



A REVIEW OF 30 YEARS OF CANID ATTRACTANT RESEARCH

Steven J. Lapidge

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INTRODUCTION

Predation by, disease spread from, and general management of introduced European red foxes (*Vulpes vulpes*) and wild dogs (*Canis*) is a multi-million dollar problem in Australia. Queensland alone recently estimated that wild dogs cost that state's economy \$33M annually. Effective local management tools for foxes and wild dogs are therefore essential for land managers to ensure they can minimise the impact of these species on stock or native wildlife. One such tool that has not been widely adopted in Australia is that of attractants or lures.

Olfaction is a primary source of communication for canids. They use it to relate information on reproductive condition, social status of individuals, and group and individual territories. Urine, faeces, vaginal and anal gland excretions, and sebcaudial (circumanal, subcaudal and subauricular) gland excretions are all potential sources of odour and information in Canidae, and all have been used as natural canid attractants by canid trappers for decades.

The term 'attractant' or 'lure' generally evokes a passionate reaction. The idea that someone or something can alter the behaviour of another being through the use of odours is highly appealing to most people. In fact it is a behaviour we constantly elicit through masking our natural human odours and replacing them with the attractive odours of animals and/or plants. In some cases, through the use of perfume or aftershave, the application of such lures is purposefully done to attract attention and cause visitation in much the same way as the canid lures discussed within. As such, the principles behind and reasons for researching canid lures are evident to most people.

Lures can be classified by what they are trying to appeal to, specifically appetite (food lures), curiosity (novel lures), reproduction (sexual lures), aggression (hierarchy lures) or nature (environmental lures). Just as no natural or synthetic smell is appealing to every human, it seems evident that this is also the case with canids. Species, age, sex, weather, life cycle, food supply and habitat are key factors contributing to what is found attractive to a canid at any one point in time. What may be highly attractive to a male fox one day may be uninteresting later as he moves into an area with abundant food and the breeding season ends.

Wild canids are highly mobile, intelligent and wary. For a canid lure to be effective it must be compelling enough for the canid to override its natural senses of wariness and seclusion so as to stop and investigate the source. It must also be potent enough to attract a dispersing animal, but not so overpowering that it creates suspicion about the source and in turn neophobia.



An ideal canid attractant should also:

- (i) volatilise to enable carriage by wind,
- (ii) create compelling interest,
- (iii) be attractive to all demographics,
- (iv) be attractive in all seasons,
- (v) be species specific,
- (vi) have a low detection threshold,
- (vii) be effective at various concentrations,
- (viii) elicit specific wanted behaviours,
- (ix) be biologically important to the animal in relation to food, sex or dominance. Further preferred characteristics of a canid lure may include factors such as;
- (x) ingredients are inert, cheap, stable, easily stored and commonly available,
- (xi) the lure is simple to make,
- (xii) it is effective in small doses,
- (xiii) it is not so volatile that it evaporates immediately,
- (xiv) it biodegrades upon exposure to the elements, and
- (xv) it is non-toxic, non-corrosive and safe for human deployers and animal consumers alike.

Availability of an effective and reliable canid lure for the attraction of coyotes (*Canis latrans*), foxes and wild dogs (collectively called canids from here on) can offer many advantages to land managers. Some of those benefits include:

- aiding in canid detection
- assisting in decision-making processes as to the necessity and feasibility of lethal control,
- increasing visitation to traps, baits or mechanical ejector (M-44) stations, and
- reducing the amount of baiting required for control of canids in a particular area.

This latter factor provides two main advantages: reducing the costly labour quotient in predator management, and reducing the toxin distribution and hence exposure of non-target animals, such as native wildlife and working dogs.

The following report reviews 30 years of canid lure research through 36 publications. Although the review is relatively exhaustive, there are other publications that could not be retrieved, and there may be others that were not found. The aim of this review was to identify:

- (i) the most promising canid lures, their ingredients and recipes,
- (ii) suitable applicators, dispensers and bait media,
- (iii) lure concentrations and volumes required,
- (iv) 'dead ends' or non-significant findings, and
- (v) the most promising lure-dispenser combinations for further investigation and potential commercialisation.

The views expressed are those of the author and are not necessarily shared by Pestat Ltd.

Synopsis of published attractant research

No.	Reference	Species	Attractant	Presentation / method	Results
1	Linhart, S.B. and Knowlton, F.F. (1975) Determining the relative abundance of coyotes by scent station lines. <i>Wildlife Society Bulletin</i> 3: 119-124	Coyote	Granulated fermented egg (FEP), as only slightly less attractive than coyote urine	-50 stations, 0.3-mile intervals, 14.7-mile route. -1 g in perforated plastic capsule in 1 m quadrat 1" above ground. Set & checked for 5 nights	-Wolves and red, kit, swift & grey foxes also recorded plus many non-canids. -Good for large-scale comparison, but not actual numbers.
2	Linhart, S.B., Dasch, G.J., Roberts, J.D. and Savarie, P.J. (1977) Test methods for determining the efficacy of coyote attractants and repellents. In <i>Test Methods for Vertebrate Pest Control and Management Materials</i> . ASTM STP 625, W.B Jackson and R.E. Marsh, Eds. American Society of Testing Materials, p 114-122.	Coyote	Repellent- cinnamic aldehyde + others Attractants- coyote urine, CFA, CFA + urine, FEP, control	-Pen: 5-20 ml poured on live rabbit then released. -Kill rates measured in 8 m ² pens -Field: as per 1. Glycerol used to slow down attractant release.	-No repellent was found to be effective in field trials. -4 attractants elicited similar visitation rates, although CFA and FEP caused more behavioural responses. -CFA best for digging.
3	Timm, R.M., Howard, W.E., Monroe, M.W., Teranishi, R. and Murphy, E.L. (1977) A method of evaluating coyote scent baits. In <i>Test Methods for Vertebrate Pest Control and Management Materials</i> . ASTM STP 625, W.B Jackson and R.E. Marsh, Eds. American Society of Testing Materials, p 151-156.	Coyote	None tested	On cotton wool in 38 x10 mm perforated disposal plastic tissue capsule.	Results not provided.
4	Bullard, R.W., Leiker, T.J., Peterson, J.E., Kilburn, S.R. (1978) Volatile components of fermented egg, an animal attractant and repellent. <i>Journal of Agricultural Food Chemistry</i> 26: 155-159.	Coyote deer	FEP- patented as a synanthropic fly bait	Technical paper	-76 volatile components identified. -Volatile fatty acids and amines occur in many fermented food products and canid anal gland secretions

No.	Reference	Species	Attractant	Presentation / method	Results
5	Bullard, R.W., Shumake, S.A., Campbell, D.A., Turkowski, F.J. (1978) Preparation and evaluation of a synthetic fermented egg coyote attractant and deer repellent. <i>Journal of Agricultural Food Chemistry</i> 26: 160-163.	Coyote, deer	FEP- 94 compounds SFE- initial formulation, 70 compounds chosen VFA- basis of SFE, 6 compounds	-Assessed using 18-member human odor panel, then trialed on deer and coyotes. -Coated on deer pellets with corn oil for deer. -As per 1 for coyotes; 1.2 g powder or 2 ml liquid on cotton ball. Polyamide resin used to prolong SFE release. 33% solution in propylene glycol absorbed into polyamide resin= 4% SFE w/w.	-Acceptance of SFE coated pellets lower than FEP coated pellets for deer (P=0.14) - Coyote visits: Conc. SFE 33% (P<0.01), VFA 25%, FEP 21%, SFE resin 15% & control 6%- liquids performed better. -SFE never surpassed by commercial or trapper lures. -VFA slightly better than SFE in eliciting digging.
6	Roughton, R.D. and Bowden, D.C. (1979) Experimental design for field evaluation of odor attractants for predators. In <i>Test Methods for Vertebrate Pest Control and Management Materials</i> . ASTM STP 680, J.R. Beck, Eds. American Society of Testing Materials, p 249-254.	Coyote	SFE ASFE SMP SFE esters SFE fatty acids	-Refinement of method in ref. 1: 10 x 4.3km transects containing 10 stations spaced 0.48km apart. 3 to 5 km between replicate transects. -1 g of each in perforated capsule -Set & checked for 5 nights over 7 locations	-Ave. visits: SFE 20%, ASFE 16%, SMP 16%, SFEe17% and SFA 18%. -location variations significant (P<0.01)
7	Turkowski, F.J., Popelka, M.L., Green, B.B. and Bullard, R.W. (1979) Testing the reponses of coyotes and other predators to odor attractants. In <i>Test Methods for Vertebrate Pest Control and Management Materials</i> . ASTM STP 680, J.R. Beck, Eds. American Society of Testing Materials, p 249-254.	Coyote	58 lures compared, incl. SFE/DRC-6500 Oregon ADC Carmans distant call Mast's no. 6 Arizona ADC Nevada ADC Nth Dakota ADC	-As per ref.1,2. Cellulose sponges with 2.4 ml of attractant in each capsule. -trials conducted over 28 mths- 8091 coyote visits -trials of SFE resin concentrations (4-12%) showed 8% conc. gave greatest coyote response -sponges twice as effective as resin	-Lure index: SFE 100, Oregon 89, Carmans 81, Masts 67, Arizona 64, Nevada 53, Dakota 52, blank 34. -Mast's no. 6 best for digging -SFE 'nearly the best attractant in all tests' and 'tends to attract more adults' -Sep/Oct biggest response -11 other carnivores, 8 ungulates & opossums also attracted to lures

No.	Reference	Species	Attractant	Presentation / method	Results
8	Whitten, W.K., Wilson, M.C., Wilson, S.R., Jorgenson, J.W., Novotny, M. and Carmack, M. (1980) Induction of marking behaviour in wild red foxes (<i>Vulpes vulpes</i>) by synthetic urinary constituents. <i>Journal of Chemical Ecology</i> 6: 49-55.	Red fox	Δ^3 -Isopentenyl methyl sulphide major comp. + 7 other synthetic volatiles identified in fox urine	-Ethanol used as a transfer solvent and polyethylene glycol (PEG) as odour fixative -PEG incr. Odour presence from 2 to 40 hrs -10-15 ml poured on fresh snow mounds	-Lure significantly increased urine marking behaviour. -Useful technique in the detection of foxes at low density.
9	Roughton, R.D. (1982) A synthetic alternative to fermented egg as a canid attractant. <i>Journal of Wildlife Management</i> 46: 230-234.	Coyote, fox	FEP- various batches 4 % SFE in resin Commercial lure FAS ASFE SFEe	-As per ref 1. -SFE in propylene glycol & absorbed into resin -6 other carriers tested: soya protein, polyvinyl alcohol, 2 powdered cellulose, natural & processed diatomaceous earth	-Batches of FEP produced varying results -SFE sig. < visitation than FEP or commercial (rated the same), esp. for coyotes -carriers produced no sig diff: 45-49% volatilization at 14 days, but no change in vapour composition -states FAS = SFE & both > SMP, but no results to confirm this
10	Roughton, R.D. and Sweeny, M.W. (1982) Refinements in scent-station methodology for assessing trends in carnivore populations. <i>Journal of Wildlife Management</i> 46: 217-229.	Coyote	Technical paper- although FAS promoted	Compared visitation to free liquid, earth, plaster, waxes and saturated plastic disk in capsules	Volatilisation highest from saturated plaster disk, although coyote visitation did not differ between presentation methods.
11	Fagre, D.B., Howard, W.E., Barnum, D.A., Teranishi, R., Schultz, T.H., and Stern, D.J. (1983) Criteria for the development of coyote lures. In <i>Vertebrate Pest Control and Management Materials</i> . D. E. Kaukeinen, Ed. ASTM STP 817, American Society for Testing and Materials, pp. 265-277.	Coyote	W-U lure Carman's Distant Call SFE	<u>W-U lure</u> : salt of Trimethylammonium decanoate (TMAD) + methylbutyl sulphide (MBS)(no recipe given).	-TMAD produced copious licking and biting, is non-toxic, cheap, stable, simple to produce and consistent odour properties. -TMAD + MBS prolongs visit -W-U more effective in breeding season -SFE visited more than CDC & W-U in field

No.	Reference	Species	Attractant	Presentation / method	Results
12	Bullard, R.W., Turkowski, F.J., and Kilburn, S.R. (1983) Responses of free-ranging coyotes to lures and their modifications. <i>Journal of Chemical Ecology</i> 9: 877–888.	Coyote	Modifying SFE to examine behaviour and for enhancement/validation purposes, FEP and abbreviated SFE	1) enhance one of the 4 odours- fruity, sulphurous, sweaty and fishy 2) delete one of the 4 odours 3) individually testing odour components 4) addition of aldehydes & indoles to SFE -presented in 1 m scent stations containing 1.2 g of powder or 1 ml liquid absorbed into sponge	-similar visitation occurred despite changes to SFE -behavioural responses incr. with odour intensity (intensity more imp. than quality) -7 component abbreviated SFE was equal to 70 component SFE -FEP better than SFE-resin
13	Turkowski, F.J., Popelka, M.L., and Bullard, R.W. (1983) Efficacy of odor lures and baits for coyotes. <i>Wildlife Society Bulletin</i> 11: 136–145.	Coyote	SFE: DRC-6500, ASFE: DRC-6503, Oregon trap, CDC, Masts 6, Arizona trap, Nevada trap, N.D. M-44	-Turkowski et al. 1979 survey technique in Texas -lures added to polyamide resin particles and placed in tissue capsules -Lure paste for traps & M44's made using 42% plaster of paris, 42% Vaseline & 16% lure -ASFE also contained in liquid resin (propylene glycol) in a pressurised aerosol can with propellant	-SFE best for visiting, pulling & carrying; high for biting & digging -ASFE ~90% as effective as SFE -11 other carnivore spp attracted to stations -ASFE caused 42% pull rate on M44's -aerosolised ASFE well received by field personnel, but corroded the valves and the samples were discarded. -Lure pastes not particularly effective
14	Conner, M.C., Labisky, R.F. and Progulske, D.R. (1983) Scent-station indices as measures of population abundance for bobcats, racoons, gray foxes and opossums. <i>Wildlife Society Bulletin</i> 11: 146-152.	Bobcats, racoons, foxes, opossums	Bobcat urine placed on cottonball	Compare scent-station indices to pop. abundance estimates based on trapping, radioisotope tagging and radiotelemetry	-Scent-station indices detected area-wide -changes in abundance and habitat use -stations spaced 0.32 km best -use 1 night for common spp, more for rarer spp.
15	Scrivener, J.A., Howard, W.E., Teranishi, R. and Fagre, D.B. (1985) Towards a more effective coyote lure. <i>Rangelands</i> 7: 52-54.	Coyote	TMAD Liver extracts	-Review paper -Promotes TMAD without evidence.	-TMAD exceeds all other single compound lures- particularly for licking & biting -possibility as M-44 capsule attractant

No.	Reference	Species	Attractant	Presentation / method	Results
16	Martin, D.J., and Fagre, D.B. (1988) Field evaluation of a synthetic coyote attractant. <i>Wildlife Society Bulletin</i> 16: 390–396.	Coyotes	W-U lure CDC Masts #6 ASFE	-Turkowski et al. 1979 survey technique in Texas -1 ml conc. lure absorbed into cellulose sponge -non-target visitation examined with all lures attracting ~ 1% non-target take.	-Visits to W-U> CDC> ASFE> Masts> control -visits & pulling highest in summer, lowest in winter & visits peaked at day 3 of 6 -W-U better than ASFE at eliciting pulling
17	Mitchell, J. (1988) <i>The development of chemical attractants for the control of dingos/wild dogs in Queensland</i> . Rural Lands Protection Board Report, Queensland.	Dingo/ wild dog	1 canid faeces/urine 2 Ed Carroll A (below) 3 Ed Carroll B (below) 4 Skunk lure 5 Long distance call 6 Tuna lure 7 SAG 8 Abbreviated SFE	-Pilot field trials followed by pen trials then extensive field trials -latter occurred at 3 densities & in different seasons (mating, whelping, pups & dispersal) following Turkowski et al. 1979	-Lure 1 & 5 best for visitation, 6 for baiting and 3 & 8 for trapping -lure 1>8>all others during diff. seasons -SFE best during dispersal -mating season is best time to use lures -SFE fits 'ideal lure requirements' best
18	Stolzenburg, H.W. and Howard, V.W. (1989) Activation of liquid bait devices by coyotes in southern New Mexico. <i>Wildlife Society Bulletin</i> 17: 306-312.	Coyote	SFE WUC GOV	CLOD- Coyote Lure Operative Device SFE- 30 ml + 500 ml bacon grease & veggie oil	GOV>WUC>SFE for CLOD activation SFE=WUC>GOV for CLOD consumption CLOD's had 19% non-target take. ∴ not as species specific as M-44's
19	Blom, S. (1990) <i>A guide to ingredients and formulations for coyote lures and baits</i> . Denver Wildlife Research Centre, U.S. Department of Agriculture.	Coyote	Numerous- paper discusses raw ingredients of all lures	Preservatives: glycerine (glycerol), propylene glycol and sodium benzoate. Tinctures: to dilute a concentrate- denatured ethyl alcohol or vodka are best.	Sugar enhances the lick-bit-chew response of food lures to coyotes. Glycerol serves as an anti-freeze in winter & retards evaporation in summer.
20	Phillips, R.L., Blom, F.S., and Engeman, R.M. (1990). Responses of captive coyotes to chemical attractants. In <i>Proceedings of the Vertebrate Pest Conference</i> . L.R. Davis and R.E. Marsh, Eds. pp. 285–289. (University of California: Davis.)	Coyote (captive)	1 W-U lure, 2 TMAD 3 ASFE, 4 FAS, 5 CFA 6 artificial smoked fish flavour 7 art. beef liver flavour 8 yeast autolysate 9 decanoic acid	-Lures soaked into gauze on M-44 shell holder tops. - Individual animals (36) tested in 225 m ² enclosures i.e. very small.	-W-U> FAS> CFA> TMAD> ASFF>DA > YA -W-U or FAS scored highest during the seasons of breeding, whelping and dispersal -SFE mainly caused sniffing and rub-rolling

No.	Reference	Species	Attractant	Presentation / method	Results
21	Jolley, S.E. and Little, L.M. (1991) The development of a target specific lure complex to increase the efficacy of canine control procedures. The Land Protection Branch, Queensland Department of Lands.	Dingo	-53 compounds from urine, faeces & glands -ASFE, tuna lure, SAG, W-U -Aim to commercialise	Pen trials- 2 ml in vial sunk into ground randomly in a 5,700 m ² enclosure Field- modified Turkowski, with lure pairs (50 m apart) every 500 m. Lures presented as disks	-Dimethyl sulphide (highly volatile) + ethyl caproate or carboxylic acid is a promising lure mixture for dingos -high correlation b/w pen and field tests -ASFE best in the field trials -W-U produced limited success in the field
22	Mitchell, J. and Kelly, A. (1992) Evaluating odour attractants for control of wild dogs. <i>Wildlife Research</i> 19: 211-219.	Dingo/wild dogs	22 attractants initially 8 superior & re-tested -same as ref 17	This published papers has developed from the internal report review as ref. 17	LDC>ASFE>all others for visitation ASFE sig better for baiting and trapping Tuna lure would be valuable bait addition
23	Jolley, S.E. and Jolley, L.M. (1992) Pen and field tests of odor attractants for the dingo. <i>Journal of Wildlife Management</i> 56: 452-456.	Dingo (captive)	ASFE, butanethiol, heptaldehyde, decanoic acid, hexylamine+ decanoic acid + 2-mercaptoethanol	This published papers has developed from the internal report review as ref. 21	-ASFE had greatest response in pen & field trials, followed by butanethiol and HDM mixture
24	Blom, S. (1994) <i>Ingredients for coyote attractants: functions and uses</i> . Pocatello, Idaho. U.S. Department of Agriculture.	Coyote	Too numerous to mention	This report, like ref 19, lists in detail the many potential ingredients for canid lures.	Synthetics: concentrate should be diluted to 20% for trapping and from 10-20% for M-44's using ethanol and glycerol etc
25	Phillips, R.L. and Blom, F.S. (1994) Field evaluation of chemical attractants for summer use on M-44's. In <i>Proceedings of the Vertebrate Pest Conference</i> . W.S. Halverson and A.C. Crabb, Eds. pp. 51-56. (University of California: Davis.)	Coyote	W-U lure art. beef liver flavour art. smoked fish flavour Fatty Acid Scent	-Used on M-44 tops- VET-WRAP dipped into a hot matrix of the attractant (10%), plaster of paris, melted paraffin wax and melted bees wax. -Measured during summer months in 5 states using Turkowski method	-M-44's take 26% of all coyotes destroyed -FAS (7%)> W-U (5.6%)> flavours (<4.7%) for visitation and pull rates -Maximum pull rate was still only 1/40 -deer and cattle attractant to M-44's, maybe for the salty tops?

No.	Reference	Species	Attractant	Presentation / method	Results
26	Windberg, L.A. (1996) Coyote responses to visual and olfactory stimuli related to familiarity with an area. <i>Canadian Journal of Zoology</i> 74: 2248-2253.	Coyote (captive)	FAS W-U Coyote urine Liquid faeces	Trialed coyotes against different sized boxes and different lures in familiar and unfamiliar enclosures to examine neophobia	-FAS>W-U>urine>faeces -coyotes more responsive during exploration in unfamiliar enclosures -visual cues (blocks) are more likely to elicit neophobic responses than lures in familiar environments
27	Travaini, A., Laffitte, R. and Delibes, M. (1996) Determining the relative abundance of European red foxes by scent-station technology. <i>Wildlife Society Bulletin</i> 24: 500-504.	Red fox	FAS ASFE Monkey pheromone	-Turkowski methodology -Trials conducted twice monthly for 1 year, then twice annually for three years	-Visitation did not significantly differ b/w lures, although FAS=ASFE>MP -ASFE selected for low cost & ease of prep. -Other carnivores, wild pigs, deer, rabbits, rodents & birds also recorded in plots
28	Woelfl, S. and Woelfl, M. (1997) Coyote, <i>Canis latrans</i> , visitations to scent stations in southeastern Alberta. <i>Canadian Field-Naturalist</i> 111: 200-203.	Coyote	FAS Sardines	-Turkowski methodology -FAS applied to cotton ball & placed in perforated plastic capsule -Sardine wrapped in bandage and nailed to stake	-FAS>sardines, although no significant difference determined -Sardines cheaper, but needed replacing more.
29	Edwards, G.P., Piddington, K.C. and Paltridge R.M. (1997) Field evaluation of olfactory lures for feral cats (<i>Felis catus</i> L.) in Central Australia. <i>Wildlife Research</i> 24: 173-183.	Feral cat	13 olfactory + 1 visual blood & bone, cod-liver oil, fish emulsion, sardines, anchovies, sun-rendered (SR) fish, SR prawns, SR oysters, fresh prawns, fresh oysters, cat-nip leaves, male anal gland + urine, female anal gland + urine, last 2 with/without feathers	-lures presented as 2 ml on sponge in plastic vials with perforated lids set 7 cm above ground - Turkowski methodology - trials occurred in winter, semi drought conditions north of Alice Springs	-Dingos visited more lure stations than feral cats, possibly causing cats to avoid them -478 dingo visits to 128 cat visits -SR prawns had highest dingo visitation (17%) and cat visitation (7.6%) -Dingos chewed vials, cats didn't i.e. M-44's or CLOD's less likely to be effective on feral cats. -SR prawns & anal glands the only lures to elicit a response in feral cats
30	Holmes, J.J. (1998) An evaluation of censuring methods and lures for feral cats (<i>Felis catus</i> L.). B.Sc. (Hons) Thesis, Australian National University.	Feral cat	Rotten egg, mouse faeces, raw beef sausage, catnip, prawn paste, tuna & control	Lures presented in standard manner in sand plots using volunteers	-Trials using volunteers discarded -Later trials showed tuna> prawn> sausage > control, however results not significant. -no synthetics trialed

No.	Reference	Species	Attractant	Presentation / method	Results
31	Kimball, B.A., Johnston, J.J., Mason, J.R., Zemlincka, D.E. and Blom, F.S. (2000) Development of chemical coyote attractants for wildlife management applications. In <i>Proceedings of the Vertebrate Pest Conference</i> . T.P. Salmon and A.C. Crabb, Eds. pp. 304-309. (University of California: Davis.)	Coyotes (captive)	-Assessed 33 commercial lures to form seven new chemical attractants. -Used FAS as positive control	-Pen trials presenting 1 ml of attractant (20% lure in glycerol) in serum tubes in ground	-Sig. greater visitation to attractants in winter than summer -Sig. diff. in each lures attractiveness between seasons i.e. N-ethyl butylamine most 'attractive' in summer and ethyl butyrate + isobutyric acid in winter
32	Kimball, B.A., Mason, J.R., Blom, F.S., Johnston, J.J. and Zemlicka, D.E. (2000) Development and testing of seven new synthetic coyote attractants. <i>Journal of Agricultural Food Chemistry</i> 48: 1892-1897.	Coyote	As above per ref 31	This publication relates directly to the above presentation.	-Lure 1 (predominantly isobutyric acid) promoted the highest amount of digging ∴ bait applicability -Lure 2 (predominantly N-ethyl butylamine) promoted the highest amount of pulling ∴ M-44 applicability -however, both produced high amounts of the undesirable traits of rubbing and rolling.
33	Saunders, G. and Harris, S. (2000) Evaluation of attractants and bait preferences of captive red foxes (<i>Vulpes vulpes</i>) <i>Wildlife Research</i> 27: 237-243.	Red foxes (captive)	Beef, chicken, tuna, trimethylamine, valeric acid, dimethyl disulphide, hexylamine, ethylcaproate, ASFE	-10 adult foxes trialed in summer to autumn (season 1) & winter to spring (season 2) -season 2 includes mating & dispersal -0.5 ml placed on filter paper in petri dish in enclosure	-ASFE obtained the highest visitation rate, particularly in season 2 -delivery of baits, particularly contraceptives, would be enhanced with ASFE -Valeric acid perhaps the most consistent in both seasons
34	Allen, L. and Gonzalez, T. (2001) Evaluating attractants for mechanical ejectors-preliminary results. In <i>Proceedings of the 12th Australasian Vertebrate Pest Conference</i> , Melbourne, Australia. pp 220-224.	Dingo & red fox	Canine Call, Magna Glan, Final Touch & Trail's end from USA Fermented meat, cooked liver, tuna oil and salami	1. Grubstakes with 3 cm of Armaflex soaked with lure placed 250 m apart on tracks 2. M-44's	-Magna Glan & Canine Call superior for attractiveness -Fermented meat & salami superior for pulling M-44's -no synthetics tested -evidence that lures can cause neophobia



Acronyms and some recipes

- FEP Fermented Egg Product.
- CFA Canine Fatty Acid.
- DFA Canine fatty acid + coyote urine.
- SFE Synthetic Fermented Egg; also known as DRC- 6500. 70 compounds.
- ASFE Abbreviated Synthetic Fermented Egg; also known as DRC-6503: 41.8% capronic acid, 35.1% butyric acid, 8% ethyl caproate, 7.1% hexyl amine, 7.2% trimethyl amine (25% aqueous), 0.6% dimethyl disulfide and 0.2% 2-mercaptoethanol.
- VFA Volatile Fatty Acid.
- SMP Synthetic Monkey Pheromone or DRC-6220 (rhesus monkey vaginal excretions): acetic 10%, propionic 7%, isobutyric 3%, butyric 40%, isovaleric 30%, isocaproic (methyl valeric) 10%.
- ADC Animal Damage Control.
- FAS Fatty Acid Scent: acetic 1.48%, propionic 4.42%, isobutyric 1.60%, butyric 26.70%, isovaleric 1.79%, valeric 8.14%, isocaproic (methyl valeric) 2.12%, caproic (hexanoic) 30.25%, heptanoic 12.70%, caprylic (octanoic) 10.80% acids.
- SFEe Synthetic fermented egg ester.
- TMAD Trimethylammonium decanoate, as in W-U lure.
- MBS Methylbutyl sulphide, as in W-U lure.
- CDC Carmen's Distant Call.
- Ed Carroll A- 200 ml fermented female sexual glands, 50 ml canid urine, 5 ml asafoetida, 10 ml glycol and 20 ml honey.
- Ed Carroll B- 600 ml fermented canid anal gland, 4 rotten eggs, 10 drops skunk essence, 10 drops SFE, 300 ml canid urine and 100 ml glycol.
- LDC Long Distance Call: 85 gm fermented canid anal gland, 20 ml canid urine, 10 ml synthetic musk, 20 drops skunk essence, 20 ml alcohol and 20 ml glycol.
- SAG Synthetic Anal Gland: 300 ml acetic acid, 40 ml propionic acid, 5 ml isobutyric acid, 35 ml butyric acid, 1 ml valeric, 35 ml trimethyl amine, 10 ml ethanol, 150 ml acetone, 10 ml isovaleric acid and 300 ml water.
- WUC® Western Regional Research Centre- University of California coyote lure.
- GOV O'Gorman's Government Call.



DISCUSSION

The review details presented above provide a limited summary of 30 years of canid attractant research. The purpose of this review was to identify synthetic canid lures with potential for commercialisation, and not to review their often very similar methods of field application (see Linhardt and Knowlton 1975 and Turkowski et al. 1979). Accordingly, in this exercise I have focussed specifically on the attractants, their formulation, presentation and performance. I have often oversimplified, or sometimes not included, other results in each study such as detailed methodologies and test site variables.

Desirable characteristics of a canid attractant suitable for commercialisation include prospective uniformity between batches, high attractiveness to the species of primary interest, availability in quantity, acceptable cost, ease of formulation, and handling convenience. Only a synthetic lure can potentially satisfy all of these characteristics. Synthetic lures also have the added advantage of being able to be used as a 'standard' against which other current or future attractants of interest can be compared. Moreover synthetic lures elicit a greater amount of information about characteristics of the canid population being studied, such as its population density, through their capacity for being maintained as a constant assessment method across time and place.

Although it was not documented in detail in the above table, numerous studies show that canids respond little to individual chemicals found naturally in urine, faeces or glands, but rather, respond to mixtures of such chemicals. Chemical mixtures do not, however, have to be complex. Sometimes two chemicals combined, such as dimethyl sulphide and butyric acid were as effective as more complex lure compositions.

Most canid lure studies and resulting publications (80%) have been undertaken in the USA. This is possible largely because, unlike the situation in Australia, wide-scale baiting of canids is not undertaken in that country. Trapping and the use of mechanical ejectors (M-44's) are the two main lethal methods of control utilised in the USA. Due to the small number of traps/M-44's that are deployed compared to area-wide baiting, both those methods need to actively draw in animals, and thus require the use of effective lures. Irrespective of these circumstances, studies undertaken in Australia on dingoes/wild dogs, and in Europe on red foxes, have produced similar findings to those undertaken on coyotes in America, and as such an assessment of the combined data set provided by those efforts is likely to be a useful aid for assessment of commercial lure prospects in this country.



Attractant

It is obvious from undertaking this review that it is impossible to identify any one canid attractant that will be the most effective for eliciting all desired behaviours, in all seasons, for both wild dogs and foxes. That aside, there is little doubt that synthetic fermented egg (SFE) is the most consistent highly-rated canid lure, of synthetic origin or otherwise, that is described in the research literature. It is possible that other canid lures can and will outperform SFE in eliciting specific behaviours, such as the biting response promoted by W-U lure, at particular times of the annual canid activity cycle. However the most dependable canid lure examined in this review, across all seasons and behaviours, is undoubtedly SFE.

Since its 'invention' in 1980 tests involving SFE have nearly always shown it to be the most potent canid attractant for coyotes, wild dogs and foxes. Of the 34 papers reviewed, 14 had trialled the lure with 79% (11) reporting it to be the most powerful or equally powerful canid attractant. Perhaps most importantly for Australia, SFE has always been the highest ranked lure in attracting dingos/wild dogs and red foxes. The lure is also known to attract other carnivores and some omnivores, including feral pigs (Eason and Henderson 1991; Henderson *et al* 1993). Although the lure was initially developed to serve as a deer repellent, herbivores have also been reported to investigate the lure. The lure is a combination of short-chain fatty acids found as fermentation products in carrion and the anal glands and vaginal excretions of both carnivores and their prey (ref #12; Bullard *et al.* 1983). As such territoriality, breeding and food seeking behaviours are all affected by SFE.

The seven-compound abbreviated synthetic fermented egg (ASFE) has been reported to be 20% less effective than the original 70-compound SFE (#6; Roughton and Bowden 1979), 10% less effective (#13; Turkowski *et al.* 1983), and similarly effective (#12; Bullard *et al.* 1983). More recent comparisons have not been reported and therefore it is still uncertain whether ASFE lost any potency compared to that of the original SFE. Since these early studies ASFE has always been used as the 'superior' standard lure that all 'newcomers' have been compared to. This has, itself, been possible only because ASFE is a synthetic, consistent and highly effective lure. It is my recommendation that if a canid lure is to be manufactured and commercialised, ASFE is the logical and likely most cost-effective choice.

In reference to use of lures to promote specific behaviours, such as visitation (curiosity), exhuming baits (digging), triggering M-44 mechanical ejectors (biting, pulling) or getting trapped, findings from this review would suggest:



- *curiosity for attraction/detection purposes*: SFE, FAS and LDC were the three lures that consistently ranked highest for canid attraction.
- *digging for buried-bait purposes*: CFA, VFA, Mast's no. 6, SFE, tuna oil and Lure 1 (#31; Kimball et al. 2000; predominantly isobutyric acid) were all reported as superior lures to promote digging in different studies.
- *biting/pulling for M-44 purposes*: FAS, W-U lure (TMAD + sulphides), SFE, Lure 2 (Kimball et al. 2000; predominantly N-ethyl butylamine) and fermented meat were all reported to promote M-44 success.
- *trapping*: SFE and Ed Carroll B were reported to be superior, particularly SFE for dingoes. Interestingly, Kimball et al. 2000 reported that their control (glycerol) promoted 5 times more scratching than FAS or other lures, a behaviour that should increase an animals trappability in leg-hold traps as most commonly used.

A significant finding in itself through this review is that very few lures do not create some reaction. As such there are no 'dead ends', but rather, products that did not perform as well in a particular study under certain variables. This does not however mean an average lure in one trial may not be exceptional in another. A case in point is the seasonal difference between SFE in the Saunders and Harris (2000; #33) paper, whereby SFE prompted 400% greater visitation rate in winter than in summer.

Presentation

Lures have generally been used in their concentrated liquid form (1-2 ml) throughout many of the studies reviewed, and pen- or field-presented in capsules. Volatilisation of lures presented in this way was reported to be high. Attempts were subsequently made to reduce the rate of volatilisation through incorporating lures into clay or plaster-of-paris disks. Clay disks, such as those developed by Jolley and Little (1991; #21), were found to significantly reduce and standardise lure volatilisation. This method is worthy of further examination, particularly for mechanical ejector tops, as commenced by Phillips and Blom (1994; #25).

Another potential method of lure presentation is aerosolisation. This technique was attempted by Turkowski et al. (1983; #13) with ASFE. This paper reports that although the product was well received by field staff, it corroded the aerosol can valves, and results from field trials were discarded. As such, the effectiveness of aerosolised SFE is unknown. Revisiting this technique is however highly recommended as this method is the only way known to the author of potentially delivering to market a highly volatile and extremely pungent canid attractant that



does not volatilise upon its first use. Aerosol can technology has developed in the last decades, and highly corrosive materials such as paint strippers or degreasers are now sold routinely and cheaply in aerosol cans; as such, successful aerosolisation of a synthetic canid attractant should be possible. Field trials should then be undertaken to assess its efficacy.

Aerosolisation of a canid lure, such as ASFE, can offer numerous advantages for land managers. Aerosol cans offer a safe, reliable, easy and consistent delivery method. Due to being fully enclosed, lure volatiles should not volatilise from the mixture/can over short- to mid-term product storage. Furthermore, the lure should not require refrigeration to retard volatilisation, something that is currently often practised for stored synthetic lures. An aerosol lure would also be safe to carry in vehicles, unlike mixtures in glass jars (and noting also that some synthetic lures can melt plastic and rapidly corrode untreated metal). All these points potentially deliver significant benefits for land managers.

Researchers that have previously worked with ASFE vow that mixing the lure is an 'unbearable' procedure due to the smell. Laboratory fume hoods are often used because of this, something not available to most land managers. The commercial mixing and enclosure of the lure will therefore also potentially result in higher uptake of the product due to the ease with which it can be obtained and applied.

Blom (1990, #19; 1994, #24) recommended that concentrated synthetic lures should be diluted to 10% (M-44 use) to 20% (trapping) before use in the field, and that dilution should occur with ethanol or vodka. It was further recommended that glycerol or propylene glycol should be added to retard the rate of lure volatilisation. Glycerol can also serve as an anti-freeze to assist use in harsh winter conditions. It is recommended that this approach be adopted if a lure is to be aerosolised.

My recommendation that ASFE be the first choice of lure for commercialisation comes with the realisation that aerosolised ASFE will not solve all the canid problems in Australia. The lure will be a tool that is an addition to the currently available canid control technologies/strategies, and it should be used in conjunction with existing and proven tools such as traps, baits and, potentially, mechanical ejectors. Other lures discussed in this review should be assessed for use in place of ASFE in order to promote specific behaviours. At this stage the recommendation to aerosolise and commercialise only one lure is based on economic reasons. Whether further lures are aerosolised and commercialised in the future should depend on



the field success of ASFE and, in turn, demand for that product.

Timing

A relatively consistent seasonal result was reported for most canid attractant studies, with visitation to lures and the intensity of responses being significantly higher in winter. Coyotes, dingos and foxes are all monoestrus with most breeding occurring in winter. This is therefore the best time to use lures in canid control. Previous studies by the author have also shown this to be one of the most effective times to bait for foxes. Hence, combining a lure (either in or on the bait) with baiting practices should ensure the highest possible uptake of baits, and the greatest effectiveness in the control campaign. An additional benefit with such timing is that breeding adults will be removed from the population before they whelp.

If a lure is intended to be combined with an immunocontraceptive bait, as currently being developed by the Pest Animal Control Cooperative Research Centre, this would also obviously be the best time to deliver it in the field.

Recommendations for further research

The ability of land managers to detect foxes and/or wild dogs at low densities would be expected to be increased if lures were widely adopted in Australia. Increasing the detectability of canids has numerous advantages. Through using permanent sentinel lure stations land managers can continually survey for the presence of canids and act, through baiting or other means, when numbers are evidently increasing beyond seasonal expectations (although note that this would potentially require some years to establish patterns of population fluctuations). Integrating lure station surveys into a land management routine, such as checking fences or waters, would mean that canids are only controlled when their prospective impact outweighs the cost of their control. This could potentially return both economic benefits for the land manager, through reduced costs of generalised on-going control campaigns, and environmental benefits, through the potential reduction in poison usage and non-target species exposure.

The use of lures can also be valuable in establishing whether local canid control campaigns have had the desired result. The recent introduction of European red foxes into Tasmania is a case in point. Wide scale use of various lures should be adopted in Tasmania, with good field records kept on the success of different lures.

Prospects for addition of lures into canid bait matrices need to be examined further. If bait uptake by foxes and wild dogs can be increased through providing canids with an easier



means of finding baits then the actual number of baits laid should theoretically be able to be reduced. This needs to be empirically tested, as scenting of baits could also have the reverse effect and make canids more neophobic of baits, thus reducing the effectiveness of baiting programs.

If Australia was to permit the use of M-44 mechanical ejectors for widespread use, further research would be required to find canid-specific lures that promote 'pulling' behaviour. Synthetic lures suggested for this purpose in the literature are W-U lure, FAS and ASFE. To my knowledge, these three lures have not previously been compared on ejectors for the control of wild dogs or foxes under Australian conditions. Although Allen and Gonzalez (2001; #34) reported meat (fermented or processed) was a more promising lure in successful (lethal) uptake, both of these were found to be attractive to non-target species that could remove the bait, possibly setting off ejectors in the process and rendering them useless. As such, a synthetic lure that promotes canid biting and pulling behaviour is more likely to be a longer-lasting and acceptable ejector lure in Australia.

Additional references

- Eason C.T. and Hendersen R.J. 1991. *Development of a toxic bait and baiting strategy for feral pig control (1989-91)*. Unpublished Forest Animal Ecology Section report, Forest Research Institute, Christchurch, New Zealand.
- Hendersen R.J., Eason C.T. and Morgan D.R. 1993. *Development of a toxic bait and baiting strategy for feral pig control (1991-93)*. Unpublished Landcare Research Contract Report: LC9293/42, Christchurch, New Zealand.



Wild dog moving on to sand plot containing pre-bait (marshmallow) scented with SFE on Currango transect at Kosciuszko National Park. Photo: R. Hunt, NSW National Parks & Wildlife Service.



Red fox investigating SFE 'baited' hair trap (meat taped to picket with double-sided tape) at 'Arthursleigh'. Photo: S. Vine, University of Sydney.