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ABSTRACT: Seasonal responses of captive coyotes (Canis latrans) to 9 chemical attractants (W-U lure, TMAD, SFE, FAS, CFA, artificial smoked fish flavor, artificial beef liver flavor, yeast autolysate and decanoic acid) were evaluated. Twenty-six additional attractants were tested only during the summer. W-U lure and FAS produced the greatest total response times from coyotes during all seasons of the year. FAS and smoked fish flavor evoked the most lick-chew-bite and pulling behaviors during the summer and have potential for improving the performance of M-44 devices in warm weather.

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INTRODUCTION

Results of a recent survey of Animal Damage Control (ADC) field personnel showed a strong interest in and need for research and development of chemical coyote attractants (Blom and Phillips 1988). Bullard et al. (1978) pioneered some of the early coyote attractant work by isolating and identifying the components of fermented egg. This led to the development of SFE and FAS. Later, Roughton (1982) demonstrated the effectiveness of FAS as a coyote attractant. Further research by Turkowski et al. (1983) summarized the responses of coyotes to 58 commercial, synthetic and ADC-formulated lures using a scent station technique (Linhart et al. 1977). More recent research by the United States Department of Agriculture (USDA)/Agricultural Research Service (ARS) and the University of California multidisciplinary team showed that TMAD (trimethylammonium decanoate) and W-U lure (trimethylammonium decanoate plus sulfides) had potential as excellent coyote attractants for increasing the efficacy of traps, M-44s[a] and placed baits (Scrivner et al. 1987). However, funding for this research effort was terminated before testing of these attractants was complete.

There has been little if any field research on developing attractants that will stimulate coyotes to pull M-44s during the warm-weather months. Availability of one or more such attractants would extend the seasonal use of M-44s which are normally removed from the field during this period. The research described in this paper complements and expands upon the work previously conducted by the USDA/ARS and University of California team.

The objectives of this study were to 1) test and evaluate the effectiveness of new chemical coyote attractants on captive coyotes, and 2) develop and evaluate the potential effectiveness of new attractants for summer use on M-44s. Reference to commercial products in this paper is for purposes of identification and does not imply endorsement by the authors or the USDA.

METHODS

Attractant tests were conducted from January 1988 to January 1990 at the USDA's Predator Research facility near Millville, Utah. Both coyotes reared in captivity as well as wild-caught coyotes were screened to determine their suitability as test animals. A group of 36 coyotes (18 males, 18 females) was established by eliminating "poor" test animals. "Good" test coyotes were defined as those who explored the test pen at will, whether they located the attractant station or not. "Poor" test coyotes were defined as those who either nervously paced the fence or were intimidated and stayed in a corner or small area of the test pen during the entire test period. Three males and 3 females were used for each seasonal attractant test. Each coyote was generally used only once per week of testing. Exposure of individual coyotes to specific attractants was alternated by season to avoid repeated exposure.

The seasonal response of coyotes to attractants was tested during 3 periods: breeding (January 1-March 10), whelping/pup-rearing or summer (March 11-September 30), and dispersal (October 1-December 31). Nine chemical attractants were selected for testing during the 3 seasons, the sources and product identification numbers for which are shown on Appendix 1. Five attractants (W-U lure, TMAD, SFE [abbreviated synthetic fermented egg], FAS [fatty acid scent], and CFA [synthetic monkey pheromone]) were chosen because they were currently available and had not been previously compared to each other. These attractants were also similar to those proven to be effective by Scrivner et al. (1987) and Turkowski et al. (1983). The remaining 4 (artificial beef liver flavor #1 [ABLF], artificial smoked fish flavor [ASFF], yeast autolysate [YA] and decanoic acid [DA]) were identified from screening trials which showed these attractants produced higher than average responses from test coyotes. All other attractants mentioned in this paper were tested only during the summer.

Attractant stations were constructed for both bare ground and snow conditions. A 9/16 in fine-threaded bolt (3 cm long) was welded to a heavy spike (10 cm long) for unfrozen bare ground tests. A fine-threaded bolt was attached to a heavy 10 x 18 x 1-cm flat metal plate for frozen ground and snow cover tests. The free end of the bolt accommodated an M-44 shell holder top which served as the attractant station. The new tops used for tests were cleaned before being wrapped with brown gauze for bare ground and white gauze for snow cover conditions. A uniform amount of liquid, powder, or paste attractant was applied to the tops. The station was placed in a different location within the 225-m^2 test pen prior to beginning each test, with only the M-44 top portion exposed to the test animals.

Coyotes were not fed or disturbed before or during tests other than hazing them in and out of the kennels and test

[a]The M-44 is a tube-like spring-loaded device partially inserted into the ground; the exposed portion is baited with an attractant which, upon being pulled by a coyote, ejects a lethal dose of sodium cyanide into its mouth.

pen. Tests were initiated early in the morning and concluded about mid-day. Individual coyotes were hazed into the test pen from an adjacent kennel area. Each was observed for a 20-minute period from an adjacent observation tower equipped with one-way windows. Responses to each attractant were recorded using a TANDY 102 portable computer which was programmed to record and summarize data from individual tests (Fig. 1). Each coyote's ear tag number and sex, as well as date and weather conditions during the test, were entered into the computer. If needed, comments concerning the coyote or the specific test could be entered after the test was completed. Six responses (sniff, lick-chew-bite, pull, rub-roll, urinate and defecate) were recorded only when they were elicited by the attractant. Activities that occurred away from the station appeared as "other" on the computer data sheet. Frequency of occurrence and total time spent on each response were recorded in seconds. Individual coyotes were returned to their kennel after each test and the attractant station was removed and a new station was placed in another location for the next test. Data were tabulated and average response times and comparisons between attractants were calculated.

```
Date:  09/22/88
Observer:  SHERM
Attractant Tested:  FAS
Coyote Number:  D685
Coyote Sex:  F
Pen Number:  K-57
Weather Conditions:  CLEAR
Humidity:  67%
Wind Direction and Speed:  0
Barometric Pressure:  30.24+
Temperature:  46F
Start Test Time:  06:32:05
End Test Time:  06:52:06
******************************************************************************
         Responses              Count          Time
                                             (seconds)

         Sniff                    1              1
         Lick-Chew-Bite           4              8
         Pull                     1              2
         Rub-Roll                 5            165
         Urinate                  0              0
         Defecate                 0              0
         Other                    3           1025
******************************************************************************

Comments:  COYOTE PULLED SCENT STATION OUT OF GROUND & CARRIED OFF.
```

Figure 1. Sample of data output form from TANDY 102 computer showing results of 1 attractant test.

At the end of each day's testing, attractant stations were thoroughly cleaned with a strong detergent in hot tap water and briefly soaked in a sodium bicarbonate solution to deodorize them. The stations were then stored outdoors in a clean box to avoid odor contamination from other sources.

RESULTS

One hundred thirty-two hours of observation time were spent recording coyote responses to 35 attractants during 396 individual trials. Of the 9 attractants tested throughout the year, the overall attractiveness of W-U and FAS were nearly identical (Table 1). FAS ranked slightly higher than W-U in 2 of 3 seasons. CFA, TMAD and artificial smoked fish also produced relatively high response times. Our results thus agreed with previous studies by Scrivner et al. (1987) which showed high mean responses for W-U and TMAD by captive coyotes. SFE, which produced high coyote visitation in field tests (Turkowski et al. 1983), ranked sixth in mean response time.

Table 1. Average seasonal response times (seconds) of captive coyotes to 9 attractants.

	Season			
Attractants	Breeding	Whelping/pup rearing	Dispersal	Total of mean response times
W-U	277.6	394.4	473.4	1145.4
FAS	219.0	424.7	496.7	1140.4
CFA	182.8	133.4	355.9	672.1
TMAD	280.9	167.0	217.2	665.1
ASFF	140.7	210.5	213.2	564.4
SFE	190.6	160.8	179.5	530.9
DA	175.6	199.3	91.2	466.1
YA	40.1	104.6	71.6	216.3
ABLF #1	58.6	104.7	19.4	182.7

A high percentage of all behavioral responses to attractants was spent in rub-rolling activity. For some attractants such as decanoic acid, SFE, and W-U, rub-rolling accounted for over 80 percent of the total recorded response time (Table 2). This behavior was most apparent for the fatty-acid based attractants and least for others such as yeast autolysate. The amount of time coyotes spent rub-rolling appeared to be an index to the attractiveness of a particular attractant. This relationship was apparent when we compared the mean response time spent rub-rolling with the mean of the total response time (Fig. 2).

All 35 attractants (Table 3) were evaluated for their potential use with traps and M-44s during the summer or whelping/pup-rearing season. FAS and W-U ranked the highest with mean response times of 424.7 and 394.4, respectively (Table 3). These 2 attractants had nearly twice the mean response times as the next closest attractant. Besides being high in overall attractiveness, they evoked high responses for lick-chew-bite and pull behavior in the summer and during other seasons, thus demonstrating their potential as M-44 attractants (Fig. 3). Several other attractants such as yeast autolysate, artificial beef liver flavors Nos. 1 and 2, and artificial smoked fish showed lower rankings in overall attractiveness, but evoked a high percentage of the mean total response time in lick-chew-bite and pull behavior.

DISCUSSION AND CONCLUSION

Attractant tests conducted on captive coyotes showed both consistent and seasonal preferences for certain attractants. No one attractant presently appears to be the "best" attractant for all coyotes tested. Individual coyote preference may change both daily and seasonally. We were unable to detect any strong relationship between coyote sex and specific attractants.

Table 2. A comparison of total seasonal response times (by percent) of captive coyotes exposed to 9 attractants.

	Attractants								
Activity	TMAD	W-U	CFA	SFE	FAS	DA	ABLF #1	ASFF	YA
Sniff	6	4	6	9	5	5	8	5	12
Lick-chew-bite	28	13	17	8	28	9	24	37	51
Pull	4	3	4	2	5	4	15	7	9
Rub-roll	62	80	73	81	62	82	53	51	28

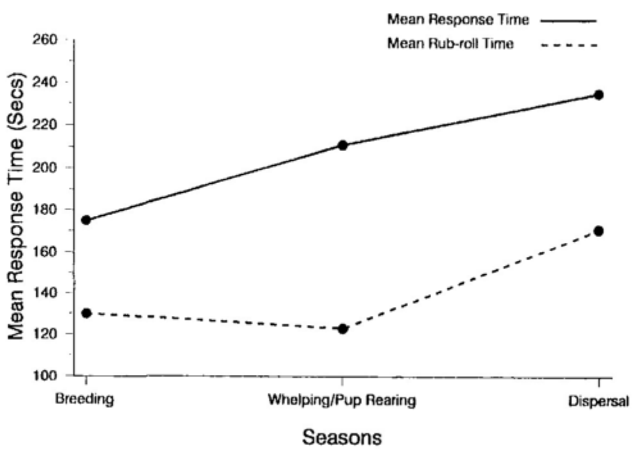

Figure 2. A comparison of the relationship between the average amount of time test coyotes spent rub-rolling to the average total response time during 3 seasons.

Although sample sizes across the large number of attractants were small, they were sufficient to give indications of coyote preferences for certain attractants. Just how closely the behavior of wild coyotes would correspond to that observed in captive coyotes can only be determined by field trials in representative habitats and geographic areas. However, measuring quantitative responses to attractants by wild, free-roaming coyotes is difficult. Some visual sign is left at scent stations, but the order of responses and how much time was spent at each response cannot be determined unless expensive or labor intensive techniques such as remote, automated recorders are used. Attractants that generate strong lick-chew-bite and pull responses can be tested on M-44s, as differences in response rates can be determined by the number of animals taken by each attractant. Scent stations and actual trap sets could be used to validate their attractiveness in the field.

Rub-rolling is a characteristic behavior of canids and has been previously reviewed by Reiger (1979). There is speculation about why coyotes display this behavior. During our tests the most common progression of response was to first locate the attractant station by smell. No visual locating or circling of the attractant station was ever observed. Once the station was located a brief period of sniffing (usually < 5 seconds) occurred, followed by the rub-roll response. Rub-rolling lasted from a few seconds to several minutes depending on the individual coyote. The lick-chew-bite and pull responses then occurred, if at all, followed by more rub-rolling. Several series of these responses usually occurred during a test. Rub-rolling occurred at 35 of 36 attractants evaluated during 396 individual trials. Yeast autolysate generated the lowest percentage of rub-roll responses of all 9 attractants (Table 2). This behavior is not necessarily desirable for both traps and M-44s because traps may be sprung and M-44s are not activated by this activity. However, rub-rolling tends to hold an animal at a particular location so that eventually it could respond to a control device. If a control measure could be developed to utilize this response, it might be highly effective.

A variety of attractants are necessary to accommodate the individual preferences of coyotes over different areas during different times of the year. The results of coyote attractant research conducted thus far indicate that organic fatty acids are a primary component of attractants for this species. They can be effective when used individually (decanoic acid) or in various combinations (i.e, CFA and FAS) to provide variety. Other chemical compounds such as aldehydes, sulfides, phenols, methyl ketones, pyrazines and thiazoles can be used either individually or in combination with acids or each other to provide different attractants. Most natural attractants probably contain these compounds in various combinations.

Future coyote attractant research should focus on determining the optimum concentrations of known attractants required to elicit responses needed to activate control devices. Work is also needed to identify more coyote-specific attractants, including possible coyote pheromones to reduce the accidental capture or death of nontarget species. Identification of coyote-selective attractants would also increase the efficiency of control measures used today.

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Table 3. Ranking of 35 attractants by mean response time during the whelping/pup-rearing or summer season. Percent of average response time (seconds) shown in parentheses.

Attractant	Mean response time [a]	Mean lick-chew-bite time	Mean pull time
FAS	424.7	195.7 (46)	24.3 (6)
W-U	394.4	71.2 (18)	22.7 (6)
Artificial smoked fish flavor	210.5	91.8 (44)	18.2 (9)
Decanoic acid	199.3	24.6 (12)	11.5 (6)
Nonanal	198.5	42.0 (21)	22.7 (11)
FAS plus W-U sulfides	198.5	23.2 (12)	12.0 (6)
TMAD	167.0	72.8 (44)	8.5 (5)
W-U acids	161.3	12.5 (8)	1.4 (1)
SFE	160.8	15.3 (10)	5.3 (3)
Decanoic acid plus W-U sulfides	156.5	19.0 (12)	3.3 (2)
Artificial beef liver flavor #2	151.1	52.7 (35)	23.2 (15)
Acids mixture #1	135.1	16.3 (12)	8.5 (6)
CFA	133.4	11.8 (9)	2.8 (2)
Antelope gland acids	125.2	7.7 (6)	2.0 (2)
Synthetic fox urine	108.5	0.7 (1)	0.0 (0)
Artificial beef liver flavor #1	104.7	31.8 (30)	20.7 (20)
Yeast autolysate	104.6	67.3 (64)	11.2 (11)
Coconut oil acids	103.1	23.7 (23)	16.7 (16)
Cheese whey	85.9	34.3 (40)	7.3 (9)
Pork liver hydrolysate	80.4	8.7 (11)	1.7 (2)
W-U cheese	73.3	0.4 (1)	0.0 (0)
Mesityl oxide	71.7	21.2 (30)	5.8 (8)
Artificial salmon flavor	63.7	15.5 (24)	6.3 (10)
W-U methyl ketones	61.7	1.9 (3)	0.7 (1)
Tallow acids	57.3	11.8 (21)	8.3 (14)
Artificial lamb flavors	45.1	12.3 (27)	0.0 (0)
Natural Flavor Blend	43.3	14.3 (33)	3.8 (9)
Artificial bacon fat flavor	39.4	18.0 (46)	2.5 (6)
Lanolin fatty acid	35.0	3.3 (9)	1.2 (3)
Aqueous beef liver extract	32.0	0.3 (1)	0.0 (0)
Anisole	21.8	0.7 (3)	0.0 (0)
Tobacco resinoid	12.3	0.3 (2)	0.0 (0)
Beechwood creosote	11.7	1.9 (16)	0.3 (3)
Corn protein hydrolysate	4.7	0.0 (0)	0.0 (0)
Oleic acid	0.0	0.0 (0)	0.0 (0)

[a]This figure was calculated by totaling the mean response times in each activity category for the 6 coyotes (3 males, 3 females) during an attractant test.

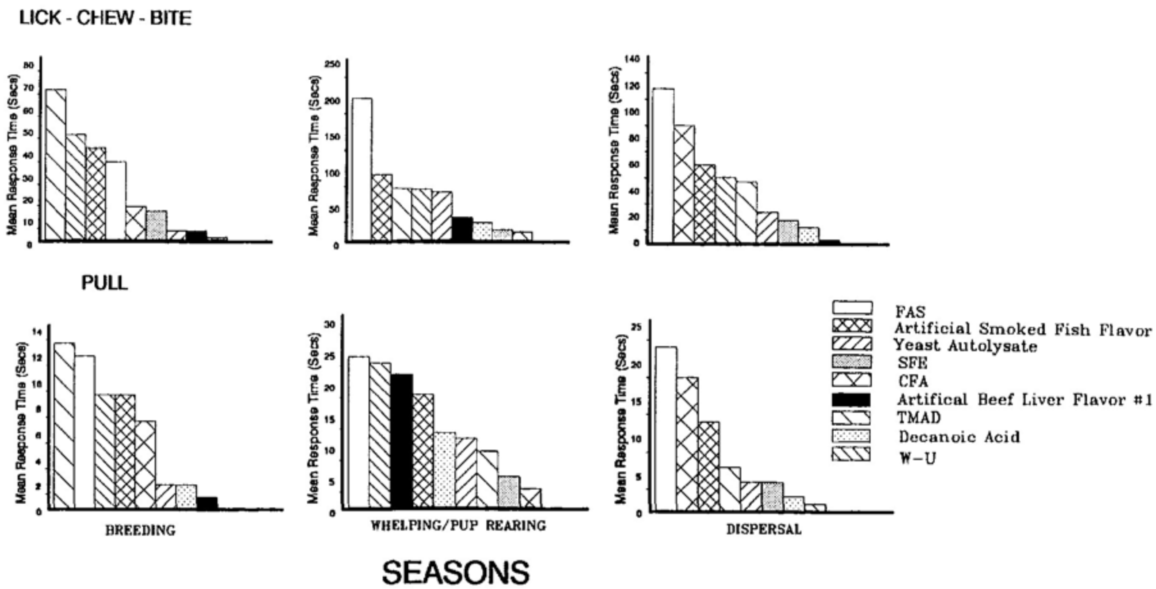

Figure 3. A comparison of seasonal lick-chew-bite and pull response of captive coyotes to 9 chemical attractants.

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Appendix 1.

Descriptive information and sources for 9 attractants tested on a seasonal basis.

Attractant	Source
	Several commercial sources including:
SFE (Abbreviated Synthetic Fermented Egg, DRC-6503)	1) M&M Fur Co. Box 15 Bridgewater, S.D. 57319 (605) 729-2535 2) Nick Wyshinski Box 245 Berwick, Pa. 18603 (717) 752-2697
CFA (Synthetic Monkey Pheromone, DRC-6220) FAS (Fatty Acid Scent)	USDA/APHIS/ADC Pocatello Supply Depot 238 E. Dillon Pocatello, Id. 83201 (208) 236-6922
TMAD (Trimethylammonium Decanoate) W-U (TMAD plus Sulfides)	J. T. Eaton & Co., Inc. 1393 E. Highland Rd. Twinsburg, Oh. 44087 (216) 245-7801
Artificial Beef Liver Flavor #1 (Product No. 13568950, Art. Liver Fl., Oil Sol.) Artificial Smoked Fish Flavor (Product No. 13598049, Art. Bonita Fl.)	International Flavors & Fragrances, Inc. P.O. Box 439 Dayton, N.J. 08810 (201) 329-4600
	Most chemical companies including:
Decanoic Acid (CAS No. 334-48-5) (Product No. 11762)	ALPHA Products 152 Andover St. Danvers, Mass. 01923 (617) 777-1970
	Several commercial sources including:
Yeast Autolysate (Product No. 103304, Yeast Hydrolysate Enzymatic)	ICN Biomedicals, Inc. P.O. Box 5023 Costa Mesa, Calif. 92626 (800) 854-0530