Baits and Baiting Strategies for Feral Goats, Pigs and Cats

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CONTENTS

PART 2: FIELD TRIALS OF NON-TOXIC POLYMER PIG BAITS (C.M.H. Clarke)

PART 3: THE DEVELOPMENT OF A TOXIC BAIT AND BAITING STRATEGY FOR FERAL PIG CONTROL
(C.T. Eason and R.J. Henderson)

PART 4: THE DEVELOPMENT OF A TOXIC BAIT AND BAITING STRATEGY FOR FERAL CATS

(D.R. Morgan, C.T. Eason, S.J. Hough and C. Ryan)

Part 1 Artificial Baits for Feral Goat Control

J.P. Parkes

1. Introduction

Extensive control of many vertebrate pests in New Zealand is done using toxic baits either distributed from the air or presented in bait stations. The Science and Research Directorate of the Department of Conservation commissioned the Weeds and Pests Division of Manaaki Whenua-Landcare Research to conduct a series of trials between 1990 and 1993 to develop an artificial bait that could be used to poison goats. Funding was initially provided until 1995, but was limited in 1993 until the results of a crucial field trial became available and could be used to determine the potential of the technique.

2. Background

The Department of Conservation allocates about $3.7 million per year for the control of feral goats (Parkes 1993, unpubl. Landcare Research contract report). This money is sufficient to sustain control on goats over about 1 million ha, about one-third of the land they inhabit, and most control is done by ground-based hunters using dogs. Managers are frustrated by their inability to extend this control, particularly into large areas of goat-infested conservation estate (such as Wanganui National Park), by the constant battle to maintain the funding base needed to sustain control in present high-priority areas (Parkes 1992, unpubl. Forest Research Institute contract report), and by the difficulty in adequately controlling some populations of feral goats living in areas not easily accessible to hunters (e.g., in the subalpine scrub on Mt Taranaki). One potential solution to at least the first and last of these frustrations is to poison the goats. One method to do so, poisoning with natural-vegetation baits already exists (Parkes 1983; 1991). However, costs for this technique are about the same as for ground-hunting, and the method also relies on access on foot.

Aerial poisoning operations aimed against brushtail possums can kill feral goats (Parkes 1989, unpubl. Forest Research Institute contract report), although the proportion killed as non-targets in these operations or as target species in the few trials aimed specifically at goats (e.g., in the 1950s and 1960s at Mt Bruce, Waiau-Toa, and Wainihinihi) was either very small or unknown.

Parkes (1989, unpubl. Forest Research Institute contract report) suggested three possible reasons for the failures:

- The goats did not eat the baits because they were unpalatable.
- The goats did not eat the baits because they dislike feeding off the ground.
- The goats ate the baits but in insufficient numbers to be killed.

The aim of this research was to develop a bait that was palatable (to account for the first reason), and to test it in a non-toxic form on the ground by measuring the proportion of a feral goat population that would eat baits (to test the second reason). If goats did have a behavioural objection to eating food off the ground, a simple feeding station to present the baits at browse height was developed, and some initial pen and field tests were conducted.

3. Objectives

- To develop an artificial bait that is palatable to feral goats.
- To measure the proportion of feral goats that will eat the baits presented on the ground and in raised bait stations.

4. Methods

Many pelletised stock foods were tested on re-domesticated feral goats. The palatability of the most preferred pellet was compared with other baits treated with a large variety of flavours, and smells as lures. When one was found to be significantly more palatable, it was included in the base pellet against which new versions were compared. Simple paired choices were presented to groups of goats, and differences in the amounts eaten were tested using paired t-tests.

Three bait marker systems were tested to measure the proportion of a wild population that ate baits. They were two plasma markers (iophenoxic and iopanoic acid), one dye (rhodamine), and a physical marker (fluorescent metal flakes).

The best lured bait with a quantitative bait marker was presented to two populations of feral goats in Marlborough; 350 kg being distributed from a helicopter over about 400 ha, and 12 bait stations being set in about 55 ha used by goats. Goats were shot after 8 or 9 days, blood samples were taken, and the number of baits eaten was calculated from the amount of iodine present (via the iophenoxic bait marker).

The specific methods used for each of the five trials described in this report are detailed in the main findings section for each trial for ease of reference.

5. Main findings

5.1 RELATIVE PALATABILITY OF BASE BAITS

Methods

The palatability (= the amounts of baits eaten) of 11 pelletised stock foods or pest-control baits were ranked by presenting all pellets to seven groups each of 10 goats held at Lincoln University Deer Unit. The goats were all females of mixed feral (from Westland) and domestic ancestry. In each trial, 5 kg of each of the pellets were presented to the goats in plastic trays set along a feeding trough in a small paddock. The goats were left for about 1 hour in each trial, then the amount of each type of pellet eaten was calculated. The relative palatabilities were compared using an LSD test. The most palatable pelletised bait was then compared with diced carrot in a separate paired trial with 19 replicates.

Results

Two commercial pelletised stock foods were significantly more palatable than five other stock foods and four pelletised pest baits (Table 1). Of these two, the Sanders stock food was eaten more than Pro-pel stock food, and was subsequently used as the basic bait material.

A tonne of this bait in 1991 cost $327 + GST and consists of:

barley	520 kg
bran	200 kg
oats	200 kg
lime	40 kg
salt	15 kg
bentonite	25 kg

Baits specifically made for the control of rabbits or possums were relatively unpalatable.

Sanders bait was significantly ($P < 0.001$) more palatable than fresh diced carrot (see Table 4).

Conclusions

- A grain-based pelletised stock food was most palatable to goats, and is relatively inexpensive to manufacture (c. $500 per tonne cf., over $1 500 per tonne for pest baits).
- The relative unpalatability of manufactured pest baits and carrots to goats may explain why so few are killed as non-target species and why past control aimed at goats using aerially-sown baits has failed (Parkes 1989, unpubl. Forest Research Institute contract report).

TABLE 1. RELATIVE PALATABILITY OF 11 POTENTIAL BAIT PELLETS TO SEVEN GROUPS OF GOATS. THOSE MARKED * ARE MANUFACTURED PEST BAITS. THERE WAS NO SIGNIFICANT INTERACTION BETWEEN THE BAIT TYPES AND EACH TRIAL.

BAIT TYPE	BAIT EATEN (G) BY EACH GROUP							MEAN WT. EATEN (g)
	1	2	3	4	5	6	7	
Sanders	1155	4020	2600	1760	2235	2510	1730	2287
Pro-pel	1500	1120	1720	850	2210	2710	2345	1779
Supastok	365	1880	510	725	450	765	1605	900
McMillans	35	975	775	950	475	1000	730	706
Mapua rabbit*	270	735	895	445	615	225	455	520
RS5 rabbit*	-	-	210	40	120	610	280	252
Archers	470	115	50	375	55	175	115	194
Multifeed	145	195	245	0	115	550	100	193
RS5 possum*	200	85	125	20	45	205	105	112
Nimarol	45	375	30	50	50	125	70	106
No. 7*	240	200	100	25	25	65	20	96

5.2 COMPARISON OF LURES

Methods

The Sanders bait was mixed or surface coated with one or combinations of potential lures, and the palatability of the modified bait was compared with that of the bland bait.

Three experimental designs were used. Initially, single goats held in covered stalls were each presented with a single choice of bland and lured bait placed in 8 kg lots in adjacent feeding trays. The amount consumed of each was measured after a day. Water was freely provided. Thirteen flavours were singly surface-coated on plain Sanders baits (4 ml of flavouring in 100 ml of water was mixed with 8 kg of pellets) and were compared using paired t-tests.

However, it was soon obvious that some confined goats became anorexic, so the experiment reverted to the design used to screen the basic pellets. Small groups of goats held outside more readily tested foods as social facilitation encouraged all individuals to eat. In these trials, 16 different flavours were applied singly to Sanders baits and the amount eaten was compared against Sanders plain bait. This trial was unbalanced, in that six flavours were compared nine times, five were compared six times, and five only three times. The amount of each bait presented at a time was reduced to 3 kg.

The third set of experiments compared the best lured bait with those with added favourite natural foods. Any time a mixture was shown to be more palatable, it became the base against which new mixtures were tested, although "calibration" trials against plain Sanders bait were carried out for the most promising mixed baits. These trials were done by presenting 1.5 kg of the base bait and 1.5 kg of the test bait in paired feeding troughs (n = 22) set out in a field containing about 30 goats. The amounts eaten after about 1 hour were measured and compared using paired t-tests.

The presence of 1.5% of salt in the Sanders bait was believed to be one factor that might enhance its palatability as goats are apparently tolerant of and have a preference for salt (Burke 1990). Salt was added to the best pest bait (Mapua rabbit) at 5%, 15%, and 30% and tested against Sanders bait.

Results

Single choice trials

None of the 13 flavours tested improved the palatability of baits to goats, and eight were rejected (Table 2).

TABLE 2. QUANTITY OF 13 PLAIN AND FLAVOURED BAITS EATEN BY SINGLE GOATS PRESENTED WITH ONE CHOICE.

FLAVOUR	MEAN WT PLAIN BAIT EATEN (g)	MEAN WT LURED BAIT EATEN (g)	# GOATS TESTED	SIGNIF.
Garlic flavour	668	680	12	NS
Rose oil	321	309	16	NS
Aniseed oil	382	347	34	NS
Peppermint oil	405	273	18	NS
Malt flavour	540	351	6	NS
Molasses flavour	682	45	6	rejected
Amyl acetate	549	94	6	rejected
Eucalyptus oil	743	143	6	rejected
Curry flavour	193	38	6	rejected
Cinnamon	439	4	6	rejected
Ginger	224	0	6	rejected
Clove oil	296	33	6	rejected
Magnolia oil	465	166	16	rejected

Multiple choice trials

Generally, the plain bait was again the most palatable, although garlic and molasses (this time as a syrup rather than as the artificial flavour used in the single-choice trial) outranked the plain bait in one set (Table 3).

TABLE 3. AMOUNT OF BAIT EATEN IN THREE SETS OF COMPARISONS BETWEEN PLAIN SANDERS BAIT AND SANDERS BAIT FLAVOURED WITH A VARIETY OF "LURES".

FLAVOUR	WT EATEN (g) SET 1	WT EATEN (g) SET 2	WT EATEN (g) SET 3
Plain bait	746	436	1367
Malt flavour	635		
Eucalyptus oil	606		
Pine oil	571		
Sheep starter	442		
Aniseed	293		
Tobacco flavour	152		
Garlic flavour		645	
Molasses syrup		620	
Underlactone		408	
Methyl sal		366	
Cattle starter		187	
Peppermint			883
Amyl acetate			745
Cassia flavour			565
Hay flavour			322
Choumollier			133

Step-wise single choice trials

The addition of both molasses syrup and finely chopped leaves of broadleaf (*Griselinia littoralis*) (a favoured food of goats in some areas) improved the palatability of plain Sanders baits. Selected results from a series of trials comparing different concentrations of broadleaf with and without molasses in

Sanders baits, and a few additional trials using other additives or naturally preferred plants are shown in Table 4.

TABLE 4. RELATIVE PALATABILITY OF VARIOUS BAITS TO GOATS.

(SB = plain Sanders bait, mol = molasses syrup at 2% by weight, bl (x%) = chopped broadleaf at x% by weight. (A) means the second bait in each pair was significantly more palatable than the first, and (R) means it was significantly less palatable than the first.)

BAIT COMPARISON	NO. TESTS	MEAN WT. EATEN (g)	T	P	SIGNIF.
SB SB + mol	22	427 623	2.12	0.046	* (A)
SB SB + bl (8%)	20	532 731	2.42	0.026	* (A)
SB + bl (8%) SB + bl (4%)	21	748 898	1.61	0.124	NS
SB + bl (4%) SB + bl (2%)	16	1097 1124	0.35	0.733	NS
SB SB + bl (2%)	22	958 1236	2.82	0.01	* (A)
SB SB + bl (2%) + mol	20	731 873	2.92	0.009	** (A)
SB + bl (2%) SB + bl (2%) + mol	22	777 946	2.24	0.036	* (A)
SB SB + mahoe (8%)	21	369 216	2.48	0.022	* (R)
SB Diced carrot	19	1712 69	16.88	0.000	*** (R)
SB SB + garlic flavour	20	1051 645	4.77	0.000	*** (R)

Effect of added salt

Added salt repelled goats in nine trials (mean amounts eaten being 2090 g for Sanders bait, 528 g for plain Mapua, and 94, 133, and 107 g for Mapua baits with 5%, 15%, and 30% salt, respectively.

Conclusions

- Goats appeared to be suspicious of new scents or tastes and avoided most flavoured baits.
- Molasses syrup and garlic may have made baits more palatable, but the evidence was contradictory.
- The most palatable bait was plain Sanders bait with 2% by weight of chopped broadleaf and 2% by weight of molasses syrup. Adding more broadleaf did not improve the palatability of the baits.
- Mahoe leaves (another favoured food of feral goats), however, did not improve bait palatability.
- Adding salt to Mapua pest baits made them less palatable.

5.3 DEVELOPMENT OF BAIT MARKERS

Methods

Known amounts of iophenoxic acid or iopanoic acid were fed to 15 and three goats, respectively, and blood samples were analysed for iodine concentrations periodically for up to 59 days (see Eason & Batcheler 1991 for details). Eight goats shot about 5 km from the nearest bait in Marlborough were used as controls for the field trials.

Rhodamine B (a fluorescent dye used previously as a marker in studies on bait acceptance by possums, e.g., Morgan 1982) was mixed with pellets at 0.05% and fed to two goats (one pellet each), one goat (two pellets) and one goat (three pellets). All goats, and one fed three un-dyed pellets as a control, were inspected about the mouth under ultra-violet light 10 min and 48 h after ingestion. Animals were killed at 48 and 96 h, and their digestive tracts inspected under UV-light for traces of the dye.

Small metal flakes impregnated with a fluorescent dye (brilliant green) were mixed with bait material (about 2.5 cc of flakes) and fed to two goats. A third goat was fed about 7.5 cc of flakes. One goat fed with 2.5 cc of flakes was killed 6 h after ingestion and the other two were killed 36 h after ingestion and their digestive tracts inspected for flakes.

FIG. 1 MEAN PLASMA IODINE LEVELS IN GOATS FED TWO AMOUNTS OF IOPHENOXIC ACID (AFTER EASON & BATCHELER 1991).

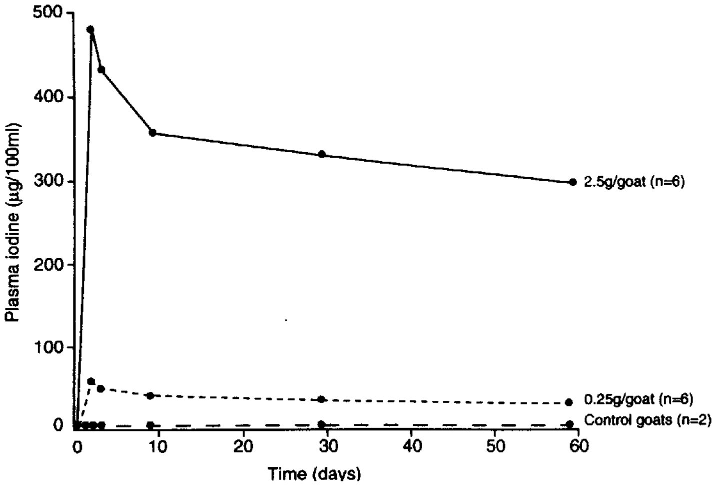
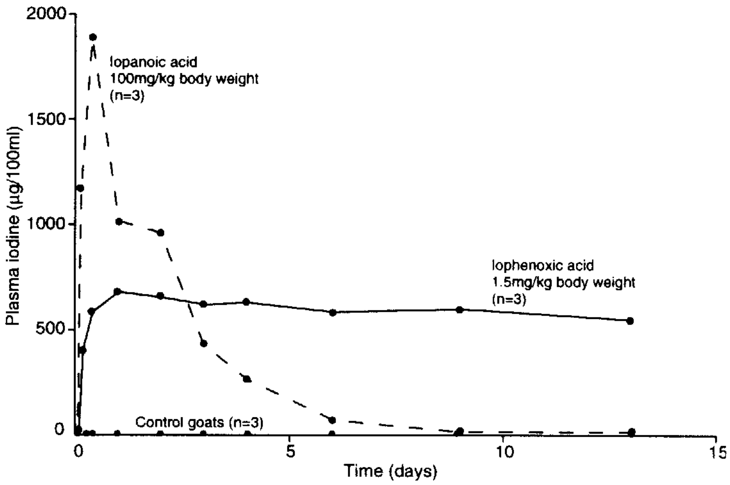


FIG. 2 MEAN PLASMA IODINE LEVELS IN GOATS FED IOPHENOXIC ACID OR IOPANOIC ACID (AFTER EASON & BATCHELER 1991).



Results

After ingestion of iophenoxic acid, plasma levels of iodine were elevated proportionally to the amount ingested (Fig. 1), and only slowly excreted (Fig. 2). Plasma-iodine levels after ingestion of iopanoic acid were elevated, but the iodine was excreted too quickly to be of use as a quantitative bait marker (Fig. 2).

The amount of iodine naturally in the blood of goats was less than 10 Mg/100 ml in pen trials (Eason & Batcheler 1991) and averaged 3.9 (range 2.2 to 6.7) ig/100 ml in eight goats not exposed to marked baits but shot near the trials in Marlborough reported next.

iophenoxic acid costs about $7/g and each analysis costs about $30

Rhodamine was visible in the mouths of all treated goats 10 min after ingestion of the dyed baits, but no trace could be detected in their mouths or digestive tracts at the later inspections.

The fluorescent metal flakes were detected throughout the gut contents and were found adhering to the wall of the rumen and reticulum of the goat killed 6 h after ingestion, but none were found in the goats killed later.

Conclusion

Only iophenoxic acid is useful as a bait marker. It has the advantage of being a quantitative marker so that if the amount in the baits is constant, the number of baits eaten by goats can be calculated.

5.4 NON-TOXIC TRIALS OF BAITS IN BAIT STATIONS

Methods

Two types of bait station were made and the reaction of goats to them was tested on eight individually identifiable, farmed adult females held at Lincoln University.

Two field trials were conducted to see whether feral goats would eat palatable baits from the stations. One, at Ahuriri on Banks Peninsula, presented unmarked baits in 10 stations attached to metal posts to a herd of free-ranging semi-feral goats, and the amount of bait eaten was measured. The second trial, in a 55-ha area of scrub and grassland in Marlborough, presented the best lured baits marked with iophenoxic acid (at 5 mg per 2-g bait) in eight bait stations to feral goats. After 9 days, 15 goats were shot and blood samples were taken and analysed for iodine levels.

Results

The most successful bait station was made from 16-cm diameter polythene piping. Each was 38 cm deep, with a removable lid, and the 16-cm feeding hole was protected by a verandah that extended into the pipe to act as a baffle to regulate the flow of baits.

All eight farmed goats fed from the bait stations. No baits were eaten from the stations at Ahuriri (although a blizzard disrupted this trial) or from the stations set out in Marlborough (mean plasma iodine of the 15 goats shot in the vicinity = 6.3; range = 4.8 to 8.1 μg/100 ml; cf. a mean of 3.9 μg/100 ml and range of 2.2 to 6.7 μg/100 ml for the unexposed control animals).

Conclusion

Bait stations show no promise as a method to control goats.

5.5 NON-TOXIC TRIALS OF AERIALLY-SOWN BAIT

Methods

The best lured baits (359 kg) marked with iophenoxic acid (5 mg per 2-g bait) were spread from a helicopter over 380 ha of mixed native scrub and pasture at Peggioh in Marlborough. After 8 days, 24 goats were shot and their blood iodine levels measured.

Results

Eighteen of the 24 goats had eaten no baits. Their plasma iodine levels averaged 6.2 μg/100 ml with a range of 4.3 to 8.2 μg/100 ml, i.e., within the range of the unexposed values. In this trial, one may have eaten part of a bait (it had a plasma iodine level of 13 μg/100 ml), one had eaten 1 bait (55 μg/100 ml), and four had eaten many baits (423-4400 μg/100 ml).

Conclusions

- Aerial poisoning is not a cost-effective method for broad-scale control of goats because of low acceptance of the baits.
- The reason for the low acceptance in the present trial and perhaps in past aerial operations may be that feral goats do not like to eat food off the ground.

6. General Conclusions

- Failure to kill goats with artificial poisoned baits is probably due to their reluctance to eat food off the ground, rather than to unpalatable baits or sub-lethal doses.
- The cost to distribute baits from the air is not justified by the low likely percent kill. High kills can be achieved for less cost using conventional control techniques such as ground hunting, Judas goats, or poisoning using natural-vegetation baits.
- Feral goats did not eat any baits from bait stations readily used by farmed goats.
- Despite the general failure of the trials to provide artificial baits for use against goats, the development of iophenoxic acid as a quantitative bait marker is now proving an invaluable tool for measuring bait acceptance in a variety of other pest species.

7. Recommendations

- The acceptance of aerially-sown baits should be remeasured for other feral goat populations at other times of the year during proposed multi-species baiting trials.
- No further work on artificial baits aimed at feral goats alone is justified.

8. Acknowledgements

We thank M. Keeley (Lincoln University Deer Unit), P. Graham (Ahuriri Farms), and B. Lee (Peggioh Station) for the use of their goats. D. Batcheler and C. Thomson performed the laboratory analyses, and R. Henderson and G. McElrae helped in field trials. J.D. Coleman and J. Orwin provided comments on drafts of this report.

Part 2. Field Trials of Non-toxic Polymer Baits

C.M.H. Clarke

1. Introduction

Field trials of non-toxic polymer pig baits were undertaken on Molesworth Station in October 1991 by the Forest Animal Ecology section, Forest Research Institute, Christchurch. The work was funded by the Department of Conservation (DOC). A method of sowing baits from a helicopter to achieve bait coverage over a wide area, and acceptance of baits by feral pigs was assessed. Because seasonal conditions were unsuitable for testing the acceptance of toxic baits that aspect of the work was delayed. That work will be reported under project S7010/535 (Development of a toxic bait and baiting strategy for feral pig control) by June 1992.

2. Background

Baits and toxins for the control of pigs in a wide range of habitats have been investigated in pen studies by FRI with funding by DOC (C.T. Eason & R.J. Henderson 1991, unpubl. FRI contract report). A polymer long-life bait containing fishmeal (Du Pont, Texas, USA) was highly palatable to pigs in pens and in a field trial (Fletcher *et al.* 1990) in USA. Although similar baits were used in a field trial on Auckland Island (summer 1991), the low pig density there meant overall acceptance by the population could not be assessed (C.M.H. Clarke 1991, unpubl. FRI contract report). It was recommended that future bait acceptance trials be transferred to a higher density mainland pig population.

3. Objectives

- To develop a method of aerially sowing non-toxic polymer pig baits from a helicopter.
- To field-test acceptance of non-toxic polymer baits by pigs.
- To bait pigs cost effectively over a wide area.

4. Methods

4.1 AERIAL INSPECTION

One month before baiting was scheduled, Molesworth and Clarence Reserve stations (Clarence River) were searched from a helicopter to locate a study site with a high pig density. A 6-min flight over the Elliott-McRae block on Molesworth Station revealed 47 pigs in about 45 km^2 (1/100 h), mainly concentrated in riparian vegetation and shrublands. Extensive ground rooting indicated a high density population.

4.2 BAIT MARKING

The baits (1.2 tonnes, 40 000 baits) were dyed with 0.5% wt/wt rhodamine B in solution with corn oil. Earlier pen trials with Rhodamine B-dyed baits showed that a single 0.5% bait was sufficient to mark pigs for at least 5 days (D.R. Morgan, pers. comm.). Although Rhodamine B at 0.5% wt/wt slightly reduced bait palatability when compared with unmarked bait, feral pigs in the study area were not presented with a bait choice.

4.3 CALIBRATION OF BAIT-SOWING RATE

A helicopter trial was carried out at Quail Flat, Clarence Valley (adjacent to the study area) to calibrate the bait-sowing rate, and to establish the flying height and speed necessary to achieve 10-m wide swaths on the ground. During four passes made by a helicopter undyed baits were trickled from a plastic bag out of the rear door opening. The more conventional means of aerially sowing baits with a bucket and spinner could not be used because of the size of the baits (50 x 25 mm). Two passes were made at 30 m altitude and two at 60 m. Swath widths and lengths were recorded and the total weight of bait sown was estimated.

From an altitude of 30 m and a flying speed of 30-35 knots, baits were sown in swaths approximately 7-8 m across. From 60 m the swaths enlarged to 10-11 m and baits were distributed at 5-10 m apart. Because coverage at 60 m was considered more than adequate, it was decided to increase the airspeed to 40-45 knots during the main operation.

The total length of swaths sown was 650 m and approximately 13 kg of bait was distributed.

4.4 BAIT DELIVERY

Because dyed baits were sticky and tended to aggregate, distribution from plastic bags proved unsuitable and a 50-litre plastic bucket was harnessed to the rear compartment of the helicopter to sow baits. Two people were needed, one to control flight logistics, and the other to sow baits. The flight controller selected areas for baiting and directed the pilot. The bait spreader then sowed baits at the calibrated rate and informed the flight controller when the bucket needed refilling or when all baits were sown. Approximately 150-200 kg of baits in plastic bags, each weighing 13-15 kg, were loaded into the rear compartment. When baits ran out during a swath the helicopter circled the area until the bait spreader had refilled the bucket. As bait swaths were sown they were mapped by the flight controller so that a systematic coverage could be achieved.

The baited area included all drainage systems and shrublands within the Elliott Stream, bounded by the upper vegetated slopes of the Inland Kaikoura Range and the Clarence River and adjacent slopes. The more extensive pasture areas, eroded areas, and high ridges were avoided. On completion of bait sowing, two bait-assessment lines 500-700 m long were sown on the boundary of the treatment area at Lake McRae.

4.5 ASSESSMENT OF BAIT TAKE

During the anticipated waiting period of 2-3 days while pigs ate the baits, assessment lines were checked. Each line was checked once, within 2 days to monitor bait take.

On the second day hunters and pig dogs were used to find and kill pigs in the treatment area. The hunting team included one professional and two recreational pig hunters with specialist dog packs. The hunters and two accompanying researchers used high-powered rifles. Pigs in areas not already hunted on the ground were also hunted from a helicopter. Coloured streamers were used to mark the location of pigs shot from the helicopter.

The use of Rhodamine B to determine bait consumption involved compromises between allowing adequate time for pigs to discover baits, killing the pigs within the lifespan of the dye (up to 5 days), and restricting the length of time from bait laying until the end of the cull to avoid problems resulting from pig movements. The hunting strategy was therefore designed to secure large numbers of pigs in the shortest possible time.

All pigs subsequently killed were examined for presence of dye about face, lips, mouth, stomach, and large bowel.

5. Results

5.1 BAIT COVERAGE

Baits were sown in 10-m wide swaths on variable length lines spaced over 44.7 km^2 from the helicopter (Fig. 1). The actual area baited was 6.7 km^2 (15% of the study area), and the total distance flown on bait lines was 67 km (20.3 km/hour). The quantity of bait sown was 1.2 tonnes (40 000 baits), giving a rate of 1 bait/5-10 m within the swaths (1.7 kg/ha) over the whole study area.

5.2 BAIT ACCEPTANCE

A preliminary check on an assessment line 1 day after bait sowing showed that about 60% of baits sown had been taken. Pig tracks were conspicuous, suggesting that pigs had followed the line. From the age of the sign it appeared that pigs first began feeding on baits within 2-3 h of baits being sown.

A check of the second assessment line 2 days after baits had been sown indicated 90% bait-take. At this stage the hunting team sampled pigs in the vicinity of the assessment lines. All 10 pigs killed had eaten bait. On the same day hunting began throughout the treatment area.

During 2 days, 70 pigs were killed (52 caught by dogs and 18 shot, including those killed during assessment), and all (100%) had consumed bait. Of 14 pigs shot from the helicopter, only eight were found by ground parties, and included in the sample. Largely because of the independent targeting skills of the dogs, entire mobs of pigs (up to 17) were killed, and very few pigs (single, or groups) escaped. Hunting was discontinued after only 60% of the treatment area had been covered, as a result of the large numbers killed and the 100% bait-take. No hunting was done outside the treatment area. Although hunting was carried out without regard to swaths, all the pigs killed were located within 600 m of a swath. This probably reflected the seasonal concentration of pigs near the streams and the thorough bait coverage.

Undigested and semi-digested baits were found in large quantities in pigs' stomachs (paunch), with associated marking of stomach walls. One-third of the 70 pigs inspected had stomach contents consisting almost entirely of bait. The estimated dry weight of bait consumed by such pigs was 10-12 kg/adult. Lips, teeth, inside the mouth, and facial bristles were marked in 79% of pigs killed. The rest had marked paunch contents, paunch linings, or marked faecal matter present in the large bowel.

Where there were large mobs of pigs (up to 17) all bait had disappeared from the ground and marked pig faeces were conspicuous. In areas with lower pig density, as much as one-half of the bait remained. Overall, up to 60% of bait remained, as pigs were absent from many baited areas.

5.3 COST-EFFECTIVENESS

Costs incurred in spreading non-toxic polymer baits by helicopter were used to estimate the cost to DOC of a similar toxic-bait operation. The estimated cost of the 15% bait coverage adequate for this seasonally aggregated pig distribution was $3.40/ha (calculated from 1991 costs for purchase of baits and toxins, spreading baits from a helicopter (Jet Ranger), and estimated expenses for planning and post-treatment assessment, including overheads). Costs for a total bait coverage would be $19.50/ha, similar to aerial-baiting costs for possums ($20-30/ha, B. Warburton, pers. comm.).

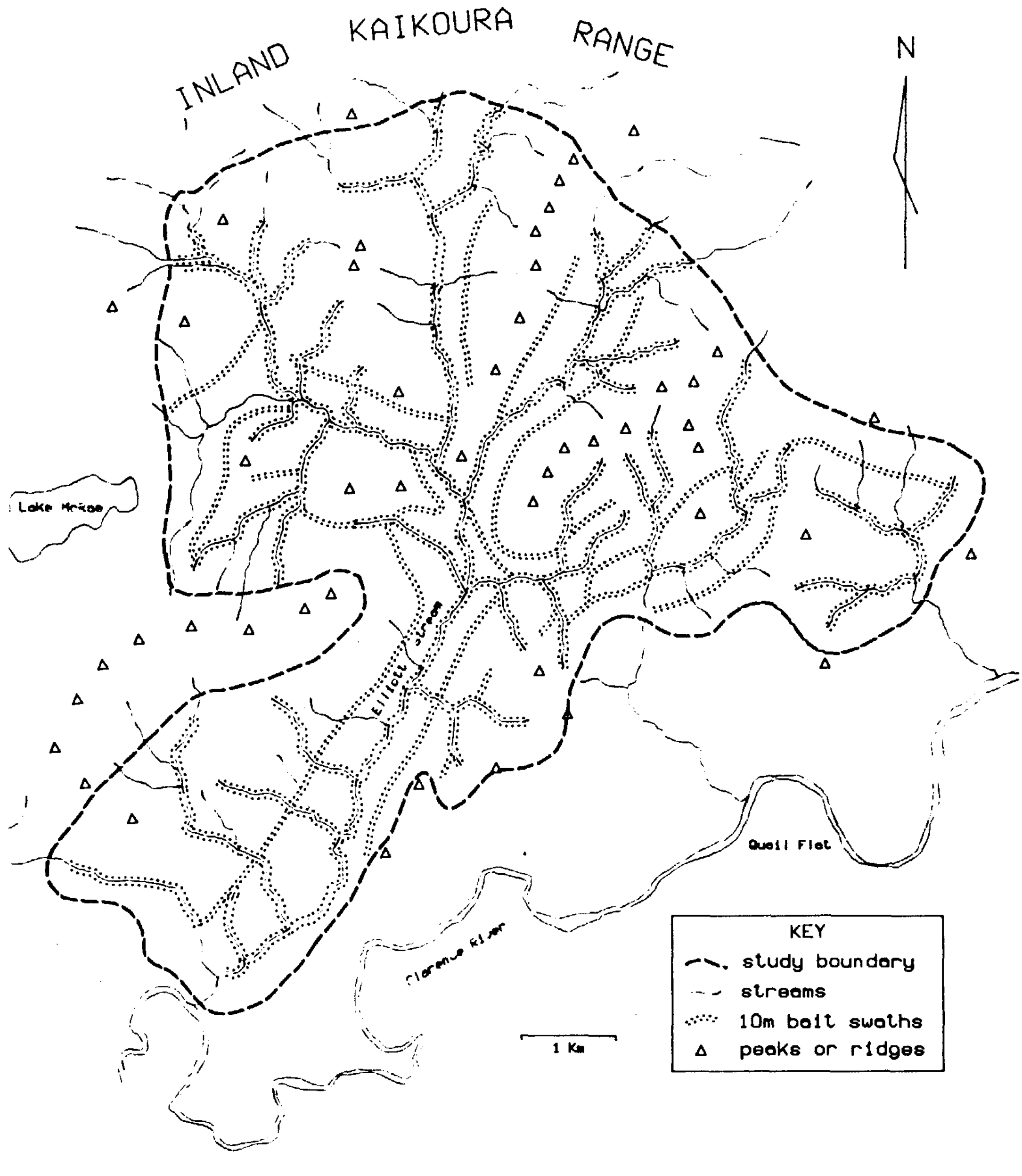
FIG. 1. AREA BAITED AND DISTRIBUTION OF BAIT LINES, ELLIOTT-MCRAE, MOLESWORTH STATION

study boundaries

streams

10 m bait swaths

peaks or ridges



6. Conclusions

The use of a helicopter and a manual bucket system provides an effective method for sowing polymer pig baits.

The 100% acceptance of non-toxic polymer baits by pigs and the large amount of baits consumed by individuals (up to 12 kg) showed that these baits were very attractive to pigs. The maximum possible acceptance also reflected the seasonally aggregated pig distribution, and the thorough bait coverage.

Sowing pig baits by helicopter appears very cost effective, especially if based on a seasonally aggregated pig distribution.

7. Recommendations

The Department of Conservation needs to fund a toxic-bait trial in an area with a high pig density (minimum 10 km^2) using the aerial baiting strategies described, and a suitable toxin. The Molesworth Station/Clarence River region would provide suitable trial areas.

8. Acknowledgements

We thank C.T. Eason, J.D. Coleman, and C.M. Frampton for their contribution to the field design. D.R. Morgan, P. Sweetapple, and T. Pachlatko are also thanked for helping to prepare and sow baits. The services of the hunters and Kaikoura Helicopters are also gratefully acknowledged. Permission to carry out the work on Molesworth Station and the use of facilities there and on Clarence Reserve Station was appreciated. M. Morrisey (DOC Kaikoura) also gave valuable logistic support.

Part 3. Development of a Toxic Bait and Baiting Strategy for Feral Pig Control

C.T. Eason, and R.J. Henderson

1. Introduction

This report covers years 1 and 2 of a 3 to 4-year programme initiated to develop a dry pelleted toxic bait and baiting strategy for feral pigs for use by the Department of Conservation. The research was done by the Animal Ecology section, Forest Research Institute, Christchurch, between 1989 and 1991.

2. Background

The feral pig (*Sus scrofa*) is found in abundance in certain areas of New Zealand and on a number of off-shore islands, such as the Auckland Islands. Feral pigs have in the past been a major agricultural pest, responsible for damage to crops and pasture and the predation of lambs. However, as numbers have declined feral pigs are now primarily confined to indigenous forest, plantations, and areas of marginal farming. Nevertheless, because of their wide-ranging habits, frequent close contact with domestic stock, and susceptibility to tuberculosis (Tb) and foot and mouth disease (FMD), feral pigs retain a high potential to act as vectors of diseases. Furthermore, their feeding habits result in damage to indigenous flora and fauna, particularly on island refuges.

Feral pigs have not recently been considered a high priority for control in New Zealand (in contrast to Australia where FMD strategies for pigs are the subject of on-going development). Little is known about the effectiveness of control strategies and how they would perform in the different New Zealand environments.

The alternatives to poisoning (hunting, shooting, fencing, and trapping) are sometimes inappropriate as the primary means of control of feral pigs in remote areas. It is therefore, important to develop highly efficient poison and baiting materials. Poisoning techniques for the control of feral pigs have traditionally included the use of phosphorus and arsenic, often incorporated into whole sheep carcasses distributed as baits. This has been replaced to some extent by 1080 in meat or vegetable baits in recent years.

Pigs are known to be difficult to poison, partly because of their large size, which means larger amounts of poison are needed than for smaller vertebrate pests such as feral cats or possums. Recent baiting strategies for feral pigs have involved 1080 gelatin capsules (containing 100 mg 1080 powder) inserted into whole or divided carcasses as bait. Alternative baits have included apples and potatoes. These techniques are hazardous since the use of 1080 powder rather than a diluted solution is a potential risk to operators (C.T. Eason 1990, unpubl. FRI contract report). Because the efficacy of poisoning programmes for feral pigs and the relative effectiveness of different toxins for pigs have never been adequately assessed in New Zealand, this programme was set up to develop a toxic pig bait.

3. Objectives

- To develop and test palatability of non-toxic baits by pigs.
- To assess bait quality and durability.
- To enhance target specificity by choice of bait material and attractants.
- To determine the toxicity and suitability of a range of poisons in feral pigs.
- To assess the acceptance of toxic baits by pigs and determine appropriate toxic loading for baits.

4. Methods

4.1 BAIT PALATABILITY

Food flavours and additives and different bait types were preference-tested for domestic and feral pigs. Test items were compared in batches of three, with a control diet (either plain barley or a standard unflavoured bait). Three groups of pigs (housed in separate pens) were provided with four alternatives to choose from in each trough. Test items were placed in trays in specially designed feeding troughs for 1.5 to 2.5 hours. Each item was rotated over four consecutive days so that all four treatments were randomly positioned within the trough. Preference was established by comparing the amount of each treatment eaten.

Stage 1

Preference for the following items was tested in domestic pigs:

- Seven non-toxic bait types, including three candidate pig baits, one containing a stock food flavour and one containing petrolatum (to increase water resistance).
- Eleven food flavours/additives, mixed with and compared with plain barley.

- Increasing amounts of meat flavour, cod-liver oil, corn oil, and a rancid fish oil, mixed with and compared with plain barley.
- Twelve different oils, including vegetable and fish oils, mixed with and compared with plain barley.
- Three different 'meals', plain barley, bran, meat, and fish were compared, and the preference for milk powder (50%) mixed with plain barley was assessed.

Stage 2

Preference for the following items, which had showed promise in Stage 1, was tested in feral pigs:

- Seven custom-designed baits.
- Additives such as SFE and rancid oils.

Additional details on the items listed above are given in Appendix 10.1.

4.2 BAIT DURABILITY

Bait durability was assessed by dripping 50 ml of water onto individual baits in 15 minutes using a burrette placed 5 cm above the bait. Baits were weighed before and after the test. In a separate test, baits were placed in a clear plastic bag containing water and observed for 1 month.

4.3 ACUTE TOXICITY

A total of eight toxins were evaluated in acute toxicity studies on feral pigs:

1080	Gliftor
(1080 + anti-emetics)	Quintox (cholecalciferol)
Warfarin	Cyanide
Brodifacoum	Nicotine

Most of the toxins were presented to the pigs using a polymer long-life bait (Du Pont, USA) as a carrier.

Six groups of pigs (with a minimum number per group of three) were given a single bait containing 20, 40, 80, 160, 240, or 360 mg 1080/bait. The effect of two potent anti-emetics, acepromazine and prochlorperazine, on 1080-induced vomiting in pigs was assessed by co-administration of the anti-emetics (10-25 mg/kg) and 1080 (6.5 and 10 mg/kg). Warfarin (7.5 and 25 mg/kg for 2 and 4 consecutive days), gliftor (300 mg/kg) and cyanide (10 mg/kg) were administered on baits. Quintox (200 mg/kg), brodifacoum (2 mg/kg) and nicotine (10 mg/kg) were administered by gastric intubation.

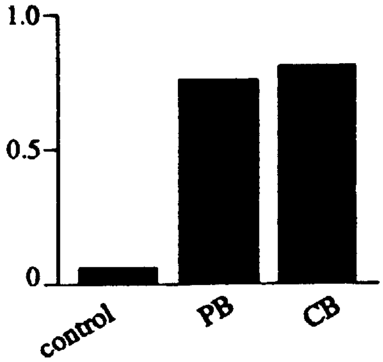
5. Results

5.1 BAIT PALATABILITY

A bait containing cod-liver oil and petrolatum (10%) and a polymer long-life bait containing fishmeal, fish oil, and a polymer were more palatable to feral pigs than a standard plain cereal bait (Fig. la). Vegetable oils and fish oils, particularly slightly rancid fish oil, improved palatability (Fig lb). Palatability was increased by increasing the amount of fish oil in the diet and by adding petrolatum. Synthetic fermented egg mixed in corn-oil increased the palatability of corn-oil alone (Fig. lc).

FIG. 1. BAIT PALATABILITY RESULTS (MEAN CONSUMPTION OF BAIT IN kg/PIG) FOR DIFFERENT BAIT TYPES AND FOR BAITS WITH AND WITHOUT LURES.

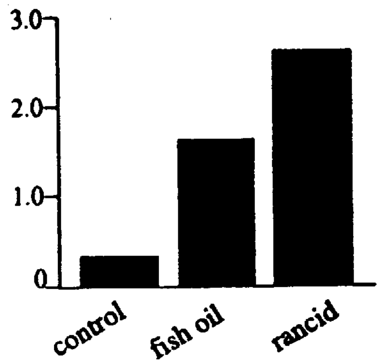
(A)



Promising baits:

- PB polymer fish meal and oil
- CB cereal with fish oil and petrolatum

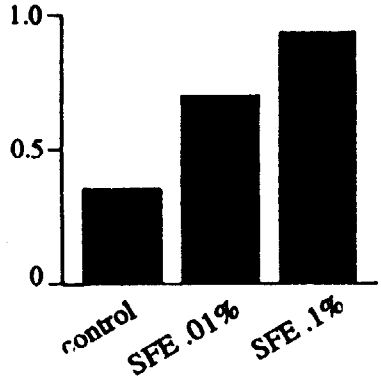
(B)



Promising lures:

- fish oil
- rancid fish oil
- SFE synthetic fermented egg

(C)



5.2 BAIT DURABILITY

Standard (NZ-made) cereal pig bait had an average weight of 15 g (77% weighed 10-20 g, 13% weighed >20 g, and 10% <10 g). The polymer baits all weighed 31 g. The standard cereal bait absorbed water dripped onto it, and softened, but a petrolatum (5%)-containing cereal bait remained relatively firm. The polymer-containing bait remained intact in water for over 1 month, but standard bait immersed in water disintegrated within 24 h. Petrolatum decreased the rate of disintegration of the cereal bait.

5.3 ACUTE TOXICITY

Even at doses of 10-15 times the published LD_{50} (1 mg/kg) for 1080 solution given by gastric intubation, we failed to kill all the pigs consistently (Table 1). Most pigs vomited between 5 and 15 times after being dosed, starting 1-2 h after eating the bait.

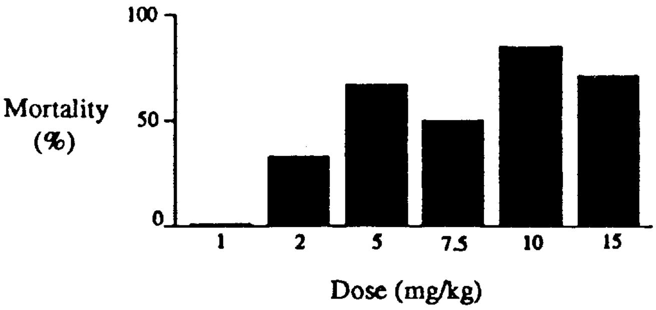
Acepromazine (10 mg/kg) caused heavy sedation before the onset of action of 1080 (6.5 mg/kg) and prevented vomiting, mania, and convulsions when both compounds were given by gastric intubation. However, acepromazine (12.5 mg/kg) and prochlorperazine (25 mg/kg) did not prevent vomiting when given in the diet or on baits.

TABLE 1 ACUTE TOXICITY OF 1080 ADMINISTERED ORALLY IN BAIT

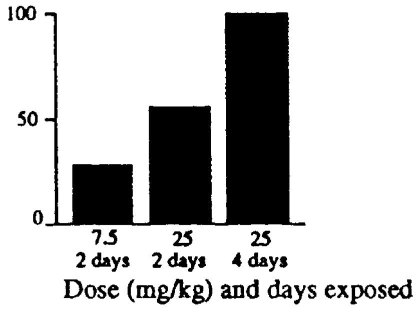
DOSE GROUP (mg/BAIT)	mg/kg	MORTALITY FOR GROUP
20	1.0	0/3 (0%)
40	2.0	1/3 (33%)
80	5.0	4/5 (60%)
160	7.5	5/8 (63%)
240	10.0	13/16 (81%)
360	14.0	4/6 (67%)

FIG. 2. THE ACUTE ORAL TOXICITY (% MORTALITY) OF 1080 VERSUS WARFARIN AFTER INGESTION OF POLYMER BAIT CONTAINING TOXIN.

(A) 1080 (SINGLE BAIT)



(B) WARFARIN (SINGLE BAIT PER DAY)



Pigs had to receive 25 mg/kg warfarin for 4 days before consistent kills were achieved (Fig.2). Both 1080 and warfarin were readily accepted on baits by pigs. Warfarin has the advantage of having a low risk of secondary poisoning and of being consistently effective; however, multiple doses are required.

- increased dosage gave inconsistent effects (Fig 2(a))
- bait consumption over four days gave maximum effect (Fig 2(b))

Brodifacoum was highly toxic and was lethal to most pigs at 2 mg/kg. None of the other toxins were effective. Toxic baits loaded with cyanide were rejected, and large amounts of cholecalciferol (>200 mg/kg), nicotine (10 mg/kg), and gliftor (>10 mg/kg) were needed to achieve lethal doses. Furthermore gliftor, like 1080, caused repeated vomiting.

6. Conclusions

The Du Pont polymer long-life pig bait was highly palatable to pigs, supporting a recent field trial in the USA where 95% of 80 wild pigs consumed the polymer bait (Fletcher et al. 1990).

Synthetic fermented egg increased palatability, and since it has a very potent aroma it may have acted as an attractant to make baits sought after by pigs.

Both 1080 and warfarin are effective poisons for pigs, but have some disadvantages. Pigs are not as susceptible to 1080 as other mammals, and its effects were inconsistent. Published LD_{50} values for 1080 in pigs vary from < 1.0 mg 1080/kg to approximately 8 mg 1080/kg. It is apparent that LD_{50} values based on gastric intubation, particularly when pigs were fasted before dosing, are irrelevant and misleading for control purposes. In our pen studies, some pigs receiving in excess of 10 mg 1080/kg survived. A 60-kg pig would require 600 mg of 1080, which would make toxic baits extremely hazardous.

The inconsistent response to 1080, even at the high dose level, suggests that alternatives must be considered. Warfarin is increasing in popularity in Australia as an alternative to 1080 for feral pigs. However, published LD_{50} values for warfarin in pigs also vary widely from 3 mg/kg to in excess of 20 mg/kg after a single oral dose.

Anti-emetics were ineffective against 1080-induced vomiting. The dose of acepromazine (12.5 mg/kg) used in our study was approximately six times the therapeutic dose. The dose of prochlorperazine was approximately 25 times the dose used by O'Brien *et al.* (1986), which failed to prevent 1080-induced vomiting. Although at these very high doses vomiting was delayed, it was not prevented. Anti-emetics therefore have no value in reducing the risk of secondary poisoning of non-target species from the toxic vomitus produced by pigs baited with 1080.

Brodifacoum is the most effective toxin evaluated so far, but could only be used in remote areas free from endangered wildlife.

7. Recommendations

- It is strongly recommended that we proceed with the development of a long-life bait, such as the polymer bait, for use in the wet conditions of the Auckland Islands.
- Preference for baits treated with synthetic fermented egg and its ability to lure pigs to baits in pen and field trials requires further experimental verification.
- Toxicity testing to identify a better toxin for feral pigs should continue.
- If a more suitable alternative cannot be found, brodifacoum or warfarin should be used on the Auckland Islands.
- Because of the large size of pigs, comparatively large amounts of poison are needed, and toxic baits must be distributed at carefully selected locations away from concentrations of non-target species such as bird and seal colonies.

8. Acknowledgements

Thanks are due to the Department of Conservation, and in particular Lou Sanson for his support and encouragement; Dr P.H. O'Brien, Bureau of Rural Resources, Canberra, Australia, for advice on the toxicity testing programme; Mrs J. Orwin and Dr J. Coleman for reviewing and editing the report. Mr Colin Clarke is thanked for obtaining wild pigs for these pen studies.

9. Appendix

9.1 BAITS, LURES, AND FLAVOURS

Stage 1: Animal baits, lures, and flavours tested for preference in domestic pigs

Seven non-toxic bait types, including three custom-made pig baits (ACP Wanganui), were compared with plain barley. All the 'candidate' pig baits had a cereal base (wholemeal approx. 60%, maize-meal approx. 10%, barley-meal approx. 20%, fruit pulp and sugar <10%) with a mean weight of 15 g. The standard bait No.1) had no special additives.

1. Standard
2. Standard containing petrolatum (5%)
3. Standard containing a commercially available pig stock feed additive (Bush, Boake & Allen).

Those baits were compared with:

1. Standard RS5 (ACP Waimate)
2. RS5 with cinnamon (ACP Waimate)
3. Cat bait - a small (1-2 g) fish-flavoured bait, currently under development (ACP Wanganui)
4. Standard No.7 (ACP Wanganui)

Stage 2: Pig baits tested for preference with feral pigs

Seven custom-made bait types were prepared to FRI specifications by Animal Control Products, New Zealand. All baits had a cereal base (wholemeal approx. 60%, maize-meal approx. 10%, barley-meal approx. 20%, fruit pulp and sugar <10%) with a mean weight of 15 g. The standard bait (No.1) had no special additives. The remaining bait types (No.2-7) contained additives as follows:

1. Standard
2. 5% petrolatum
3. 10% petrolatum
4. 20% petrolatum
5. 10% petrolatum + 2% cod-liver oil
6. 2% cod-liver oil
7. 2% peanut oil

Some additives were tested by surface loading of the standard ACP baits; these were:

1. 10% plain fish oil
2. 10% mildly rancid fish oil

3. 10% moderately rancid fish oil
4. 10% very rancid fish oil
5. 10% corn oil
6. 10% corn oil + 1.0% synthetic fermented egg (SFE)
7. 10% corn oil + 0.1% SFE
8. 10% corn oil + 0.01% SFE

One bait custom-designed to FRI size specifications contained 15% polymer matrix surrounding various fish/plant meals and oil was obtained from the Polymer R & D Division, Sabine Research Laboratory, USA.

The following additives, including food flavours and candidate lures mixed with plain barley, were compared:

a) Flavours

apple (0.1%); garlic (0.1%); liver (0.25%); molasses (0.1%); meat (0.1%); fish (0.1%); mushroom (0.1%); anchovy (0.1%); boysenberry (0.1%); truffle (0.1%). These foods were obtained from Bush, Boake & Allen, Auckland, New Zealand, and the amounts, mixed with plain barley, were based on the recommendations of the manufacturer.

b) Candidate lures/flavours

Asafoetida oil (0.1%, 0.33%) obtained from Wholefoods, Hereford Street, Christchurch; Skatol (0.1%) obtained from Sigma Chemical Co., St Louis, USA; pharmaceutical grade cod-liver oil (0.03%); extracts from asafoetida, oil, powder, and block, prepared by DSIR, Chemistry Division, Petone.

Dose response experiments

a) Meat flavour (Bush, Boake & Allen)

- mixed at three different concentrations (0.05%, 0.25%, and 0.1%) in plain barley, was compared.

b) Cod-liver oil (pharmaceutical grade)

- mixed at three different concentrations (0.33%, 1.6%, and 3.33%) was compared.

c) Fish oil (Orange roughy)

- at five different concentrations (2.5%, 5%, 10%, 20%, and 40%) obtained from Superstock, Christchurch, was compared.

d) Corn oil (obtained from Woolworths)

- at three different concentrations (2.5%, 5%, and 10%) was compared.

Comparison of oils:

The following fish oils, mixed at 3.33% in barley, were compared: cod (pharmaceutical grade); corn, olive, walnut, peanut, sunflower (Woolworths); orange roughy (a slightly rancid fish oil), Chilean fish, a blend containing orange roughy and other fish oils, salmon, and a mixed fish oil. Fish oils were obtained from Superstock Animal Feeds, or Independent Fisheries (Christchurch).

Comparison of different dietary materials:

Fishmeal, meatmeal, bran, and barley-meal were compared and barley-meal incorporating 50% milk powder was compared with plain barley-meal.

Part 4 The Development of a Toxic Bait and Baiting Strategy for Feral Cats

D.R. Morgan, C.T. Eason, S.J. Hough and C. Ryan

1. Introduction

This report describes the pen trials conducted during the final year of a programme to develop a dry pelleted cat bait and baiting strategy for feral cats. The study was undertaken for the Department of Conservation by Manaaki Whenua - Landcare Research during 1989-94.

2. Background

Feral cats (*Felis catus*) in New Zealand generally predate mainly rodents and young rabbits, but they have been known to cause reductions in bird populations (e.g., Roberts 1992), particularly on islands (Fitzgerald 1992). Where it is necessary to control rodents and rabbits, predation of native birds by cats and other predators may increase (e.g., Murphy & Bradfield 1992). Control of predators at the same time as, or shortly after, rodent control is therefore likely to become common practice.

Feral cats are difficult to control as they are solitary and often sparsely distributed. In the past, compound 1080 injected into fresh fish or meat baits has been used, as in the eradication of cats from Little Barrier Island, which was achieved only after a sustained effort over 3 years (Veitch 1985). This method is potentially hazardous to the operators and time-consuming, and the bait remains palatable for only 2-3 days.

We therefore initially developed a fishmeal-based dry pellet bait (manufactured by the US company, DuPont) that is attractive and palatable to most cats but to few other mammals or birds tested (Eason *et al.* 1992). Difficulties in arranging a commercial supply of this bait during 1992-93 led us to develop an alternative bait of similar composition and effectiveness (see project interim report June 1992), although with a shorter field life (Steven 1994 unpublished DoC report). In developing this alternative bait with local suppliers, we found that a powdered form of *Actinidia polygama* (Pip-Fujimoto Co. Ltd., Tokyo), a plant related to kiwifruit, could be used as an alternative attractant to catnip (Clapperton *et al.* in press), which is available fresh for only a limited season. As actinidia also enhanced palatability, we replaced catnip with actinidia as a dual-purpose (attractant and flavour) additive.

Field trials of the locally made bait on Chatham Island reaffirmed that, despite their shorter field-life, the baits were as effective as similarly treated DuPont bait. However, 5 of 12 radio-collared cats (42%) survived exposure to the locally made baits, and 6 of 12 (50%) survived exposure to the DuPont baits (see project interim report June 1993). We believe the cats were able to detect the 1080 since earlier trials on the Chatham Islands and elsewhere, using iophenoxic acid as a bait marker, showed that non-toxic baits were eaten by most feral cats (project interim report June 1992).

In the last 12 months, we have further examined the “aversion” problem and attempted to solve it by masking the 1080. We have also attempted to improve bait durability by the use of a polymer coating.

3. Objectives

- To assess the efficacy of toxic bait in pen trials.
- To improve the efficacy of toxic bait in pen trials.
- To assess the palatabilty of polymer-coated baits.
- To arrange commercial manufacture of cat bait.
- To provide advice on the use of the bait.

4. Methods

4.1 EFFICACY OF TOXIC BAIT

DuPont pellet cat baits and locally made pellet baits were surface-coated with 0.1% wt:wt 1080 (Eason *et al*. 1992), 0.1% powdered actinidia, and 0.01% Acid Brilliant Green dye to deter birds. Water was used to apply the additives uniformly to baits.

The response of individually penned feral cats to each bait type was observed using time-lapse video recording. Baits (100 g) were placed in a tray late in the afternoon and removed 15 h later. We recorded the time until cats investigated baits, total time spent at baits, time until cats appeared affected by the 1080 (latent period), and behaviours as a result of poisoning. The weight of bait eaten was recorded by reweighing remaining bait.

4.2 IMPROVING BAIT EFFICACY

We investigated the effectiveness of alanine, an amino acid known to enhance the palatability of dried cat food (Eason *et al*. 1992) as a mask for 1080 in locally made baits. We tested the effectiveness of 1% alanine in baits, with all the additives (including 0.1% wt:wt 1080, 0.1% actinidia, and 0.01% Acid Brilliant Green dye) either applied as a surface coat or incorporated as ingredients. Water was used to apply the additives uniformly to baits. The response of six cats to 100 g of baits, surface-coated or with ingredients mixed throughout, was monitored in the same way as described above.

Bacon oil, a strong smelling compound that also enhances the palatability of dried cat food (Eason *et al*. 1992), was also assessed as a mask for 1080. A group of four cats was presented with 300 g of bait surface-treated with 1% actinidia and 1% bacon oil, and 300 g of bait surface-treated with actinidia and alanine as a control. The consumption of baits was recorded for 2 nights.

4.3 PALATABILITY OF POLYMER-COATED BAIT

Locally made baits were surface-coated with a polymer that improves the resistance of possum pellet baits to rain without reducing their palatability to possums (Morgan *et al*. 1993, unpubl. Landcare Research contract report). Before carrying out trials on bait durability, we assessed whether the polymer coating was palatable to cats by presenting two groups of cats (n=5,4) with a choice of bait (300 g) treated with polymer, actinidia, and alanine, and bait (300 g) treated with actinidia and alanine (control treatment). Baits were presented for 2 nights. All studies were conducted with the approval of the Landcare Research Animal Ethics Committee.

5. Results

Sample sizes used in this study were small because of a limited budget. Results are therefore indicative only, unless statistical significance is indicated.

5.1 EFFICACY OF TOXIC BAIT

Locally made surface-coated bait appeared more effective, killing three out of four cats, than surface-coated DuPont baits, which killed two out of six cats (Table 1). Cats were also quicker to investigate the locally made bait, spent significantly longer feeding on it, and consequently ate more. Mean consumption of toxic baits was, however, lower than that previously recorded for non-toxic DuPont (61.9 g) and locally-made bait (82.1 g).

TABLE 1. EFFICACY OF DUPONT AND LOCALLY MADE 1080 CAT BAITS SURFACE COATED WITH ACTINIDA

BAIT TYPE	NO. OF CATS	MEAN TIME UNTIL BAIT INVESTIGATED (MINS)	MEAN TIME SPENT FEEDING ON BAIT (MIN)	MEAN WEIGHT OF BAIT EATEN (GRAMS)	NO. CATS KILLED (%)
Dupont	6	55	1.2	4.8	2(33.3)
Locally made	4	41	3.8	14.2	3(75)

One survivor (offered locally made bait) ate a sub-lethal quantity of bait (<2 g): the other four all refused bait.

Only one reliable estimate of latent period was obtained: for locally made bait this was 4 h.

5.2 IMPROVING BAIT EFFICACY

Adding alanine to locally made bait did not assist in masking the 1080. Cats' response to baits was similar, regardless of whether the additives (i.e., alanine, actinidia, 1080, and dye) were applied as a surface coat or mixed throughout the bait (Table 2). The latent period for surface-coated bait was significantly less (100 min) than that of bait with additives mixed throughout (4 h 32 min) and death was also significantly more rapid (3 h 12 min and 5 h 13 min respectively).

Bacon oil-treated bait was significantly less palatable (mean consumption=83 g) than alanine-treated bait (138 g).

TABLE 2. EFFICACY OF ALANINE-TREATED LOCALLY MADE 1080 CAT BAITS EITHER SURFACE-APPLIED OR MIXED THROUGHOUT

BAIT TREATMENT	NO. OF CATS	MEAN TIME UNTIL BAIT INVESTIGATED (MIN)	MEAN TIME SPENT FEEDING ON BAIT (MIN)	MEAN WEIGHT OF BAIT EATEN (GRAMS)	NO. CATS KILLED (%)
Surface coated	6	55	4.4	6.7	4(66.6)
Mixed throughout	6	23	2.1	8.0	4(66.6)

Of the 13 cats that were killed in the efficacy and masking trials combined, most became increasingly lethargic over the 4 h that it took, on average, until death. No consistent signs of discomfort were observed, though three (13%) were seen vomiting and a further three were observed undergoing spasms in the later stages of poisoning when they were unconscious.

5.3 PALATABILITY OF POLYMER-COATED BAITS

Polymer-coated baits were significantly less palatable (mean consumption=54 g) than uncoated baits (148 g).

5.4 COMMERCIAL MANUFACTURE

We have made arrangements for the commercial manufacture of locally made cat bait with Animal Control Products (ACP), Wanganui. We have also supplied ACP with a package of data to support an application for registration of the product by the Pesticides Board. Registration has been granted.

We have not, as yet, been able to arrange for local manufacture of cat bait using the longer-life DuPont formulation as no organisation we have contacted is willing to invest the required capital for local production.

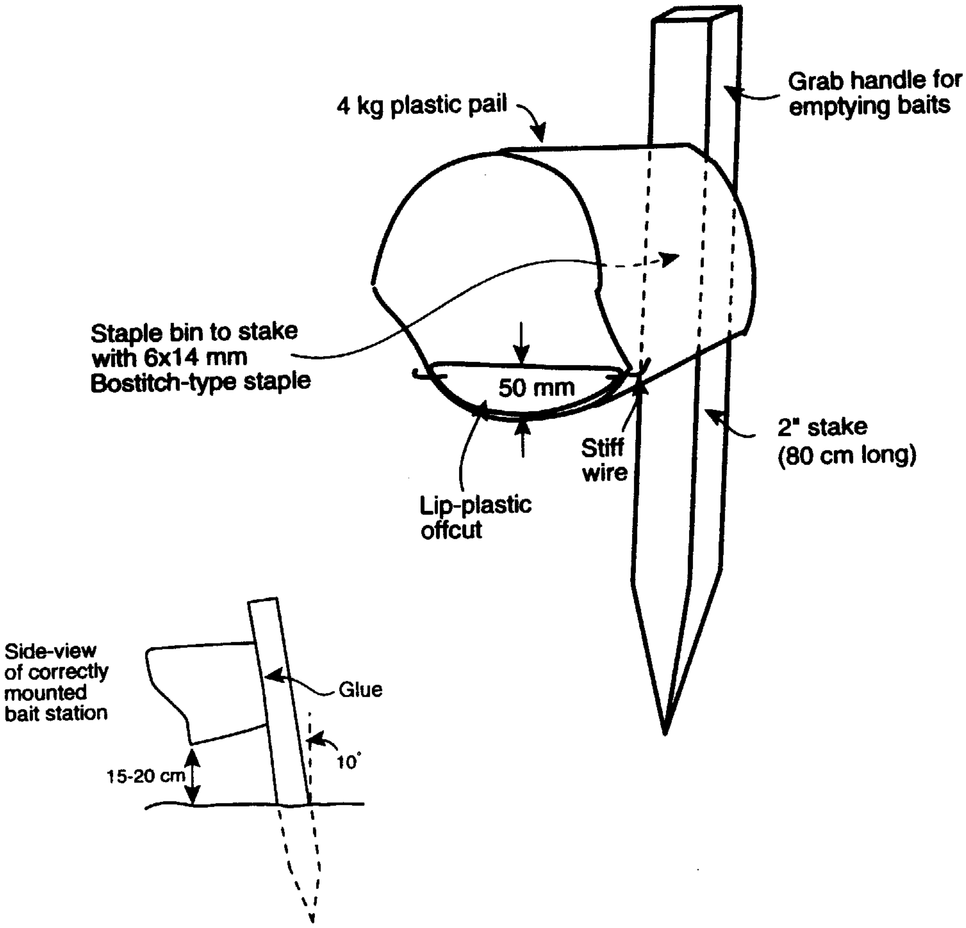
5.5 USE OF THE BAIT

Presently, the bait is treated with actinidia and alanine, and we expect that this type of bait will kill at least 70% of cats. Baits will be available only to holders of a 1080 licence and the usual procedures for the use of 1080 must be followed. It is particularly important to ensure that domestic cats and dogs do not have access to baits.

It is usually appropriate to present the baits in a bait station. A wide aperture is necessary for cats to feed readily from a new object in their environment. The design shown is cheap and easy to make, and used correctly will keep bait in palatable condition for at least 1 week (Fig.1). It is important to angle the mounting stake forward 10° to protect the bait from rain and sun. Only 150-200 g (two handfuls) of baits need to be used in each bait station. The optimal layout of bait stations will depend on the size of the area to be protected from cats, the density of the cat population, habitat type, cat movements, and public access. Although we have not systematically investigated optimal layout, our experience suggests that stations spaced 100 m apart in a grid layout will generally be adequate to ensure that cats find bait. To prevent entry of cats into a “protected” area, a boundary line of bait stations may be adequate, e.g., such a line placed around the dotterel colony on Table Hill, Stewart Island, is helping to protect the colony from cat predation (Dowding 1993).

Occasionally, it may be desirable to treat an area by aerial distribution of baits if, for example, the area is large (e.g., for planned eradication of cats on Raoul Island) or cats are one of a number of species being targeted in an aerial operation (Morgan 1993). Since the mean weight of bait is 2 g and most cats will be killed by eating one or two baits (with 0.1% 1080), we recommend an application rate of 2 kg/ha to provide 1000 baits/ha or 1 bait/10 m^2. This density of baits will ensure that all cats encounter baits within the limited time the bait remains palatable when fully exposed to the weather.

FIG. 1 A BAIT STATION SUITABLE FOR PRESENTING TOXIC PELLET BAITS TO FERAL CATS



6. Conclusions

6.1 EFFICACY OF TOXIC CAT BAIT

The locally made fishmeal pellets are more palatable to cats than DuPont fishmeal pellets.

6.2 IMPROVING BAIT EFFICACY

In contrast with earlier results (Eason et al. 1992), treatment of the bait with alanine reduced bait palatability. This may be due to the combination of alanine with actinidia, which was not used in earlier trials.

The trial results reported here (Table 2) for alanine/actinidia treated baits are probably a conservative estimate of field efficacy because our captive cats were well fed and far less active than cats in the wild.

The greater latent period and time to death for bait with the ingredients incorporated throughout than for surface-coated bait probably resulted from slower absorption of 1080 from the bait matrix than from a more "readily available" surface coating.

Although the strong odour of bacon oil may assist in masking 1080, the results indicate that bait palatability will be impaired.

Although no physiological data are available, we believe that 1080 kills cats humanely. Unlike dogs, cats did not respond to the toxin with repeated convulsive fits. The symptoms were more similar to those displayed by herbivores such as possums, rather than other carnivores such as dogs.

6.3 COMMERCIAL AVAILABILITY OF CAT BAITS

Cat bait, registered by the Pesticide Board, is available from Animal Control Products, Wanganui. We have undertaken to provide the manufacturer with technical advice on improvements to the bait.

If the demand for long-life DuPont cat bait increases, and we are unable to prolong the field life of the locally made bait, the necessary investment for local production of the long-life bait may be found. The recent prominence accorded to the control of feral cats in Australia may provide further impetus.

6.4 USING BAITS FOR FERAL CAT CONTROL

Although some cats survive exposure to the bait in its present form, its use will considerably reduce the cost of cat control operations and safety to operators compared with the traditional use of fresh meat or fish baits injected with 1080.

7. Recommendations

- Cat bait supplied by Animal Control Products should be used to improve the efficiency of current feral cat control operations. Use of the bait should be supplemented by other techniques such as trapping if more than a 70% reduction in cat numbers is required.
- Extension of bait life by the use of polymers as either coatings or bait ingredients should be investigated further.
- Alternative toxins to 1080 that are non-aversive should be sought. (This work was commissioned by DoC in April 1994 and will be reported separately).
- Cat aversion to 1080 should be further investigated.

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