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Development and Testing of Attractants for Feral Cats, *Felis catus* L.

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Abstract

As part of a programme to improve feral-cat control and eradication techniques, various odours were tested as candidate lures. They included food odours (fish oils), social odours (urine and its components, anal-sac secretions and commercial wild-animal lures) and plant materials (catnip, matatabi and their essential oils). Pen bioassay experiments used a preference procedure on captive feral and domestic cats to compare the time spent investigating the odours and the number of cats visiting each odour. Field trials at rubbish dumps used scent stations to assess cat activity. Catnip and matatabi were the most promising candidate lures in both the pen bioassay and the field trials. Future directions for lure developments are suggested.

Introduction

Feral cats, *Felis catus*, are introduced predators in island ecosystems worldwide. They have had a devastating effect on populations of both sea birds and forest birds (Merton 1978; Karl and Best 1982; van Aarde 1984; Fitzgerald and Veitch 1985). The effects of cat predation in mainland situations are hard to discern from other factors. In New Zealand, cats are major predators of the endangered black stilt, *Himantopus novaezelandiae* (Pierce 1986). They are also implicated in the decline of lizard populations (Fitzgerald 1990), and prey upon two endemic species of bat, *Mystacina tuberculata* and *Chalinolobus tuberculatus* (Daniel and Williams 1984).

Cat-eradication programmes on islands are a combination of trapping, poisoning and hunting (Veitch 1985; Bloomer and Bester 1992). Their success has been limited in part by the availability and persistence of attractants and baits. A palatable, weather-resistant polymer bait that can carry compound 1080 (sodium monofluoroacetate) has been developed to improve cat-eradication programmes (Eason and Frampton 1991; Eason *et al.* 1992).

An eradication programme requires not only an effective poisoning operation, but also follow-up monitoring of the success of the operation. Potential scent attractants could be useful at all stages of the eradication programme: (1) directly on baits or at bait stations to improve efficiency and species-specificity of the poisoning operation (Turkowski *et al.* 1983; Fagre *et al.* 1983); (2) as trap lures in the follow-up period, especially to catch individuals that have avoided edible baits; and (3) at scent stations to establish population levels before and after an island eradication or mainland control programme (Conner *et al.* 1983).

Food odours, in the form of fresh or canned fish, have been the lures most often used for cats in the past (Veitch 1985). They can attract cats to traps or to edible baits. However, fish rapidly becomes rancid and loses its attractiveness. Social odours like urine and anal-sac secretions, which have communicative value to the target species, are used as lures for other carnivores (Conner *et al.* 1983). Synthetic lures based on the components of social odours have been

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developed for the coyote, *Canis latrans* (Murphy *et al.* 1978), and the ferret, *Mustela furo* (Clapperton *et al.* 1989). While these have value as trap lures, they may produce conflicting stimuli if added to edible baits.

Another group of odours with potential as cat lures are the plant-derived compounds that elicit distinct behavioural responses in the Felidae (Leyhausen 1973; Tucker and Tucker 1988). These are the lactones found in high concentrations in catnip, *Nepeta cataria*, catmint, *N. mussinii*, and the silver vine matatabi, *Actinidia polygama* (McElvain *et al.* 1941; Sakan *et al.* 1965). While their behavioural and physiological effects on cats have been well studied, there has not been an investigation of their potential as scent lures. These compounds induce licking, chewing and sniffing (Tucker and Tucker 1988), so they have potential as bait additives or bait-station attractants as well as trap lures.

The aim of this study was to determine which of this variety of odours showed the most potential as a scent lure for feral cats. Various formulations of the most attractive materials were also tested.

Methods

Pen Bioassay

Twenty wild-caught and four domestic cats were held at the Forest Research Institute animal facility at Rangiora, New Zealand. They were housed either singly in outside pens (2·3×5 m) or in groups of four in larger pens (7×5 m). They were fed a diet containing fresh meat, offal and cat biscuits.

Twleve sets of choice tests to determine the relative attractiveness of odours were run in the evenings under low artificial light in these pens. Direct observations were made for 15 or 30 min from an adjacent glass-fronted room. Observations in Trial 12 were made by video-taping cats' responses at odour stations over a whole night. Odour materials were presented on cotton wool in perforated plastic containers. These odour stations were placed 0·5 m apart, either attached to wire stakes 20 cm high or secreted in the grass in the pen.

Candidate lures were tested in various combinations as they became available (Appendix). The odours were rotated around the stations randomly for each subject. Each cat was tested 1–4 times on each set of odours. The time spent investigating each station was used as a response criterion; the data were ln-transformed and analysed with repeated-measures ANOVA, and differences between treatments tested by Least Significant Difference (LSD) tests. The number of cats visiting each odour station was also analysed with ANOVA and pairwise comparisons. Where data deviated markedly from a normal distribution, treatments were compared with non-parametric, rank-sum, two-sample tests.

Field Trials

Field trials were run on three populations of semi-feral cats, at the Whangarei city landfill and the rural refuse dumps at Ruatangata and Tauraroa in Northland, New Zealand.

Scent stations were established at permanent positions (at least 20 m apart) for any one trial but varying from trial to trial. A station consisted of a scent container on a stake as used in the pen trials, surrounded by a tracking tile made from a 0·25-m^2 sheet of painted or formica-covered hardboard, coated in blue carpenter's chalk (sprayed on in methylated spirits). Odour materials were placed in the containers in the late afternoon or early evening. Each station was checked the following morning for animal signs and cleaned before the next trial.

Cat sign was recorded on a scale of activity: 0 = no prints; 1 = one or two sets of peripheral prints; 2 = one or two sets of central prints; 3 = multiple sets of prints across the whole board. The presence of mammalian non-target species prints (Norway rats, *Rattus norvegicus*, mice, *Mus musculus*, and brushtail possums, *Trichosurus vulpecula*) was recorded. Disturbance to the scent container was also noted.

In any one trial, the stations were divided into several equal-sized groups, each station within a group receiving one of the treatments on the first night. Treatments were rotated around the stations within a group on subsequent experimental nights, until each station had received each treatment. Experimental nights were at least three nights apart for any one study site. Six trials were conducted between March 1990 and October 1992.

Data on the number of stations visited by cats were analysed with Chi-square analysis. Cat activity scores were ln-transformed and analysed with repeated-measures ANOVA and LSD tests for pairwise comparisons of treatments.

Results

Pen Bioassay

There were significant differences in the time spent at the odour stations for Trials 1 ($P<0{\cdot}01$), 4 ($P<0{\cdot}02$) and 5 ($P<0{\cdot}05$). Mean response times and significant differences between pairs of treatments are shown in Fig. 1. Odour stations containing urine, matatabi and catnip oil were visited by as many cats as the catnip station, in Trials 2, 4 and 5, respectively (Table 1). There were significant differences in visitation rates between catnip and 4-Merc (Trial 1; $P<0{\cdot}025$), fish oil (Trial 3; $P<0{\cdot}02$) and water (Trials 1–5 combined; $P<0{\cdot}002$).

Catnip was investigated for longer than the other treatments in Trial 6 ($P<0{\cdot}001$) (Fig. 1*f*). None of the wild-animal lures received significantly longer responses than the water control in Trial 7 (Fig. 1*g*). Neither the cat urine nor the synthetic-urine component at either concentration generated much investigation by the subjects in Trial 8 (Fig. 1*h*). The only significant difference in numbers of cats visiting the various treatments in Trials 6–8 was that WC2 was visited more often than water ($P<0{\cdot}046$) (Table 1).

The urine odours tested in Trial 9 did not vary significantly from water in investigation time (Fig. 1*i*). More visits were recorded to the male urine odour than to water ($P<0{\cdot}014$). Neither the oestrous nor the anoestrous female urine odours were visited significantly more than the water.

There were differences in the time spent investigating the treatments in Trial 10 ($P<0{\cdot}001$). All three urine odours received less response than the catnip (Fig. 1*j*). In this trial the female urine odours outperformed the male urine in visitation rate (Table 1). Male urine was the only odour visited significantly fewer times than the catnip ($P<0{\cdot}003$).

The subjects spent more time at the odour stations containing anal sac secretions than at the blank control station in Trial 11 ($P<0{\cdot}05$) (Fig. 1*k*). There was no difference between their responses to the male and female secretions. The three treatments were visited by a similar proportion of the subjects (Table 1).

In Trial 12, matatabi as a powder proved to be a more effective lure than frozen catnip (Fig. 1*l*). The matatabi powder was discovered in each of the 20 tests, significantly outperforming the catnip and control in visitation rates ($P<0{\cdot}05$) (Table 1).

Table 1. Percentage of cats visiting odour stations during pen trials

Full treatment names are given in Appendix; *n*, total number of replicates for each treatment

Trial 1 (n = 15)		Trial 2 (n = 15)		Trial 3 (n = 15)		Trial 4 (n = 15)	
Catnip	60·0	Catnip	40·0	Catnip	73·3	Catnip	46·6
4-Merc	26·7	Urine	60·0	Fish Oil	26·7	Matatabi	53·3
Water	20·0	Water	25·0[A]	Water	62·5[A]	Water	12·5[A]
Trial 5 (n = 15)		**Trial 6 (n = 14)**		**Trial 7 (n = 14)**		**Trial 8 (n = 14)**	
Catnip	33·3	Catnip	64·3	Wildcat 1	57·1	Urine	71·4
Catnip oil	33·3	Imitation	64·3	Wildcat 2	71·4	3-Merc (H)[B]	57·1
Water	0	Musk	50·0	Fisher	64·3	3-Merc (L)[B]	35·7
		Water	35·7	Water	42·8	Water	50·0
Trial 9 (n = 18)		**Trial 10 (n = 12)**		**Trial 11 (n = 17)**		**Trial 12 (n = 20)**	
Female/o	61·1	Catnip	91·7	ASS/female	64·7	Froz. catnip	15·0
Female/ano	50·0	Female/o	66·7	ASS/male	70·6	Matatabi	100·0
Male	61·1	Female/ano	50·0	Blank	47·0	Blank	40·0
Water	27·8	Male	16·7				

[A] n = 8. [B] H = 0·26%, L = 1ppm.

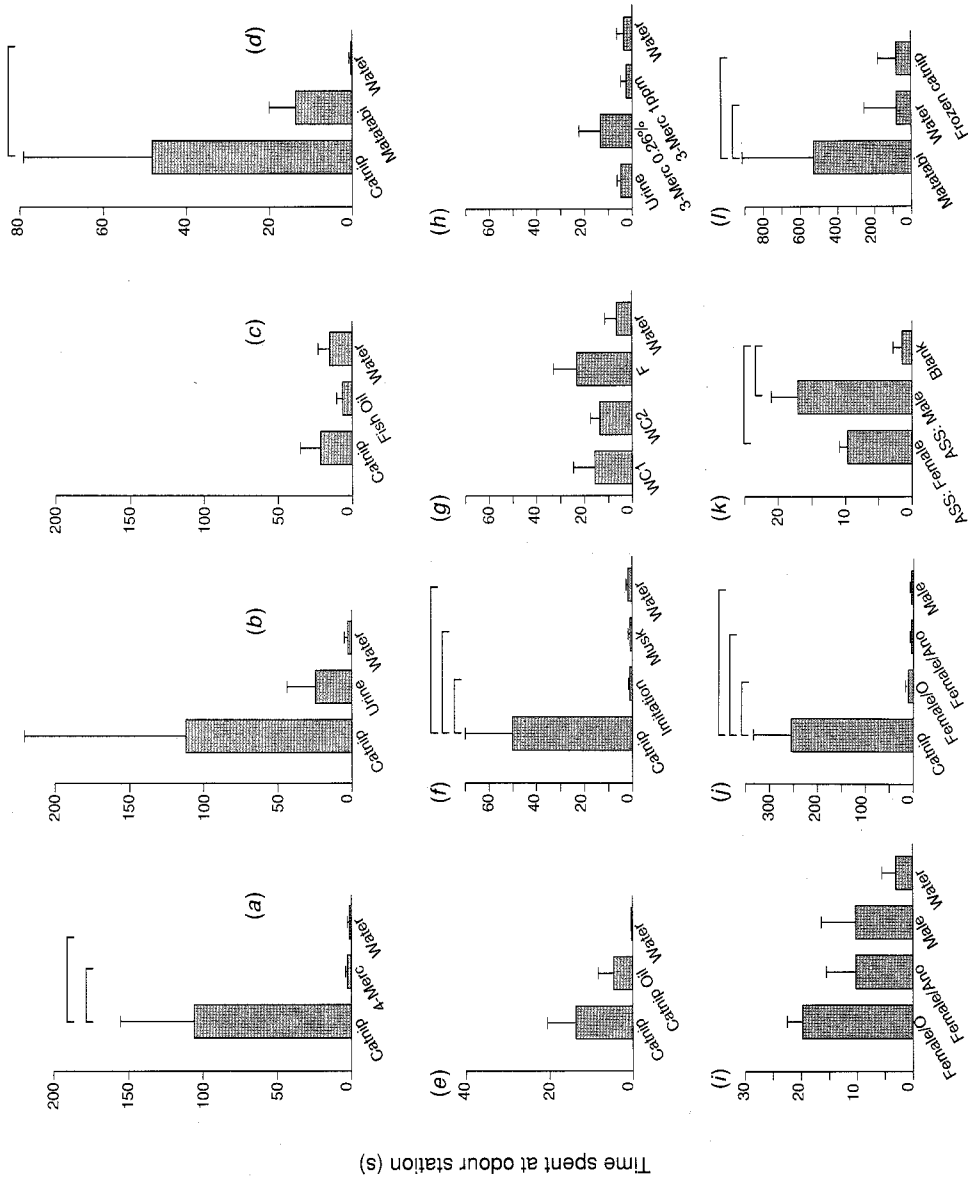

Fig. 1. Mean (+1 s.e.) time spent sniffing at each odour station in Pen Trials 1–12 (*a–l*). Eight cats were used in Trials 1–5, 18 in Trials 6–8, seven in Trial 9, six in each of Trials 10 and 11, and 14 in Trial 12. Pairs of treatments that differed significantly from each other (LSD pairwise comparisons, $P<0{\cdot}05$) are indicated by horizontal bars.

Field Trials

Stations containing catnip were visited twice as often as those containing urine, fish oil or water ($P<0{\cdot}05$) (Table 2). There were differences in levels of cat activity amongst the treatments ($P<0{\cdot}001$), with catnip scoring more than all the other treatments (Fig. 2*a*). The scent container was disturbed at seven sites, always when the treatment was catnip. Rodents visited each treatment in similar numbers (Table 2).

There was no significant difference amongst treatments in the number of stations visited by cats in Trial 2 (Table 2). However, fresh catnip induced higher levels of cat activity than the catnip and matatabi oils and water ($P<0{\cdot}001$) (Fig. 2*b*). The scent container was disturbed at 33% of the stations containing fresh catnip, and at one station containing low concentration catnip oil. No disturbance occurred with the other treatments. There were no significant differences in the responses of non-target species to the various treatments (Table 2).

Table 2. Visitation rates of cats and non-target species to scent stations during field trials

n, total number of replicate stations for each treatment

Trial	Treatment	No. of stations visited			
		Cats	Rats	Mice[A]	Possums
1 ($n = 36$)	Freshly chopped catnip leaves	25	7	–	0
	Frozen cat urine	13	10	–	0
	Commercial fish oil	12	11	–	1
	Rain water	11	7	–	0
2 ($n = 18$)	Freshly chopped catnip leaves	14	1	1	1
	Catnip oil in paraffin 1:100	5	2	1	2
	Catnip oil in paraffin 1:1000	8	0	0	0
	Matatabi oil in paraffin 1:100	10	4	1	1
	Matatabi oil in paraffin 1:1000	7	4	0	3
	Rain water	7	4	0	0
3 ($n = 36$)	Freshly chopped catnip leaves	25	5	1	1
	Undiluted catnip oil	22	4	0	1
	Catnip oil in paraffin 1:10	20	4	0	1
	Matatabi oil in paraffin 1:10	25	3	1	3
	3-Mercapto-3-methyl-butan-1-ol	11	3	0	1
	Rain water	18	7	1	1
4 ($n = 15$)	Freshly chopped catnip leaves	12	4	0	0
	Cat Pack lure[B]	11	7	0	0
	Pro's choice lure[C]	7	9	0	0
	Bobcat gland lure[C]	5	6	0	0
	Rain water	8	5	0	0
5 ($n = 12$)	Freshly chopped catnip leaves	12	4	0	0
	Synthetic nepetalactone (1:100)	4	7	0	0
	Catmint oil (1:10)	5	7	0	0
	Rain water	5	6	0	0
6 ($n = 30$)	Freshly chopped catnip leaves	24	12	0	0
	Matatabi powder	21	10	0	0
	Rain water	20	12	0	1

[A] A single category of rodents was used in Trial 1. [B] Commercial lure from Laugheman Big Sky Lures Co. [C] Commercial lures from Russ Carmen's Superior Animal Lures Co.

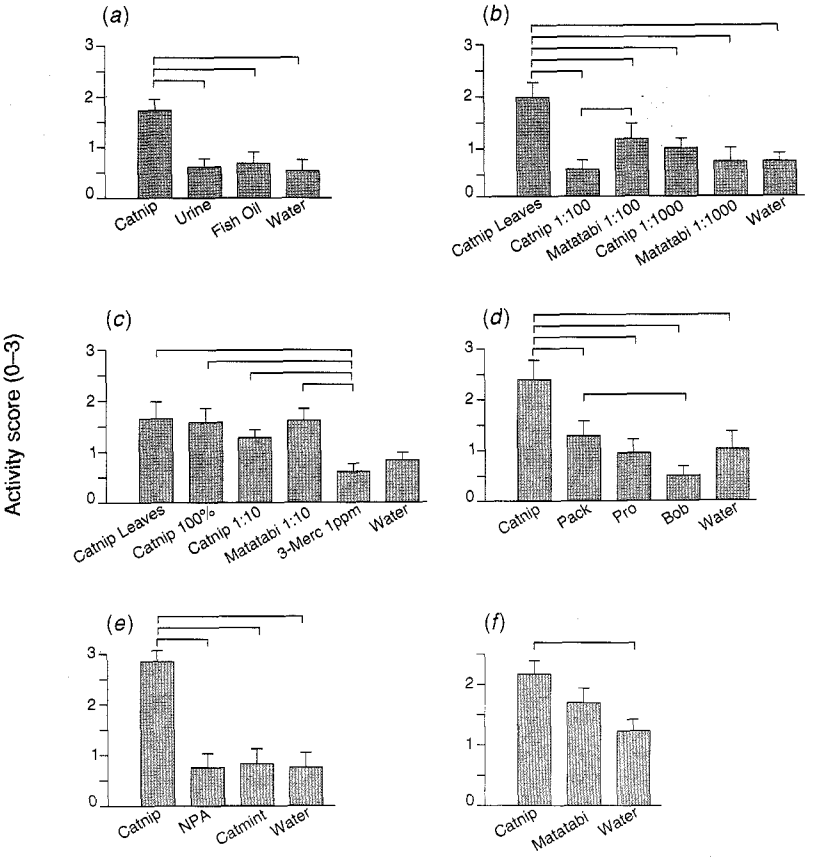

Fig. 2. Mean (+1 s.e.) activity score for scent stations containing each treatment in Field Trials 1–6 (*a–f*). Pairs of treatments that differ significantly from each other (LSD multiple comparisons, $P<0{\cdot}05$) are indicated by horizontal bars.

Cat visitation rates did not vary amongst treatments in Trial 3 (Table 2). There were differences amongst treatments in the level of cat activity recorded at the stations ($P<0{\cdot}001$). The catnip and matatabi oils performed similarly to the fresh catnip leaves, while the water and urine component received less activity (Fig. 2*c*). Containers were disturbed at 31% of the stations containing catnip leaves and pure catnip oil, at 19% of 1:10 catnip oil and 28% of 1:10 matatabi oil stations, and at 6% of 3-Merc and 8% of water stations. Non-target species visited all stations in similar numbers (Table 2).

Cat visitation rates did not vary with treatment in Trial 4 (Table 2). Catnip stations had greater activity scores than any of the other treatments ($P<0{\cdot}001$). None of the commercial cat lures were more attractive than the water control (Fig. 2*d*). While the scent container was disturbed at 60% of stations containing catnip, only one instance of disturbance was recorded with the other treatments (Pro's choice 7%). Rats were the only non-target species recorded, and they showed no particular interest in any of the treatments (Table 2).

While catnip received the greatest number of cat visits in Trial 5, the differences amongst treatments were again not significant (Table 2). Catnip outperformed both the synthetic nepetalactone and the catmint oil in cat activity scores ($P<0{\cdot}001$) (Fig. 2*e*). Containers were disturbed at 83% of the catnip stations, 8% of catmint and none of the remaining stations. Rat visits were evenly spread amongst the treatments (Table 2).

There were similar numbers of visits by cats to the three treatments in Trial 6 (Table 2). Cat activity did vary amongst the treatments ($P<0{\cdot}005$). The catnip leaves were more attractive than water, but the matatabi powder did not vary significantly from the other treatments (Fig. 2*f*). Both the catnip and matatabi treatments induced more scent-container disturbance (57% and 43% respectively) than the water (10%). Similar numbers of rats visited each treatment (Table 2).

Discussion

Lure Success

Catnip and matatabi were the most promising candidate lures tested. The 'catnip-response' is inherited as an autosomal dominant (Todd 1962). In our trials, behavioural observations showed that 50% of the subjects (including all four domestic cats and 8 of 20 feral cats) showed the full catnip response (B. K. Clapperton, unpublished data). This includes sniffing, licking, rubbing and head-over rolling (Tucker and Tucker 1988). Nine of the remaining 12 feral cats approached and sniffed at the catnip samples. This suggests that, although not all cats are genetically determined to respond to catnip and matatabi, these odours may act as more general attractants.

The methods used for preparing the test materials may have affected their attractiveness to cats. The frozen matatabi used in Pen Trial 4 was less attractive than the powdered matatabi (Pen Trial 12) compared with the controls. Similarly, the frozen catnip used in Pen Trial 12 did not produce responses in the majority of the cats tested. This is in contrast to the results of both fresh catnip and extracted catnip oils.

Although some of the feral cats responded strongly to urine in Pen Trial 2, overall the urine samples did not perform well as attractants. This is surprising, considering the roles that urine plays in communication in cats (De Boer 1977; Wemmer and Scow 1977). While Verbene and Ruardij (1982) found that male cats responded more to urine of oestrous females than that of anoestrous females, the same was not demonstrated here. The captive conditions of these trials, with many cats held in adjacent pens, may have resulted in the cats becoming desensitized to urine.

The synthetic urine components tested here were not successful attractants. This may have been either because of urine-odour desensitisation or because the two compounds tested were components of *aged* tomcat urine (Joulain and Laurent 1989). Cats can discriminate between fresh and one-day-old urine marks, and prefer to investigate the fresh marks (De Boer 1977).

The lack of success of the commercially obtained imitation catnip is not surprising. Chemical analysis revealed the presence of peppermint oil and diethyl phthalate but no nepetalactone (R. J. Weston, unpublished data). The unsuccessful synthetic nepetalactone was the mirror image of the naturally occurring nepetalactone, but this should not have affected its attractiveness. Sakurai *et al.* (1988) found that both forms of the compound induced responses in cats. The 'catnip response' does not necessarily include approaching the odour source from a distance. Cats may be brought to the station by a learnt association of the pleasant nepetalactone experience with the general smell of catnip, produced by a combination of monoterpenes.

Experimental Design

The cats used in both our pen and field trials are not necessarily representative of all cats. The captive animals may not have responded as they would in the wild. The semi-feral cats at the refuse dump sites are likely to be different from truly feral cats in more natural environments, in their responses to novel stimuli (Barnett and Cowan 1976). They may have been either pre-disposed to investigating new odours or they may have been so acclimatised to changing smells that they ignored the lures.

The use of the time spent at the odour stations as a response criterion in the pen bioassay may have biased the results in favour of catnip and matatabi, because of the long behavioural

response they induce. The proportion of cats responding to each station should be less biased but more open to chance encounters affecting the results. Even on this measure, catnip and matatabi stations ranked highly.

The scent station procedure used in the field trials allowed for the simultaneous testing of a number of different lures. It was similar to that used by Roughton and Bowden (1979). The cat-activity scale successfully discriminated amongst the candidate lures. The results of the cat-activity scores were supported by the recordings of disturbance rates of scent containers.

The analyses of time spent at the odours and cat-activity patterns do show that the lures have an important role to play in modifying the behaviour of cats at a trap or bait station. They do not demonstrate the ability of a lure to attract a cat to a control device. Jolly and Jolly (1992) found that for dingoes, *Canis familiaris dingo*, there was little correlation between the time spent at odour stations during pen trials and visitation rates of wild dingoes in field trials. They suggested that the proportion of animals responding in pen trials is the best indicator of how attractive a lure will be in the field.

Visitation rates did discriminate amongst some of the odours in both our pen and field trials. Although there were no significant differences in visitation rates in Field Trials 2-6, catnip always scored the largest number of visits. Cats at the study sites, which were used repeatedly in successive trials, may have learned to associate the visual characteristics of the stations with the pleasant catnip experience and may have become conditioned to visit each station. Occasional high scores on the water controls may have resulted from contamination with traces of catnip or matatabi material. Cats show the 'catnip response' to concentrations of nepetalactone in the air as low as one part per 10^{11} (Todd 1962).

These experiments were not designed to determine over what distance the lures are effective. From our observations during pen trials, it was apparent that the cats could detect the plant materials from a 1-m distance. On two occasions, two different cats emerged from a nest box and walked directly over a distance of about 5 m to a station treated with matatabi powder (D. R. Morgan, personal observation).

Non-target Species

Non-target species were not attracted to the catnip or matatabi materials, but nor did they appear to be repelled by them. This lack of a rat-deterring property in catnip is contrary to popular belief (Grieve 1971). The use of refuse dumps as study sites meant that only a few non-target species were present. Trials in other habitats are needed to determine the responses of other species to the lures. The 'catnip response' is, however, unique to members of the felid family (Tucker and Tucker 1988).

Conclusions

Catnip and matatabi have been identified as successful candidates for cat lures. The value of these lures is primarily in modifying the behaviour of an animal when it is near a poison bait or trap. They stimulate close investigation and sniffing, licking and chewing — behaviours that will increase the success of a control device. Further tests to confirm the effectiveness of the extracted catnip and matatabi oils and the commercially available matatabi powder as trap lures and bait-station attractants for feral cats are needed. If these are successful, further work should concentrate on formulating them into weather-resistant, slow-release devices. Further work is also needed to determine the distance over which the lures will attract cats.

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Appendix. Treatments used in each pen trial

Trial 1	Trial 7
Freshly chopped catnip leaves	Wildcat lure 1[C]
4-Mercapto-4-methyl-pentan-2-one[A]	Wildcat lure 2[C]
Distilled water	Fisher lure[C]
	Distilled water
Trial 2	
Freshly chopped catnip leaves	Trial 8
Frozen male or female cat urine	Fresh male cat urine
Distilled water	3-Mercapto-3-methyl-butan-1-ol[A] (0·26 %)
	3-Mercapto-3-methyl-butan-1-ol (1 ppm)
Trial 3	Distilled water
Freshly chopped catnip leaves	
Commercial fish oil	Trial 9
Distilled water	Fresh oestrous female cat urine
	Fresh anoestrous female cat urine
Trial 4	Fresh male cat urine
Freshly chopped catnip leaves	Distilled water
Frozen chopped matatabi leaves	
Distilled water	Trial 10
	Catnip leaf infusion
Trial 5	Fresh oestrous female cat urine
Freshly chopped catnip leaves	Fresh anoestrous female cat urine
Catnip oil[B]	Fresh male cat urine
Distilled water	
	Trial 11
Trial 6	Female cat anal sac extract
Catnip oil	Male cat anal sac extract
Imitation catnip	Clean cotton wool
Musk ambretta	
Distilled water	Trial 12
	Matatabi powder[D]
	Clean cotton wool
	Frozen catnip leaves

[A] A component of male cat urine (Pearce *et al.* 1967). [B] Oils were steam-extracted and contained 75–95% nepetalactone. [C] Commercial lures from Stanley Hawbaker Co. [D] Commercial product from Pip–Fujimoto Co. Ltd.

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