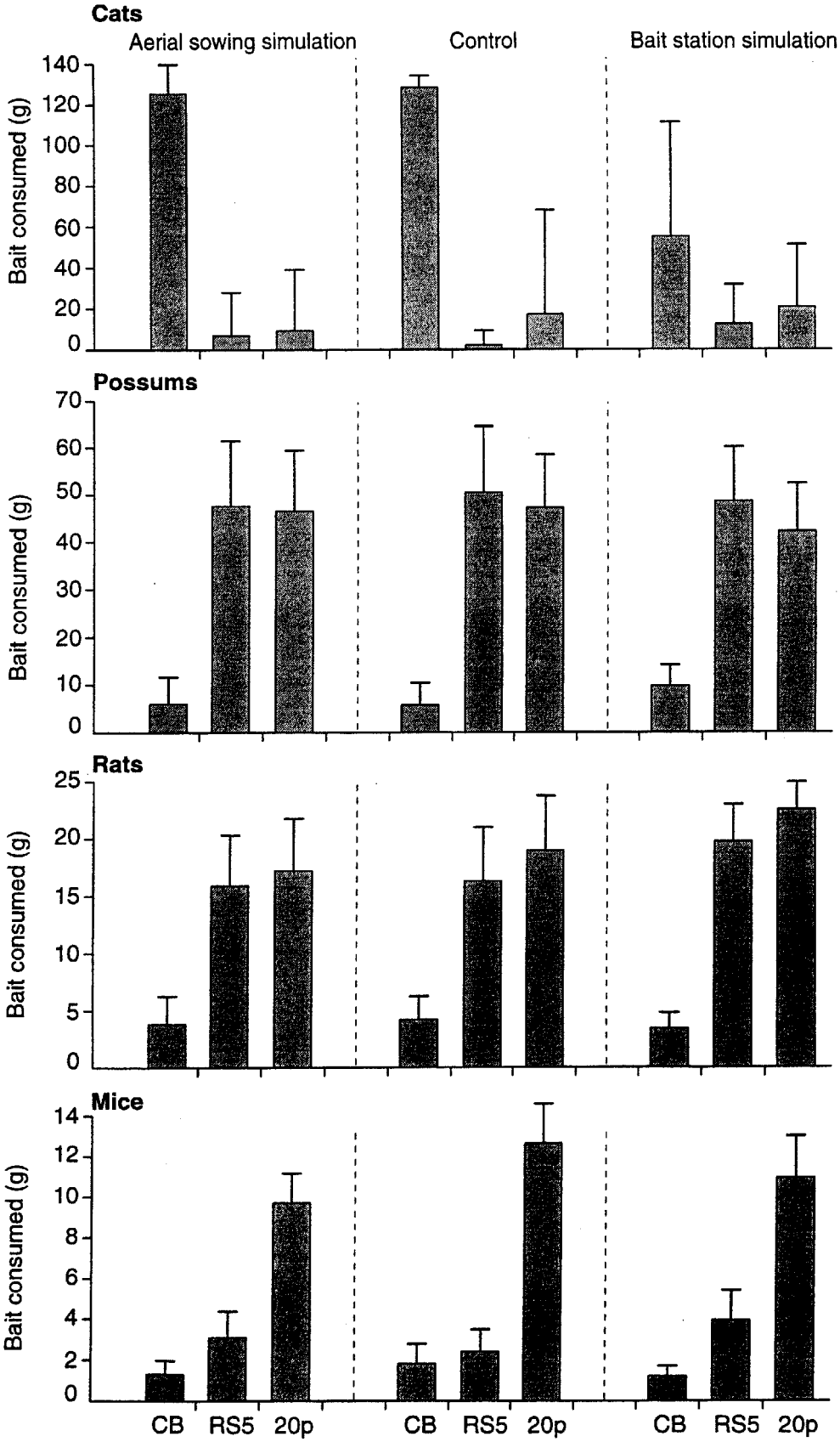

FIGURE I CONSUMPTION OF THREE NON-TOXIC BAIT TYPES (g) IN DIFFERENT PRESENTATIONS (MIXED "AERIAL", NON-MIXED "CONTROL", AND MIXED "BAIT STATION") BY FOUR PEST SPECIES. CB = CAT BAIT, RS5 = CEREAL PELLET, 20P = CEREAL PELLET.

TABLE 1. MORTALITY AND BAIT CONSUMPTION OF CATS, POSSUMS, RATS, AND MICE FED THREE TYPES OF TOXIC BAIT IN SIMULATIONS OF A) BAIT STATION CONTROL, AND B) AERIAL CONTROL.

SPECIES	N	% MORTALITY	ESTIMATED AVERAGE TIME UNTIL DEATH (H)	MEAN WEIGHT EATEN (g)		
				Cat bait	RS5	Talon 20p
a) Bait station control						
Cat	6	100	<15.0	6.1	0.1	0.8
Possum	10	100	14.4	1.2	11.4	4.5
Rat	12	92	15.2	0.1	1.9	1.5
Mouse	10	100	27.6	0.0[1]	0.3[1]	0.9[1]
b) Aerial control						
Cat	6	66	12.0	3.2	0.0	0.0
Possum	10	90	15.2	0.7	6.7	4.4
Rat	9	100	16.0	0.3	1.0	0.9
Mouse	10	100	84.0	0.1[1]	0.1[1]	3.1

[1] These values may be underestimated as moisture uptake by baits made weight measurements unreliable.

TABLE 2. DOSE RESPONSE OF POSSUMS TO GLITTER BAITS AND PERSISTENCE OF GLITTER IN FAECES.

DOSE LEVEL (%)	MEAN CONSUMPTION (g)	RANGE OF PERSISTENCE (DAYS)[1]
1	8.4	0-5
2	8.5	1-4
4	6.1	0-7

[1] Excluding possums that rejected all bait

6. Conclusions

6.1 PALATABILITY TRIALS

Palatability of baits was generally unaffected by storage as a mixture for 2–6 weeks, irrespective of whether baits were presented alone (as for aerial sowing) or as a mixture (bait stations).

Only cats showed a changed response to mixed baits presented as a mixture, eating less cat bait and more Talon and RS5 than when presented singly. The reduced consumption of cat bait could be explained by inability to select baits, rather than reduced palatability. Cats use their mouths to handle baits, perhaps making it more difficult to select preferred bait types. Possums, rats, and mice all use their paws to handle baits, and can therefore pick out preferred baits. This problem could be eliminated through appropriate bait station design.

Mice showed the greatest dislike of baits stored as a mixture.

6.2 EFFICACY OF MIXED TOXIC BAITS

The high kills obtained in simulated bait station and aerial control operations were acheived by most animals eating appropriate baits rather than baits intended for other species. Therefore, if any baits became contaminated by the odour of other bait types during storage as a mixture, this did not reduce bait efficacy.

Time to death was rapid for rats, indicating that 1080 was probably the cause of death. Therefore it may not be necessary to include Talon 20p baits in a multi-species control operation targeting rats (unless control of mice, which are less likely to eat 1080 RS5 baits, is also required). High kills of rats during 1080 possum control operations have been shown by Innes *et al.* (1995). A disadvantage of including Talon in aerial operations is that it may lead to persistent brodifacoum residues in game animals such as pigs and deer since research has shown that the toxin is highly persistent in sheep and goats (Laas *et al* 1985). The two cats that survived the aerial control simulation were both immature animals, suggesting that young animals may be less adept at foraging for baits. Both received sub-lethal doses of 1080 from the single bait they ate, indicating that bait size may need to be larger. This is preferred to increasing the toxic concentration in baits (Eason & Frampton 1991). Alternatively, field sowing rates of baits could be adjusted to ensure that cats can rapidly find more than one bait in a short period of time.

6.3 GLITTER BIOMARKER TRIALS

The glitter did not reduce the palatability of standard baits, and therefore can be used as a marker to indicate whether cats are killed by primary or secondary poisoning during control programmes. Results from persistence trials in cats seem to indicate that the glitter may persist in the gut longer than most food

would, perhaps by lodging in folds of the gut lining and also from being indigestible. This needs to be confirmed by examining the gut lining of cats at various time periods after small doses of glitter have been eaten.

6.4 FIELD TRIAL OF EFFICACY OF MULTI-SPECIES BAITING

The failure of the control operation against possums was unexpected after the success of the efficacy trials with captive animals. Although No.7 pellets were selected by DoC for the Rotoehu operation, these are similar to the RS5 pellets used in our preliminary trials. It was suggested that, despite our earlier trials, mixing possum baits with cat baits may have reduced their palatability. We therefore carried out further trials retrospectively to check this possibility (Appendix 10.2). Mixing the baits had no effect, but both "mixed" and "fresh No.7 baits were, however, less effective than expected from our earlier trials with RS5 pellets.

We therefore carried out a second retrospective trial to test the efficacy of another manufacturing batch of ACP No.7 pellets (Appendix 10.3). Ten of 11 possums were killed indicating that standard No.7 pellets are palatable and effective in killing possums. This suggests that those used at Rotoehu were of lower palatability.

Possums are known to be averse to 1080 if it is not masked, and it was therefore suggested that the 0.18% 1080 content of the No.7 baits may have been high enough to cause aversion, despite the inclusion of cinnamon as a mask. This would seem unlikely, however, as previous tests showed that this bait type containing 0.17% 1080 killed 95% of possums (Morgan 1990).

The reason for the failure of the operation against possums therefore has not been firmly established, but it appears that bait palatability may have been impaired by some unknown factor leading to a reduction in efficacy. It is possible that an abundance of natural, palatable foods at the time of the operation may have been mainly responsible for possums' lack of interest in the bait, as has been suspected previously in failed operations (e.g., Morgan 1992 unpublished contract report).

The concept of multi-species control against cat and ferret populations remains untested. Although 8 of the 13 cats were relocated in the study area during the month before control, none of these were present immediately after. However, the two cats relocated 5 months later may have been in the study area during the operation. Translocation of cats into the study area to increase sample size was unsuccessful as none of these cats remained in the area. Large movements by cats of up to 40 km over a period of a few months have been recorded in another recent radio-telemetry study on cats in Otago (Norbury, pers. comm.), and it appears that most of the cats that we radio-collared left the study area. Although DoC conservancy staff suggested at the outset that ferrets were relatively abundant at Rotoehu, this was subsequently found to be untrue.

Rats were greatly reduced by the control operation.

7. Recommendations

Possible causes of failure in the Rotoehu trial should be examined:

- The efficacy of No.7 pellets with 0.18% 1080 should be tested to determine whether excessive toxin was a likely cause of operational failure.
- The efficacy of No.7 pellets loaded with standard 0.15% 1080 should be tested as an assurance that the baits are suitable for routine use.

Further field-scale assessment of multi-species control should be attempted. To increase the chances of a succesful operation and evaluation:

- Baits should be distributed by GPS-guided helicopter, and coverage assessed.
- Bait acceptance by possums should be assessed immediately before the operation.
- It should be known that the area targeted contains the home ranges of cats (or other predators being targeted).
- Whip-aerial transmitters should be used for radio-tracking cats and loop-aerial transmitters, carefully tuned, used only on mustelids.
- Talon 20p baits should be included in an aerial trial only if mouse control is required.
- All baits should be made at least 2 months before intended use to permit thorough laboratory Quality Assurance testing before bait is accepted for use.
- Samples of baits used operationally should be retained in case any subsequent testing is required.

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9. References

Eason, C.T.; Frampton, C.M. 1991. Acute toxicity of sodium monofluoroacetate (1080) baits to feral cats. *Wildlife research* 18: 445–449.

Innes, J.; Warburton, B.; Williams, D.; Speed, H.; Bradfield, P. 1995 Large-scale poisoning of ship rats (*Rattus rattus*) in indigenous forests of the North Island, New Zealand. *New Zealand journal of ecology* 19: 5–18.

Laas, F.; Forss, D.A.; Godfrey, M.E.R. 1985 Retention of brodifacoum in sheep and excretion in faeces. *New Zealand journal of agricultural research* 28: 357–359.

Morgan, D.R. 1992. Aerial control of possums at Puketi Forest, March 1992 – appraisal of possible causes of a poor kill. Unpublished Forest Research Institute contract report FWE 92/21. Forest Research Institute, Christchurch. 8 p.

Morgan, D.R. 1993. Multi-species control by aerial baiting: a realistic goal? *New Zealand journal of zoology* 20: 367–372.

Murphy, E.; Bradfield, P. 1992. Change in diet of stoats following poisoning of rats in a New Zealand forest. *New Zealand journal of ecology* 16: 137–140.

10. Appendices

10.1 RESPONSES OF CAPTIVE KOKAKO TO NON-TOXIC CAT BAIT

Two trials were conducted by staff at Mt Bruce Field Centre during June 1994 using our procedures.

Trial 1 – to test the palatability of cat bait to kokako

Method: Two types of cat bait were tested: standard ACP cat bait (A) and standard bait with a bird repellent added (B). The two bait types were presented (100 g of each) in identical plastic containers placed on the aviary feeding tray with the birds' normal food at normal feeding times. Baits were presented for 24 h as feeding trays were rodent-proofed. Remaining baits were reweighed and replaced with fresh baits daily for 3 days. Birds were observed for the first 30 min after baits were presented each day.

Results: Only minor changes in bait weight of up to -0.7 g and +1.3 g were recorded. Although feeding stations kept baits sheltered, the weight gains were considered to be due to climatic influence rather than feeding by the birds. Birds clearly saw the baits but showed no interest in them during the 30-min observation periods.

Trial 2 – simulating aerial sowing of cat bait

Method: Individual baits were presented to kokako in three aviaries. Standard ACP cat baits were placed on leaves (to assist relocation) in a grid layout approximately 1 m apart. Conspicuous locations were deliberately chosen. Baits were laid out from 0900 to 1600 h each day for 3 days. Results are shown in Table A1.

TABLE A1. RESULTS OF TRIAL 2.

AVIARY	KOKAKO SEX AND ORIGIN	NO. BAITS PRESENTED	BAITS REMOVED		
			Day 1	Day 2	Day 3
1	Male, wild caught	19	1	1	0
2	Female, captive bred	21	1	0	0
3	Male, wild caught. Female, captive bred.	24	0	0	0

Mouse droppings were found on the leaf from which a bait was removed in aviary 2.

Conclusions: Since all kokako regularly ate all, or almost all, of the food offered to them, it is likely that if the cat baits had been attractive and palatable to them, some would have been eaten. The three baits removed in Trial 2 are assumed to have been removed by mice.

10.2 EFFICACY OF POSSUM BAITS AS USED IN THE ROTOEHU FIELD TRIAL

Method: No.7 possum baits (nominally 0.15% 1080 but found to contain 0.18%) were stored with cat baits (4:1) in a plastic bag for 30 min and then gently agitated for 2 min to simulate handling at Rotoehu. Four of these baits were offered to each of eight settled, caged possums. Four "fresh" baits (i.e., not stored with cat bait) were offered to another eight possums.

Results: "Stored" baits killed 5/8 possums and "fresh baits" killed 4/8 possums. Mean consumption of the two treatments was 3.7 and 6.5 g, respectively.

Conclusions:

- The two bait treatments were similarly effective. Mixing with cat baits had no effect.
- Both bait types were, however, less effective then expected. Previous trials indicate an expected kill of at least 7/8 and a mean consumption of 27 g. The bait was therefore less palatable than expected.
- The higher than expected 1080 content may have caused some aversion though previous tests with baits containing 0.17% 1080 and 0.1% cinnamon showed 95% mortality (which was equivalent to the 95% possums eating non-toxic, non-cinnamon baits in the same study).

10.3 EFFICACY OF POSSUM BAITS MANUFACTURED AFTER THE ROTOEHU FIELD TRIAL

Method: No baits were available from ACP from the same manufacturing batch as that used at Rotoehu. Therefore No.7 baits made subsequently were tested to determine whether current baits meet palatability/efficacy specifications. Baits supplied were 0.08% 1080 rather than 0.15%. However, these were tested to determine whether current bait formualtion, irrespective of 1080 content, is acceptable.

Each of 11 settled, caged possums were offered 50 g of pellets.

Results: Ten (91%) of the possums were killed. Mean bait consumption was 12.3 g.

Conclusion: Current 0.08% No.7 pellets are palatable and effective in killing possums. The lower consumption compared with previous trials (27 g) may be partly explained by possums in earlier trials being free-roaming in pens, and therefore having had a higher metabolic requirement than the caged possums used in this trial.

Part 2. Assessment of brodifacoum and alphachloralose as toxins for feral cat control

D.R. Morgan and L. Meikle

Abstract

Commercially available 1080 cat baits (Animal Control Products Ltd.) are eaten by, and kill about 70% of feral cats. Aversion to 1080 appears to be the main reason why some cats survive exposure to the bait. We therefore tested brodifacoum and alphachloralose as alternative toxins to 1080 in an attempt to improve bait efficacy. Captive feral cats were presented with standard cat baits containing brodifacoum or alphachloralose. Brodifacoum at 0.005 and 0.01% was non-aversive after the first night and toxic baits were as palatable as non-toxic baits. Alphachloralose at 3% and 6% was aversive, toxic baits being eaten much less than the non-toxic baits. Neither toxin was more effective than 1080 in killing cats: brodifacoum baits killed about 40% of cats and alphachloralose baits killed 40–55%. Cats were far less susceptible to brodifacoum than expected from the literature, but our results may underestimate effectiveness of the toxins under field conditions. Alphachloralose appeared to kill cats humanely, but brodifacoum caused prolonged discomfort. Brodifacoum could prove effective at 0.02% and may kill cats more quickly than at 0.01%, but the higher concentration may prove too costly (at least $3 per cat killed). If encapsulation technology for masking toxins becomes available, it should be used to overcome the aversiveness of alphachloralose, which otherwise is a highly appropriate toxin for cat control.

1. Introduction

Pen trials were conducted during May–August 1994 to assess the efficacy of cat baits containing either alphachloralose or brodifacoum as potential alternatives to 1080, which causes aversion in some cats. The study was undertaken for the Department of Conservation by Manaaki Whenua – Landcare Research, Christchurch.

2. Background

A 1080 bait for the control of feral cats was developed by Landcare Research (Eason *et al.* 1992) and is now available through Animal Control Products Ltd, Wanganui. This bait kills about 70% of feral cats (Morgan *et al.* 1994) achieving this level of control more efficiently than the conventional use of traps and fresh meat baits. Since eradication of cats is often the management goal, particularly where island habitats are being restored, effective cat baits that kill 100% of cats that encounter them are needed. Cats that survived exposure to the 1080 bait in our earlier trials were able to detect the 1080, and attempts to mask 1080 have so far proved unsuccessful. Identification of alternative toxins to 1080 that do not induce aversion is another way of trying to overcome this problem. An alternative toxin is also needed because use of 1080 poison for controlling feral cats is unacceptable in some areas (e.g., on the Chatham Islands because of concerns about weka).

3. Objective

- To assess the palatability and efficacy of cat baits containing brodifacoum and alphachloralase.

4. Methods

Captured feral cats were transferred to outdoor pens at the Animal Facility in Rangiora and allowed to acclimatise for at least 4 weeks. Cats were fed half rations (beef mince) in the morning and afternoon for 7 days before the study started, and during trials, on the assumption that this would approximate the average level of hunger among cats encountering baits in the wild (i.e., cats would have neither empty nor full stomachs).

Brodifacoum was obtained from ICI Crop Care Ltd., Richmond and alphachloralose from Animal Control Products Ltd., Waimate. Brodifacoum is a "second generation" anticoagulant toxin that is reported as being highly toxic to many mammal species, although published LD_{50} values for cats range from 0.25 mg/kg (Hayes & Laws 1991) to 25 mg/kg (Osweiler *et al.* 1985). An antidote, vitamin K, is available for cases of accidental poisoning by brodifacoum.

Alphachloralose causes central nervous depression and hypothermia in small mammals and birds (Thomas *et al.* 1988) and is registered for use in bird control in New Zealand. Cats are reported as being more susceptible to

alphachloralose (LD_{50}=100mg/kg) than dogs (600–1000mg/kg) (Cornwell 1969). The use of this toxin would potentially reduce the relatively high risk to dogs associated with the use of 1080.

4.1 PILOT STUDY

A pilot study was conducted to determine palatability and efficacy of the two toxins at estimated optimal concentrations in bait. Since LD_{95} values are generally 3 or 4 times greater than LD_{50} values, we estimated that the amount required to kill most cats in a single dose would be 1 mg/kg for brodifacoum (assuming an LD_{50} of 0.25 mg/kg, which is similar to the value for five other mammalian species (Osweiler *et al.* 1985)), and 400 mg/kg for alphachloralose. We assumed an average body weight for cats of 3 kg and an average consumption of 30 g of brodifacoum bait (being a slow acting poison) or 20 g of alphachloralose (quicker acting). So that a lethal dose would be contained in these quantities of bait, 0.01% (i.e., 100 ppm) brodifacoum and 6% alphachloralose were used to prepare standard cat baits (Morgan *et al.* 1994, unpubl. Landcare Research contract report), as currently manufactured (with 1080) by Animal Control Products Ltd, Wanganui.

Brodifacoum and alphachloralose were tested in separate trials. In each trial, 200 g of toxic and 200 g of non-toxic bait were presented simultaneously to two cats in an outdoor pen. Baits were placed in two trays mounted in a shelter to prevent fouling and exposure to rain. Tray positions were alternated daily for 7 days. Consumption of baits was recorded daily, and the baits were replenished. Consumption was corrected for moisture loss/gain using the variation in a 200-g sample of baits similarly placed but not available to cats. Beef mince (50% of daily ration) was presented at the same time as baits in the afternoon and early morning.

Palatability of toxic bait was be determined by:

$$\frac{\text{Mean wt. toxic bait}}{\text{Mean wt. toxic bait + mean wt. non-toxic bait}} \times 100$$

A value of 50% therefore indicates that toxic bait was as palatable as non-toxic. Efficacy was expressed as the proportion of cats killed by eating toxic baits.

4.2 MAIN STUDY

As the pilot study indicated that cat baits containing brodifacoum or alphachloralose showed promise, a second study was conducted to determine the optimum concentration of these toxins.

Brodifacoum was tested at 0.005% and 0.01%, and alphachloralose at 3% and 6%. Each treatment (200 g) was presented to five individual cats, none of which were used in more than one trial. Non-toxic bait was not presented. Weight of bait consumed daily and the fate of each cat were recorded. Beef mince was provided in two half-portions daily as described above.

Observations of signs of poisoning were made throughout the trials. This research was carried out with the approval of the Landcare Research Animal Ethics Committee.

5. Results and discusion

5.1 PILOT STUDY

Brodifacoum baits (0.01%) were eaten cautiously at first, but after the first night cats continued to feed on brodifacoum baits as eagerly as on non-toxic baits (Table 1). Overall, brodifacoum baits were as palatable (50%) as non-toxic baits. The two cats died after 9 and 10 days.

TABLE 1. AMOUNT OF BAIT (g) EATEN BY TWO PAIRS OF CATS IN PILOT TRIAL.

DAY	BRODIFACOUM		ALPHACHLORALOSE	
	TOXIC	NON-TOXIC	TOXIC	NON-TOXIC
1	16	107	24	200
2	69	51	0	0
3	70	100	0	0
4	75	34	0	0
5	65	27	0	0
6	87	55	0	0
7	12	9	0	0
Total	394	383	24	200

Alphachloralose baits were eaten cautiously by both cats. Palatability of the toxic bait was low (8.0%). One cat died approximately 16 hours after eating baits, the other after approximately 24 hours.

5.2 MAIN STUDY

Brodifacoum and alphachloralose baits killed only 40–55% of cats (Table 2).

Brodifacoum baits, unlike 1080 baits, did not induce aversion in cats, many of which continued to eat large amounts of bait until shortly before dying. Cats proved far less susceptible to brodifacoum than expected, as the mean intake of brodifacoum by cats that survived the toxin was 16.9 mg/kg (SD=6.5).

Cats that ate lethal doses of brodifacoum took 7–12 days to die and those that ate sublethal doses were affected by the toxin for up to 20 days before recovering. Affected cats haemorrhaged around the mouth, ears, and anus, and their eye-whites turned red. Dead cats had extensive haemorrhaging under the skin and around the kidneys and heart. Cats typically became reluctant to move, and some appeared uncomfortable when moving. Brodifacoum therefore appeared less humane for cat control than 1080, which kills cats within 12 hours with little outward sign of pain.

Alphachloralose baits at 6% induced aversion in two of five cats, but reducing the concentration of alphachloralose to 3% reduced cats' aversion to the toxic baits (as indicated by the greater proportion of cats eating bait and larger amount eaten). However, the increased consumption was not sufficient to greatly increase mortality (Table 2).

Alphachloralose is generally considered a humane toxin as it is soporific and eliminates the sense of pain (Hayes & Laws 1991). In our trials, most cats developed spontaneous jerks and convulsions when nearing death, but we cannot be sure that they did not experience discomfort. Those that were killed died within 24 hours. While Lees (1972) reported that cats became excited and aggressive when sub-lethally poisoned by feeding on contaminated rodents, we did not observe this type of behaviour, perhaps as a result of the larger doses of alphachloralose ingested by cats in our study.

TABLE 2. PROPORTION OF CATS EATING AND BEING KILLED BY BRODIFACOUM AND ALPHACHLORALOSE BAITS, AND TIME UNTIL DEATH.

TOXIN	CONC. WT:WT	NO. CATS	% CATS EATING BAIT	WT. EATEN (g)		% CATS KILLED	MEAN TIME UNTIL DEATH
				MEAN	RANGE		
Brodifacoum	0.01%	12	100	362	268–648	42	12.3 days
Brodifacoum	0.005%	5	100	357	212–477	40	8.5 days
Alphachloralose	6%	5	60	17.7	0–31.8	40	20 hrs
Alphachloralose	3%	9	89	26.3	0–99.9	55	19 hrs

6. Conclusions

Both brodifacoum and alphachloralose at the concentrations tested proved less suitable than 1080 for feral cat control. Both were less effective than 1080 (which typically killed 60–70% (Morgan *et al.* 1993) in pen and field trials). The mean dose of brodifacoum ingested by surviving cats (16.5 mg/kg) suggests that the LD_{50} value of 25 mg/kg given by Osweiler *et al.* (1985) is more accurate than the 25 mg/kg given by Hayes & Laws (1991). Our results are, however, based only on pen trials. Results from field trials may differ since

haemorrhaging is more likely to occur in cats that are more active in the wild and this may enhance the effectiveness of the toxin. Also, cats may experience more extreme exposure in the wild and this may improve the effectiveness of both brodifacoum and alphachloralose.

As brodifacoum does not induce bait shyness, it is possible that higher concentrations than those used in this study may prove more effective. However, assuming a concentration of 0.02% in baits (since 0.01% brodifacoum baits killed less than half of the cats), and an estimated price of $30–40/g (M. Shirer, ICI, pers. comm.), the required amount to kill a 3 kg cat would cost $3–4. The price of bait to deliver this amount of toxin would further increase cost. This may, however, be more cost-effective than the use of traps for controlling feral cats.

Data from the trials reported here suggest that few cats are likely to succumb to secondary poisoning from eating rodents poisoned by Talon bait, an ICI product containing brodifacoum. Although tissues from feral cats found dead after rodent control operations in which Talon baits were used contained brodifacoum, they would have to eat large numbers of rodents to receive a lethal dose. It is more likely that the cats sent to our laboratory ate Talon bait. However, results from another study (Part 1, this report) indicate that Talon is unpalatable to cats compared with ACP cat baits, and we would expect only a low proportion of cats to be killed by Talon.

When alphachloralose baits were presented alone in the main study, some cats refused them, suggesting that the presence of non-toxic baits in the pilot study may have encouraged cats to eat the toxic baits. A mixture of alphachloralose-treated and non-toxic baits may therefore be more effective than alphachloralose baits alone. However, it appears unlikely that the effectiveness of alphachloralose in cat baits can be greatly improved unless the toxin can be adequately masked. Alternatively, if encapsulation techniques are developed that render toxins undetectable without restricting their assimilation, alphachloralose and perhaps some other aversive toxins could be used more affectively in controlling feral cats and other vertebrate pests (Marsh 1990).

7. Recommendations

- The efficacy of 0.02% brodifacoum in cat baits should be tested, and an assessment made of its efficiency and humaneness for cat control.
- If encapsulation technology for masking toxins becomes available, it should be used to overcome the aversiveness of alphachloralose, which otherwise is a highly appropriate toxin for cat control.

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9. References

Cornwell, P.B. 1969. Alphakil - a new rodenticide for mouse control. *Pharmacology journal* 202*:* 74–75.

Eason, C.T., Morgan, D.R., Clapperton, B.K. 1992. Toxic bait and baiting strategies for feral cats. In *Proceedings of the 15th Vertebrate Pest Conference, California*, pp. 371–376.

Garner, R.J. 1967. Veterinary toxicology. Balliere Tindall and Cassell, London. 477 p.

Hayes W.J., Laws, E.R. 1991. Handbook of pesticide toxicology. Academic Press, London. 1576 p.

Lees, P. 1972. Pharmacology and toxicology of alphachloralose : a review. *The veterinary record* 91*:* 330–333.

Marsh, R.E. 1990. Microencapsulation of rodenticides. In *Proceedings of the 14th Vertebrate Pest Conference, California*, pp. 62–64.

Morgan, D.R., Eason, C.T., Hough, S.J., Ryan, C. 1994. The development of a toxic bait and baiting strategies for feral cats. Landcare Research contract report LC9394/97 (unpublished) 14 p.

Osweiler, G.D., Carson, T.L., Buck, W.B., Van Gelder, G.A. 1985. Clinical and diagnostic veterinary toxicology. Kendall Hunt Publishing Company, Iowa.

Thomas H.M., Simpson, D,, Prescott, L.F. 1988. The toxic effects of alpha-chloralose. *Human toxicology* 7*:* 285–287.