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SHORT COMMUNICATION

SUITABILITY OF AERIALLY SOWN ARTIFICIAL BAITS AS A TECHNIQUE FOR POISONING FERAL GOATS

Summary: The preferences of a captive herd of goats with feral ancestry were evaluated for 11 artificial pest control baits and commercial stock feed pellets. A commercial stock food pellet (based on barley, bran, and oats) was the most preferred basic bait. A mixture of 2% diced *Griselinia littoralis* (broadleaf) leaves (a preferred natural food plant) and 2% molasses (per weight of basic bait) increased palatability of this basic bait. The best lured bait was aerially sown at 1 kg ha^{-1} in a 380 ha area with about 50 feral goats. Only 25% of the goats were shown by the biological tracer iophenoxic acid to have eaten baits after 8 days. We conclude that one-hit aerial poisoning of goats is unlikely to be effective as a control method because most goats are unlikely to eat food from off the ground.

Keywords: Feral goats; baits; feed preferences; aerial control.

Introduction

Feral goats (*Capra hircus* L.) are considered serious pests on about 20 000 km^2 of the conservation estate in New Zealand (Rudge, 1990; Parkes, 1993a). Considerable effort, costing about $3.7 million yr^{-1} since 1990, is spent attempting to control and/or eradicate goat populations over about 10 000 km^2 of this estate (Parkes, 1993a). Current control operations in New Zealand mostly use ground-based hunters, often with teams of dogs to track and bail goats (Parkes, 1993a). Some shooting is done from helicopters, sometimes using radio-telemetered Judas goats to find the animals (Parkes, 1993a). Foliage-bait poisoning (smearing a toxin on to leaves of preferred plants) has been successfully trialled (Parkes, 1991), but the 1080-gel toxin (10% sodium monofluoroacetate in a gel carrier) is not registered with the New Zealand Pesticides Board for operational use against goats. Ground-based hunting and foliage-bait poisoning require foot access for the hunters, and aerial shooting is most effective in open country (Parkes, 1990). Hence, there is no effective method for killing goats in rugged country inaccessible to ground-based hunters and too well forested for aerial hunting.

Anecdotal reports suggest few goats are killed during extensive aerial control operations using 1080 poisoned baits against European rabbits (*Oryctolagus cuniculus* L.) and Australian brushtail possums (*Trichosurus vulpecula* Kerr) conducted in New Zealand (Parkes, 1989). Incidental or non-target deaths of other ungulates, where estimated, have also been modest when compared with operations targeting the ungulates using other techniques. For example, 43% ± 25% of red deer (*Cervus elaphus* L.) were estimated to have been killed by a 0.08% 1080 cereal-based bait (Wanganui No. 7) in an operation aimed at possums in Pureora Forest (Fraser, 1989).

Trials or operations targeting ungulate species have rarely killed more than about half of the population, and often no deaths were reported. Aerially-sown carrot baits (with between 0.04 and 0.08% 1080) killed an estimated 50% of fallow deer (*Dama dama* L.) in a trial in the Caples Valley (Daniels, 1966), 52% of Himalayan thar (*Hemitragus jemlahicus* Smith) in a trial in the Dobson Valley (Douglas, 1967), 0% of feral goats at Waiau Toa in the lower Clarence Valley (Parkes, 1989), and 63%, 42%, 20%, and 9% of feral sheep, red deer, feral pigs, and feral goats, respectively, in a trial in the Haurangi Range (Parkes, 1989).

There are four possible reasons for the apparent failure of aerially-sown baits to kill large numbers of goats: the density of baits sown may have been so low that goats rarely encountered them; the baits may have been unpalatable; goats may dislike eating otherwise palatable baits from off the ground; or the concentration of toxin may have been too low to kill the goats for the amount of bait eaten.

This research aimed to identify the reason for failure. We developed an artificial bait that was palatable to feral goats and tested it in a non-toxic form by measuring the proportion of a feral goat population that would eat aerially sown baits.

Methods

The palatability to goats (the proportion of baits eaten) of 11 pelletised cereal-based stock foods and commercial pellet baits (Table 1) was tested on a captive goat herd at Lincoln University, Canterbury, New Zealand. The herd of 80 females aged between 3 and 6 years had been in captivity for many years but orginated from feral goats from Westland. The herd was kept year-round in large pasture paddocks and received supplementary feed (silage) only in winter. Water was provided *ad libitum* during all trials. In seven independent trials, 5 kg of each of the pellet-types were presented in plastic crates to groups of 10 different goats. Each trial ran for 1 hr, and the arrangement of crates was made randomly. The amount of bait eaten was calculated as a percentage of the total bait presented in each trial (55 kg), and differences between baits were compared using the Wilcoxon Signed Rank test.

We then attempted to improve the palatability of the best of these basic baits (best basic bait = BBB) by adding lures such as molasses or chopped leaves of favoured plant species (broadleaf - *Griselinia littoralis* Raoul or mahoe - *Melicytus ramiflorus* J. R. et G. Forst.). The amounts eaten were compared for each of 1.5 kg of two baits presented in paired feeding troughs to groups of 10 goats each on 16 to 22 occasions. The chopped leaves in amounts of 2%, 4%, or 8% by weight and molasses (2% by weight) were mixed alone or in various combinations (see Table 2) with bait ingredients before pelletising. Diced carrot baits were also tested against BBB in this trial. The choices were presented in a step-wise fashion over several months, starting with comparisons with BBB until a lured bait was found to be significantly more palatable (differences were tested using paired *t*-tests) when it became the best bait for further comparison.

A field-trial to evaluate the proportion of a feral goat herd that would eat aerially-sown bait (acceptance) was undertaken in about 380 ha of low hill country in Marlborough. The vegetation consisted of remnant beech (*Nothofagus* spp.) forest and manuka (*Leptospermum scoparium* J.R. et G. Forst.) scrub in the gullies intergrading into tussock grassland faces and small bluffs. About 50 goats were known to be present. The best lured bait combination from the previous trial was mixed with the quantitative bio-tracer, iophenoxic acid, at a concentration of 5 mg per 2 g bait. We assume this did not affect the palatability of the bait as the same compound did not appear to affect goats' feeding behaviour in earlier pen trials (Parkes, 1991), and a high proportion of other species eat otherwise palatable baits containing iophenoxic acid (e.g., Hadidian *et al*., 1989). The bait pellets (359 kg) were aerially-sown by a helicopter, giving a bait density of *c*. 500 ha^{-1}. After eight fine days 24 goats were shot and blood samples were taken from the jugular vein. The blood was centrifuged, then plasma samples were analysed for total iodine content using the methods described in Eason and Batcheler (1991). Eight goats shot 5 km from the nearest baits were used as controls for the plasma iodine analysis.

These studies were conducted in accordance with the guidelines of the National Animal Ethics Advisory Committee, and with the approval of the Manaaki Whenua - Landcare Research Animal Ethics Committee.

Results

Basic bait preferences (palatability)

Two commercial pelletised stock foods were significantly more palatable than five other stock foods and four pelletised pest baits (Table 1). Of

Table 1: *Relative palatability of 11 cereal baits to goats. Data are presented as the percentage eaten per bait of the total bait presented in each trial of seven trials (T1 - T7). No significant differences in bait-take are represented by the use of the same letter in the last column. RS5 rabbit and possum baits were provided by Animal Control Products Ltd, Waimate, and No. 7 possum baits by Animal Control Products Ltd, Wanganui.*

Bait type	T1	T2	T3	T4	T5	T6	T7	Mean	Differences
Stock food 1	4.56	2.31	3.15	8.04	4.73	3.20	4.06	4.29	A
Stock food 2	4.93	3.00	4.26	2.24	3.13	1.55	4.02	3.30	AB
Stock food 3	1.39	0.73	2.92	3.76	0.93	1.32	0.82	1.70	BC
Stock food 4	1.82	0.07	1.33	1.95	1.41	1.73	0.86	1.31	C
Mapua bait	0.41	0.54	0.83	1.47	1.63	0.81	1.12	0.97	CD
RS5 rabbit bait	1.11	-	0.51	-	0.38	0.07	0.22	0.46	DEH
Stock food 5	0.32	0.94	0.21	0.23	0.09	0.68	0.10	0.37	DEF
Stock food 6	1.00	0.29	0.18	0.39	0.45	0.00	0.21	0.36	EG
RS5 possum bait	0.37	0.40	0.19	0.17	0.23	0.04	0.08	0.21	FG
Stock food 7	0.23	0.09	0.13	0.75	0.05	0.09	0.09	0.20	FGH
No 7 possum bait	0.12	0.48	0.04	0.40	0.18	0.05	0.05	0.14	FG

Table 2: *Comparisons of palatabality of pairs of baits to goats. BBB = Stock food 1.*

Bait comparisons	No. of trials	Mean wt. eaten (g)	Paired *t*	*P* (paired comparisons)
BBB	22	427	2.12	< 0.05
BBB + 2% molasses		623		
BBB	20	532	2.42	< 0.05
BBB + 8% broadleaf		731		
BBB + 8% broadleaf	21	748	1.61	NS
BBB + 4% broadleaf		898		
BBB + 4% broadleaf	16	1097	0.35	NS
BBB + 2% broadleaf		1124		
BBB	22	958	2.82	< 0.05
BBB + 2% broadleaf		1236		
BBB	20	731	2.92	<0.01
BBB + 2% broadleaf + 2% molasses		873		
BBB + 2% broadleaf	22	777	2.24	<0.05
BBB + 2% broadleaf + 2% molasses		946		
BBB	21	369	2.48	<0.05
BBB + 8% mahoe		216		
BBB	19	1712	4.77	<0.001
Diced carrot		69		

these two, Stock Food 1 was eaten more than Stock Food 2, and was subsequently used as the best basic bait (BBB). This stock food consists of (by weight): barley 52%, bran 20%, oats 20%, lime 4%, salt 1.5%, and bentonite 2.5%.

Lure preferences

Preliminary trials comparing the palatability of BBB with the same baits with a variety of added flavours showed all but molasses either repelled goats or made no difference to the baits' palatability (Parkes, 1993b).

Only molasses and chopped leaves of broadleaf significantly increased the palatability of BBB. The most favoured lure/bait combination was a mixture (by weight) of 2% of molasses syrup and 2% chopped broadleaf (Table 2). Baits with chopped mahoe leaves, and diced carrot baits were significantly less palatable than BBB (Table 2).

Acceptance of the aerially-sown best bait

The amount of iodine in the blood of the eight goats not exposed to baits ranged from 2.2 to 6.7 μg 100 cm^{-3}. The iodine concentration of 18 of the 24 goats shot within the baited area was within this range, i.e., they had eaten no baits. Only six goats (25%) had eaten baits. One may have eaten part of a bait (it had a plasma iodine level of 13 μg 100 cm^{-3}), one had eaten one bait (55 μg 100 cm^{-3}), and four had eaten many baits (423-4400 μg 100 cm^{-3}).

Discussion

We made no formal attempt in the experimental design of the pen trials to test which sense (e.g., taste or smell) goats were using to discriminate between baits, although this may have affected the relative palatabilities when comparisons between baits changed from pairs with olfactory and/or gustatory cues for the goats. However, we did compare the current best bait against earlier recipes to check that our current choice was still valid.

Four possible reasons were suggested for past failures of aerial baiting to control goats; low probabilities of goats finding baits, unpalatable baits, behavioural problems with eating off the ground, and low concentrations of toxin if only a few baits were eaten. Our field trial showed only about 25% of the goats presumed to be at risk ate baits that were palatable to domestic goats when presented in feeding troughs. Only 16% had eaten sufficient baits to have been killed if the baits had contained 1080 at the concentrations used in possum operations (i.e., given an LD_{50} for goats of *c.* 0.5 mg kg^{-1} body weight (McIlroy, 1983) and 0.08% 1080 in toxic possum baits (Morgan, 1982)). The bait density of 1 bait every 20 m^2 seems sufficient so that a goat should encounter many baits during its normal activities over 8 days; four goats after all did find many baits. The baits were palatable to the farmed animals, and all of the goats in the trials ate baits - although there is clearly more chance of social facilitation among farmed goats than

in the wild, where individuals may not be in such close contact with each other. Therefore, on balance we conclude that this field trial and previous trials failed to kill a high proportion of goats mainly because the animals did not eat baits off the ground. This is not unexpected as goats are browsers rather than grazers (e.g., Bullock, 1985). Many previous trials used carrot baits, which we have shown to be relatively less palatable than cereal baits, so accentuating the likelihood of failure.

Aerial baiting as a potential method to control feral goats is unlikely to kill more goats than other cheaper methods. The cost to produce and apply aerial baits from a fixed-wing aircraft at sowing-rates of less than 5 kg ha^{-1} in possum operations is *c.* \$20 ha^{-1} (Morgan, 1994), and we assume this would be about the cost to produce and distribute goat baits. Ground hunting or foliage-bait poisoning can kill more than 90% of goat populations for lower costs (Parkes, 1990). Aerial baiting to control goats living in areas inaccessible to both ground and aerial shooters might be a possibility, although the low acceptance achieved in our one-shot field trial indicates that further research, either with pre-feeding with non-toxic baits to improve acceptance or with repeated applications of toxic baits (both with added costs), would be needed to achieve high percentage kills.

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