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Evaluating Odour Attractants for Control of Wild Dogs

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Abstract

Attractants (odours) were assessed for their ability to attract wild dogs (dingoes, feral dogs or their hybrids) in field trials over three levels of population density and four life-cycle behaviour 'seasons'. Visitation rates and the elicited behaviour responses were recorded for eight attractant formulations. Population density exhibited no reliable effect on odour attractiveness. Seasonal factors were shown to influence the attractiveness of specific attractants. The combination of attractiveness and the correct behavioural response towards specific odour-based control devices are discussed.

Introduction

Wild dogs—dingoes (*Canis familiaris dingo*), feral domestic dogs (*C. f. familiaris*), and their hybrids—have long been regarded as serious predators of domestic livestock (Rankine and Donaldson 1968; Fleming and Korn 1989), and are responsible for significant economic losses to the pastoral industry of Queensland (Donohue 1981; Breckwoldt 1983). Growing interest in predator management in Queensland has highlighted the need for more efficient and target-specific control techniques.

Poison baiting and leg-hold trapping are two current control techniques. Both rely on the dogs' olfactory senses, such as an ingestive response to poisoned baits or investigative response to trapping devices. Increasing control effectiveness could therefore be achieved by using attractants or odours to enhance a bait or a leg-hold trap to attract a wild dog to a point of physical contact. A knowledge of the response that wild dogs exhibit to specific odours can be used to develop attractants for improving the effectiveness in terms of target specificity, reduced costs and increased efficiency of control procedures.

The use of attractants for coyote (*Canis latrans*) control in the U.S.A. has been well documented (Linhart *et al.* 1977; Roughton and Bowden 1979; Turkowski 1979, 1982; Fagre *et al.* 1981, 1983; Teranishi *et al.* 1981; Turkowski *et al.* 1983; Bullard *et al.* 1983). In addition, data on olfactory communication in the family Canidae have accumulated in recent years (Johnson 1973; Fox and Cohen 1974; Reiger 1979; Macdonald 1985; Gorman and Trowbridge 1989), with considerable research being conducted on the behaviour of canids towards specific chemicals (Kleiman 1966; Lehner 1978; Goodwin *et al.* 1979; Fagre *et al.* 1981; Bullard 1985). Despite the magnitude of the wild-dog problem in Australia, minimal research has been aimed at acquiring reliable data on the response of dingoes or feral dogs to specific odours.

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The aim of this study was to investigate attractants for incorporation into compound 1080 (sodium monofluoroacetate)-poisoned baits, in order to identify any changes in palatability, species' selectivity and encounter rates. The effectiveness and selectivity of attractants for leg-hold trapping was also considered.

Methods

Study sites were selected in southern and central Queensland: Bringalilly State Forest (28°15'S., 151°10'E.), Western Creek State Forest (27°50'S.,151°5'E.), Barakula State Forest (26°16'S.,150°30'E.), Hillside State Forest (25°48'S.,147°30'E.) and 'Knockbreak' (25°15'S.,150°35'E.). These areas were chosen on the basis of differing densities of wild dogs, as determined by fresh dog 'signs', and on the basis of there being sufficient area to enable the required length of transect lines to be established (minimum of 200 km).

In all, 22 attractants currently used for canine control in Australia and the U.S.A. were initially tested across all seasons to provide baseline data on visitation rates.

Population pressure or 'density' was incorporated into this study to observe whether variations in population size influenced the communicatory power of odours. Since population densities of wild dogs vary according to numerous environmental factors (Mitchell *et al.* 1982), the use of a particular odour or attractant as a control device could be limited if density levels affect the behavioural response to the odour.

Similarly, the influence of changes in behaviour observed during stages of the life cycle were also addressed. If behavioural 'seasons' influence the response to various odours, then the broad use of a particular attractant as a control technique may be restricted to certain periods only.

Density levels were established according to the criteria of Mitchell *et al.* (1982), and consisted of a 'low' population located at Bringalilly State Forest (Inglewood), a 'medium' population at Barakula State Forest (Chinchilla) and Western Creek (Millmerran), and a 'high' population at Hillside State Forest (Mitchell) and 'Knockbreak' (Cracow). A study site corresponding to each density level was then chosen for further testing (low at Bringalilly, medium at Barakula and high at Hillside). These sites were then tested during four behavioural life-cycle seasons corresponding to the mating period (May), the whelping period (August), the denning period (November) and the dispersal of juveniles (February).

The initial field screening of potential attractants recorded 532 wild-dog visits to the 22 selected attractants exposed for a total of 13 040 operable station nights. Eight attractants (Appendix) were selected, on the basis of their superior visitation rate, for subsequent further evaluation in the three density sites selected above. These attractants were further exposed over 20 226 attractant-exposure nights. A total of 77 counting nights was recorded for the 12 individual trials (3 densities $\times$ 4 seasons). Each candidate attractant was exposed approximately 2250 times (the differences in total exposures between attractants was insignificant); 564 scent stations were classed as inoperable during the 12 trials (animal visits could not be determined because of external factors such as rain or cattle trampling).

The field technique employed is a modified version of the procedure used for coyote census in the U.S.A. (Linhart and Knowlton 1975; Roughton and Bowden 1979; Turkowski 1979).

Scent stations (1 m^2 of brushed earth or sand) were established at 500-m intervals on alternate sides of secondary roads, forestry tracks or fence lines. A 5-mL plastic vial filled with cotton wool was placed within the station, 10–20 cm above ground on 20-gauge fencing wire. Individual vials contained 1 mL of a test attractant. Attractants within each group (one sample of each of the eight attractants plus a blank control) were randomly allocated to scent stations. Attractant groups were replicated 30 times for each trial. The presence of animal footprints in the brushed area surrounding the vials was recorded for all visiting species. Footprints of a particular species were counted as one visit regardless of how many prints were observed. All scent stations were examined daily and animal tracks, if present, were smoothed over. Inspections for each trial continued for 5–10 days, depending on environmental conditions and the level of data received. Vials were replaced if contaminated by urine, faeces or saliva, or if they were chewed or removed. Vials containing no attractant were included as controls with each attractant group to examine the visual attraction effects of the vial and the disturbed earth at the scent station.

The behavioural responses exhibited by visiting species to the attractants were broadly categorised into three individual responses: a 'luring' response, where the animal visited the attractant vial and departed; a 'baiting' response, where some ingestive behaviour was shown such as biting or mouthing the attractant vial; and a 'trapping' response, where defaecating, urinating, digging or rolling on the attractant indicated prolonged investigation of the odour.

Visitation rate, the proportion of scent stations visited per night, was calculated for each attractant within seasons and densities. Attractants were first ranked according to visitation rates in terms of their attracting superiority across density levels and behavioural seasons. Secondly, attractants were ranked in terms of the three categories of response described under differing density levels and behavioural seasons.

The effect of density and seasons on the attractiveness was determined by fitting a generalised linear model with a binomial error distribution. A least significant difference test was applied, by using the approximate standard errors predicted by the model. A superior group was defined as those attractants that had either a significantly higher or equivalent visitation rate to all other attractants. Significant differences in the behavioural responses were determined by χ^2 analysis, by using individual χ^2 contribution significant at the 5% level.

Results

Visits of the wild dogs to the attractants totalled 1090. The total visitations to the attractants and the behavioural responses recorded during these visits over all seasons and density levels are presented in Table 1.

Table 1. Visits of wild dogs ($n = 1090$) and behavioural responses to attractants for all trials

Attractant formulations are presented in the Appendix. *Denotes significant χ^2 result ($P < 0 \cdot 05$)

Attractant	Visitation rate (%)	Behavioural response (% of attractant visits)		
		Luring	Baiting	Trapping
1	4·8	82	15	3
2	4·6	58	21	21
3	7·1	47	25*	28*
4	4·9	61	19	20
5	8·6	66*	19	15
6	6·2	54	30*	16
7	5·6	67	18	15
8	7·2	48	24*	28*
9	0·7	67	27	6

In the model for visitation rate, the 2-way interactions between density and attractant, and season and attractant, were significant ($P < 0 \cdot 05$).

Within each density level a number of attractants were ranked in the superior group. Attractants 5 and 3 had a visitation rate either significantly higher than, or equivalent to, other attractants for all density levels (Table 2). The visitation rate for Attractant 6 was either significantly higher than, or equivalent to, that for other attractants at low and medium density. Also, Attractant 8 had a significantly higher or equivalent visitation rate at medium high density.

Comparison between density levels revealed that the high density area attracted significantly ($P < 0 \cdot 05$) more visits than the medium or low density area, for all attractants.

Within each season a number of attractants were ranked in the superior group (Table 3). Across the four seasons, Attractants 3 and 5 had either a significantly higher or an equivalent visitation rate to other attractants. The visitation rate for Attractants 6 and 8 was either significantly higher than, or equivalent to, that for the other attractants for all seasons but one: dispersal for Attractant 6 and whelping for Attractant 8.

Table 2. Mean visitation rates (%) at three densities of wild dogs for each attractant

Within columns, means followed by the same letter are not significantly different ($P > 0 \cdot 05$)

Attractant	Density level		
	Low	Medium	High
1	$3 \cdot 2^{bc}$	$4 \cdot 0^{b}$	$8 \cdot 4^{c}$
2	$3 \cdot 4^{bc}$	$3 \cdot 8^{b}$	$7 \cdot 9^{c}$
3	$4 \cdot 6^{ab}$	$5 \cdot 2^{ab}$	$12 \cdot 8^{ab}$
4	$2 \cdot 9^{bc}$	$3 \cdot 7^{b}$	$9 \cdot 4^{bc}$
5	$5 \cdot 7^{a}$	$7 \cdot 8^{a}$	$14 \cdot 6^{a}$
6	$4 \cdot 1^{ab}$	$6 \cdot 5^{a}$	$9 \cdot 7^{bc}$
7	$1 \cdot 8^{c}$	$3 \cdot 5^{b}$	$14 \cdot 1^{a}$
8	$3 \cdot 5^{bc}$	$5 \cdot 4^{ab}$	$13 \cdot 9^{a}$
9	$0 \cdot 1^{d}$	$0 \cdot 5^{c}$	$2 \cdot 1^{d}$

Table 3. Visitation rates (%) of populations of wild dogs during four behavioural seasons for each attractant

Within columns, means followed by the same letter are not significantly different ($P > 0 \cdot 05$)

Attractant	Behavioural seasons			
	Mating	Whelping	Denning	Dispersal
1	$6 \cdot 3^{c}$	$4 \cdot 7^{bc}$	$5 \cdot 2^{abc}$	$4 \cdot 6^{bc}$
2	$8 \cdot 1^{abc}$	$3 \cdot 4^{cd}$	$3 \cdot 7^{c}$	$4 \cdot 9^{bc}$
3	$7 \cdot 8^{abc}$	$6 \cdot 0^{abc}$	$6 \cdot 6^{ab}$	$9 \cdot 7^{a}$
4	$7 \cdot 2^{bc}$	$6 \cdot 0^{abc}$	$3 \cdot 9^{c}$	$4 \cdot 2^{c}$
5	$11 \cdot 8^{a}$	$8 \cdot 9^{a}$	$6 \cdot 9^{a}$	$9 \cdot 8^{a}$
6	$8 \cdot 2^{abc}$	$7 \cdot 4^{ab}$	$5 \cdot 2^{abc}$	$6 \cdot 2^{bc}$
7	$7 \cdot 5^{bc}$	$7 \cdot 1^{ab}$	$4 \cdot 1^{bc}$	$7 \cdot 2^{ab}$
8	$10 \cdot 6^{ab}$	$3 \cdot 3^{cd}$	$6 \cdot 3^{abc}$	$10 \cdot 3^{a}$
9	$1 \cdot 4^{d}$	$1 \cdot 4^{d}$	$0 \cdot 3^{d}$	$0 \cdot 9^{d}$

Table 4. Significant visitation differences across seasons for each attractant

Within rows, the same letter denotes no significant difference ($P > 0 \cdot 05$) between means (Table 3)

Attractant	Seasons			
	Mating	Whelping	Denning	Dispersal
1	a	a	a	a
2	a	b	b	ab
3	ab	b	ab	a
4	a	ab	b	ab
5	a	ab	b	ab
6	a	a	a	a
7	a	a	b	a
8	a	c	b	a
9	a	a	a	a

Comparisons between seasons for each attractant revealed a number of season by attractant interactions. Some attractants performed consistently across seasons, while performance of others was dependent on seasons (Table 4).

A synopsis of the results (Table 5) shows the attractants that are in the superior group, for each of the three density levels and the four seasons.

Table 5. Summary of the superiorly visited attractant(s) for each condition of density (from Table 2) and season (from Table 3), and the significant behavioural response they initiated

	Behavioural response category			
	Luring	Baiting	Trapping	No significant behavioural response
Density				
High	5, 7	3	3, 8	–
Medium	5	6, 8	–	3
Low	5	3, 6	–	–
Season				
Mating	5	–	8	3, 2, 6
Whelping	5	6	3	4, 7
Denning	1	3, 5	3, 8	6
Dispersal	5	8	3, 8	7

Discussion

The analysis of visitation rates between the density levels demonstrated a consistent increase in visitation rates for all attractants, from low to medium density, with high density having a significantly higher visitation rate. A higher concentration of animals would increase the probability of an animal randomly encountering a scent station. The only inconsistent result, that of Attractant 7, which performed well in high density and poorly in the other densities, cannot be explained.

Analysis of visitation rates between seasons showed that behavioural seasons influenced the attractiveness of particular odours. Turkowski (1979) also found a seasonal effect on odour attractiveness in coyotes. This result is important when considering strategic control procedures. For example, poison baiting in Queensland has generally been a seasonal operation, most baiting being conducted in the mating season (May) or the denning season (October). Attractants incorporated into these control programmes need to consider the effect that seasonal life-cycle patterns may play in influencing the attractiveness of particular odours.

Attractant 5 was in the superior group across all population densities and behavioural seasons. A significantly higher visitation rate was shown in the mating season than in the denning season. Attractant 5 was derived from a popular U.S.A. coyote lure ('long distance call'). The biological components of this attractant (anal glands and urine) are assumed to have communicatory significance in terms of territorial maintenance and identification, and sexual status of individuals (Preti *et al.* 1976; Bullard 1982). Thus, the components should have a significance to wild dogs in most situations because the behavioural drives of territory maintenance, sexual status and identification are paramount to all sections of wild-dog populations. The reduced visitation rate in the denning season could be explained by the undeveloped behavioural response of young pups not exhibiting this territorial identification and sexual response.

Analysis of the behavioural response of Attractant 5 revealed a significantly high response in the luring category. This attractant could be beneficial for the technique of 'luring' wild dogs into specific control areas. Consequently, the encounter rate of the devices could be increased. These luring or 'calling' attractants (Turkowski 1982) could also be used in close proximity to baits or leg-hold traps to increase their sphere of influence. For example, baits with ingestive or baiting attraction may only influence the behavioural response from a relatively short range. The use of a 'calling lure' would entice the dog close enough to the bait for the baiting attractant to exert its desired behavioural influence (ingesting the bait). This two-part effect could also be used in trapping situations.

Attractant 3 was also in the superior group for all densities and for all seasons. This formulation of various biological (anal glands, urine and fermented eggs) and synthetic (synthetic fermented egg and synthetic skunk) components, was also derived from a coyote-trapping lure formulation. There was a significantly higher visitation rate during the dispersal season than the whelping season for this attractant. This could be explained by the assumed reduced response during the whelping season to sexual and territorial stimuli that are found in this attractant's components. The behavioural responses indicated for this attractant include both the baiting and trapping responses. The range of odours contained in this formulation may explain the level of visitation under varying conditions of density and season.

Attractant 8, synthetic fermented egg, was derived from the major components of a fermented egg product (Bullard *et al.* 1978), which is currently used in the U.S.A. for coyote control. Synthetic fermented egg consists primarily of short-chain fatty acids which are also found in canid anal sacs and decaying animal tissues (Bullard 1982). Bullard *et al.* (1983) suggest that the volatile fatty acids are probably the most critical odour components for attracting coyotes. These are found in a variety of animal tissues and scent-gland secretions, and may influence hunger and mating drives (Turkowski 1979). The hunger drive may account for the significantly high response in the baiting behaviour category, where an ingestive response was displayed. The mating drive may explain the significantly high response in the trapping behaviour category, which is consistent with scent-rolling and scent-gland investigation of conspecifics. This attractant also showed significant differences in visitation rate related to seasonal influences. Again, as indicated with Attractants 5 and 8, a significantly low visitation rate in the whelping season may be assumed to be due to reduced response to stimuli not directly related to caring for the pups.

Attractant 6 could be considered to be a baiting attractant, i.e. one that is incorporated on or within bait material. In terms of behavioural response, this attractant received a significantly higher response in the baiting category in the whelping season, when food procurement would be a priority. Indeed, tuna oil could be assumed to represent a food source. The attractant was in the superior group for all seasons and all densities (except dispersal), making it acceptable for baiting purposes under the broad range of environmental conditions encountered in Queensland.

Attractant 1, the faeces–urine mixture, was only included in the superior group once, in the denning season. A luring behavioural response was provoked by this attractant but not the defaecating, rolling or scratching behaviour desired to increase trap success. The attractant ranked significantly low in the trapping behaviour response. This result is interesting in that the components, dog urine and faeces, have traditionally been regarded as major components of the lures set by professional dingo-trappers.

The effectiveness of wild-dog control techniques currently used in Queensland depends largely upon the passive odour attraction of wild dogs to these control devices. Visitation rates reveal the attractiveness of the odour while the behavioural responses signify the types of control devises that would have an increased probability of success. Thus, an odour that stimulates urine-marking or rolling behaviour will obviously have little control effectiveness if incorporated into a poison bait. A particular control device must incorporate the odour which stimulates the dingo to interact with the device in the desired manner to ensure the successful operation of the device.

Hence, an attractant with a high visitation rate may not necessarily be the most effective in a control situation. The behavioural response will determine the type of control technique in which the attractant could be utilised; however, the visitation rate or the attractiveness will determine its effectiveness. It is the combination of attractiveness and desired behaviour that will ultimately determine the effectiveness of the attractant in a particular control situation.

The attractants identified in this study were not presented to wild dogs in the most effective manner. Odours in plastic vials, on disturbed earth plots and in non-strategic positions do not constitute an effective control technique. Also, the addition of attractants to bait material may present problems of acceptability or palatability. The bait medium may also influence the acceptance of palatability of baits, as Newsome *et al.* (1972) found in their assessment of aerial baiting with commercial 'cracknel' baits. Here, the incidence of dogs ingesting baits in field trials was very low and a low palatability was observed in pen studies. Allen *et al.* (1989) found fresh meat to be significantly more palatable to wild dogs than commercially available factory baits. Further studies are required to optimise the bait–attractant–delivery-system matrix for field control situations.

The prospects for utilising attractants in control programmes are influenced by diverse factors such as manufacturing costs, availability of ingredients, and the time and expertise needed for manufacture. The development of synthetic attractants will alleviate many of these problems; odour qualities would be consistent, ingredients would be easily obtainable and the attractants could be used immediately after formulation. The attractant formulations identified in this study as showing some potential to increase the effectiveness of wild-dog control should be viewed in a preliminary capacity. The components of the odour that influence attractiveness or stimulate a required response need to be identified so that research can continue into the development of inexpensive, effective and commercially produced synthetic attractants. This study is intended to generate further research in this direction.

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Appendix. The eight attractants (1–8) plus the control (9) formulations

Attractant	Formulation
1	Equal-parts mixture of canid faeces, urine and water
2	200 mL fermented female dingo sexual organs, 50 mL canid urine, 5 mL asafoetida, 10 mL glycol, 20 mL honey
3	600 mL fermented canid anal glands, 4 rotten eggs, 10 mL 1-Butanethiol, 10 mL synthetic fermented egg (8), 300 mL canid urine, 100 mL glycol
4	500 mL canid urine, 50 mL glycol, 5 mL 1-Butanethiol
5	85 g fermented canid anal glands, 20 mL canid urine, 10 mL synthetic musk, 20 drops mercaptan, 20 mL alcohol, 20 mL glycol
6	20 mL synthetic fermented egg (8), 500 mL commerical tuna oil, 10 mL canid urine, 100 mL glycol
7	300 mL acetic acid, 40 mL propionic acid, 5 mL isobutyric acid, 35 mL butyric acid, 1 mL valeric acid, 35 mL trimethyl amine, 10 mL ethanol, 150 mL acetone, 10 mL isovaleric acid, 300 mL water
8	418 mL caproic acid, 351 mL butyric acid, 71 mL hexyl amine, 72 mL trimethyl amine, 6 mL dimethyl disulfide, 2 mL 2-mercaptoethanol, 90 mL ethyl caproate
9	Visual attractant only

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