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American Midland Naturalist, Vol. 109, No. 2. (Apr., 1983), pp. 266-273.

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Seasonal Changes in Coyote Food Habits as Determined by Fecal Analysis

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ABSTRACT: Feces were analyzed to determine the food habits of coyotes (*Canis latrans*) in Cuyamaca Rancho State Park, San Diego Co., California. Of 748 food items identified from 223 scats, mammals made up 53%, vegetation 23%, arthropods 9%, reptiles 1%, birds 1% and miscellaneous items 3%. Percent relative frequency of mammalian food items decreased significantly from winter (78%) to summer (52%). Conversely percent of arthropod remains in summer scats (11%) increased significantly from winter scats (0%). Percent occurrence of vegetation in feces also increased significantly from winter (12%) to summer (22%). Observations of coyotes did not vary significantly between seasons. These results suggest that coyotes feed opportunistically in Cuyamaca Rancho State Park.

INTRODUCTION

Past studies of coyote (*Canis latrans*) food habits (Bond, 1934; Murie, 1940, 1951; Ferrel *et al.*, 1953; Fichter *et al.*, 1955; Korschgen, 1957; Gipson, 1974; Holle, 1978; Johnson and Hansen, 1978; Litvaitis and Mautz, 1980) prompted some authors to categorize the feeding behavior of coyotes as opportunistic (Murie, 1945; Fichter *et al.*, 1955; Nellis and Keith, 1976; Bekoff, 1977; Litvaitis and Shaw, 1980), whereas others suggested their feeding was highly selective (Clark, 1972; Johnson and Hansen, 1979; Todd *et al.*, 1981). Seasonal variation in the food habits of coyotes has been well-documented (Ferrel *et al.*, 1953; Fichter *et al.*, 1955; Korschgen, 1957; Bowen, 1981), but limited data are available for southern California. The purpose of this study was to examine seasonal fluctuations in the number of coyotes in relation to corresponding changes in their food habits.

STUDY AREA

East Mesa is located in Cuyamaca Rancho State Park, San Diego Co., Calif., at an elevation of 1525 m. This area consists of extensive upland meadows, intermixed with stands of oak (*Quercus kelloggii* and *Q. agrifolia*) and pine (*Pinus jeffreyi*) and is surrounded by dense chaparral. Bowyer and Bleich (1980) provide a more complete description of this area.

METHODS

Scats were collected along a 8.2-km dirt road on East Mesa on 268 days from June 1977 through January 1979. Sightings of 278 coyotes occurred along this fixed transect throughout the sampling period. Scats were stored in paper bags, and location, date and method of scat identification were recorded. Coyote feces were identified by their characteristic morphology and the presence of coyote tracks nearby. For laboratory analyses, scats were placed in nylon stockings and thoroughly rinsed under tap water. Remains were spread across a dissection pan and carefully examined with a dissection microscope for food items. Additionally, four or five random points were examined for food items in each pan. Mammalian species were identified from hair morphology as

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described by Mayer (1952) and compared with reference slides of mammalian hairs. Remains of jaws and teeth were classified according to Hall and Kelson (1959), Ingles (1965) and Glass (1973). Birds in coyote feces were identified by the presence of feathers, eggs and feet, and reptiles by the occurrence of their skins. Arthropods were identified using Borror and DeLong (1964). Plant nomenclature and identification followed Munz (1974). Laboratory premises and equipment were disinfected with hot sodium hypochlorite after fecal analysis, as recommended by Leiby and Dyer (1971) to prevent possible contamination by *Echinococcus granulosus*. Scats, laboratory instruments and protective clothing were autoclaved after each use.

Percent occurrence of species found in coyote scats were calculated using both total number of food items found in all scats and total number of scats. Statistical analyses were performed only on proportions derived from total food items; computations using total number of scats often yielded proportions greater than unity when grouped by class. A two-sample *Z*-test for proportions (Remington and Schork, 1970) was used to test for differences in food habits between seasons, whereas a chi-square test with Yates' correction (Little and Hills, 1978) was used for within-season comparisons. A *t*-test (Remington and Schork, 1970) was employed to compare seasonal differences in the mean number of coyotes observed per transect.

RESULTS

Mammals comprised the largest group of food items found in coyote feces throughout the year, followed by vegetation, arthropods, miscellaneous items, reptiles and birds (Table 1). Based on total food items, the most common mammalian species in coyote scats were beaver (*Castor canadensis*) (12%), deer mice (*Peromyscus* spp.) (7%), opossum (*Didelphis virginiana*) (7%), pocket gopher (*Thomomys bottae*) (6%), mule deer (*Odocoileus hemionus*) (6%) and badger (*Taxidea taxus*) (3%). Human hair, found in a scat collected in October 1978, most likely was consumed as carrion.

Plants found in coyote feces included grasses (2%) (only cheatgrass *Bromus tectorum* was identified), berries from manzanita (*Arctostaphylos* spp.) (8%), holly-leaved cherry (*Prunus ilicifolia*) (1%) and chokecherry (*Prunus virginiana*) (1%). Grasshoppers (Acrididae) (4%) were the most commonly identified arthropods in coyote feces followed by beetles (Caribidae) (3%) and ticks (Ixodidae) (<.01%). Miscellaneous items in order of importance were cellophane (2%), mud (1%), stones (0.1%), paper (0.1%) and rubber (0.1%). Because of the low relative frequency of birds and reptiles in feces, identification below class was not attempted.

Twenty-six mammalian species were identified in coyote feces; the greatest number occurred in autumn (22 spp.), followed by summer (21 spp.), spring (14 spp.) and winter (7 spp.). Significant differences were found only for pairings between summer and winter ($\chi^2 = 6.04$, $P < 0.02$) and autumn and winter ($\chi^2 = 6.76$, $P < 0.01$). Percent occurrence of mammal remains in scats dropped significantly (Table 2) from 78% in winter to 56% in spring, to 52% in summer to 56% in autumn (Table 2). Of 34 food items identified during winter, 24% were opossum; this was significantly higher than in other seasons (Table 2). Deer mice accounted for 9% of summer food items and 4% during autumn; this decrease also was highly significant (Table 2). Remnants of badger were identified in all seasons (spring 4%, summer 4%, autumn 2%) except winter, and significant differences were found only for seasonal pairings with winter (Table 2). No significant seasonal variation occurred in the amount of beaver or mule deer in coyote feces (Table 2).

Seasonal consumption of vegetation by coyotes was 38% in autumn, 19% in spring, 22% in summer and 12% in winter. All seasonal pairings with autumn differed significantly (Table 2). Spring (15%) and summer (11%) were peak times of arthropod occurrence in coyote scats (Table 1). Arthropods decreased to 5% in autumn and were not found in coyote feces during winter. No significant difference occurred in the frequency with which arthropods were found in scats during spring and summer.

TABLE 1.—Food items identified in 223 coyote scats collected in Cuyamaca Rancho State Park, San Diego Co., Calif., from June 1977 through January 1979. A complete list of species found in coyote feces is available from the authors

Food Item	Year				Winter (Jan-Mar)		Spring (Apr-Jun)		Summer (Jul-Sept)		Autumn (Oct-Dec)	
	% Freq. total scats N = 223	% Freq. total items N = 748	% Freq. total items N = 11	% Freq. total items N = 34	% Freq. total items N = 32	% Freq. total items N = 133	% Freq. total items N = 89	% Freq. total items N = 365	% Freq. total items N = 91	% Freq. total items N = 216		
Mammalia	181.8	53.2	236.0	78.0	231.0	56.2	221.0	51.7	127.0	56.0		
Marsupialia												
Didelphidae	24.0	7.0	73.0	24.0	41.0	10.0	20.0	5.0	16.0	7.0		
Chiroptera	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5		
Molossidae												
Lagomorpha												
Leporidae	1.3	1.3	0.0	0.0	0.0	0.0	1.0	0.3	2.0	0.9		
Rodentia	100.7	28.2	145.0	48.0	112.0	27.8	118.0	27.7	73.0	32.0		
Castoridae	44.0	12.0	64.0	21.0	53.0	13.0	51.0	12.0	26.0	11.0		
Heteromyidae	1.4	0.6	9.0	3.0	0.0	0.0	3.0	0.8	1.0	0.5		
Cricetidae	27.4	7.6	36.0	12.0	40.0	10.0	41.0	9.3	10.0	4.5		
Sciuridae	5.9	2.0	0.0	0.0	3.0	0.8	6.0	1.6	9.0	4.0		
Geomysidae	22.0	6.0	36.0	12.0	16.0	4.0	17.0	4.0	27.0	12.0		
Carnivora	33.0	10.0	9.0	3.0	50.0	11.4	51.0	11.4	18.0	8.1		
Procyonidae	3.0	1.2	0.0	0.0	3.0	0.8	7.0	1.5	1.0	0.5		
Canidae	8.0	1.9	9.0	3.0	19.0	4.0	8.0	1.8	4.0	1.8		
Felidae	6.0	1.9	0.0	0.0	9.0	1.8	7.0	1.5	5.0	1.9		

TABLE 1.—(continued)

Food Item	Year				Spring (Apr-Jun)		Summer (Jul-Sept)		Autumn (Oct-Dec)	
	% Freq. total items	% Freq. in scats	% Freq. total items	% Freq. in scats	% Freq. total items	% Freq. in scats	% Freq. total items	% Freq. in scats	% Freq. total items	% Freq. in scats
	N = 223	N = 478	N = 11	N = 34	N = 32	N = 133	N = 89	N = 365	N = 91	N = 216
Mustelidae	16.0	5.0	0.0	0.0	19.0	4.8	29.0	6.6	8.0	3.9
Artiodactyla										
Cervidae	21.0	6.0	9.0	3.0	19.0	5.0	30.0	7.0	16.0	7.0
Primata										
Hominidae	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.5
Unidentified mammals	1.0	0.5	0.0	0.0	9.0	2.0	1.0	0.3	0.0	0.0
Arthropoda	34.0	9.0	0.0	0.0	63.0	15.0	14.8	11.1	11.0	4.9
Acrididae	15.0	4.0	0.0	0.0	13.0	3.0	24.0	5.0	9.0	4.0
Caribidae	10.0	3.0	0.0	0.0	9.0	2.0	20.0	4.0	2.0	0.9
Ixodidae	<0.1	<0.1	0.0	0.0	3.0	0.8	1.0	0.3	0.0	0.0
Unidentified insects	9.0	2.0	0.0	0.0	38.0	9.0	9.0	1.8	0.0	0.0
Reptilia	4.0	1.0	9.0	3.0	9.0	2.0	5.0	1.0	0.0	0.0
Aves	3.0	1.0	9.0	3.0	6.0	2.0	5.0	1.0	0.0	0.0
Vegetation	83.7	23.4	36.0	12.0	81.0	19.0	84.0	21.8	89.0	38.0
Ericaceae	29.0	8.0	0.0	0.0	0.0	0.0	26.0	6.0	46.0	19.0
Rosaceae	7.0	1.9	0.0	0.0	0.0	0.0	6.0	1.0	11.0	4.5
Poaceae	42.0	11.0	18.0	6.0	72.0	17.0	50.0	12.0	27.0	12.0
Unidentified plants	5.7	2.5	18.0	6.0	9.0	2.0	2.0	2.8	5.0	2.5
Miscellaneous	14.0	3.0	18.0	6.0	25.0	6.0	20.0	4.0	6.0	2.0

TABLE 2. — Pairwise seasonal comparisons of selected coyote food items using Z-values

	Spring-summer	Spring-autumn	Spring-winter	Summer-autumn	Summer-winter	Autumn-winter
Mammalia	0.20 ^{NS}	0.18 ^{NS}	2.35*	0.00 ^{NS}	2.70**	2.60**
Marsupialia						
<i>Didelphis virginiana</i>	1.76 +	0.96 ^{NS}	1.80 +	0.96 ^{NS}	2.56**	2.26*
Rodentia	0.00 ^{NS}	0.40 ^{NS}	1.91 +	0.51 ^{NS}	2.03*	1.75 +
<i>Castor canadensis</i>	0.30 ^{NS}	0.55 ^{NS}	1.06 ^{NS}	0.37 ^{NS}	1.25 ^{NS}	1.37 ^{NS}
<i>Peromyscus</i> spp.	0.36 ^{NS}	1.48 ^{NS}	0.62 ^{NS}	2.50*	0.52 ^{NS}	1.40 ^{NS}
<i>Thomomys bottae</i>	0.00 ^{NS}	2.87**	1.37 ^{NS}	3.29**	1.41 ^{NS}	0.00 ^{NS}
Carnivora	0.30 ^{NS}	1.19 ^{NS}	2.70**	1.96*	3.70***	1.98*
<i>Taxidea taxus</i>	0.00 ^{NS}	1.03 ^{NS}	2.36*	1.43 ^{NS}	3.90***	2.11*
Artiodactyla						
<i>Odocoileus hemionus</i>	0.87 ^{NS}	0.78 ^{NS}	0.58 ^{NS}	0.00 ^{NS}	0.62 ^{NS}	1.18 ^{NS}
Aves	0.00 ^{NS}	0.00 ^{NS}	0.66 ^{NS}	0.00 ^{NS}	0.67 ^{NS}	0.00 ^{NS}
Arthropoda	0.56 ^{NS}	3.26**	4.87***	4.08***	7.40***	3.01**
Reptilia	0.76 ^{NS}	0.00 ^{NS}	0.32 ^{NS}	0.00 ^{NS}	0.67 ^{NS}	0.00 ^{NS}
Vegetation	0.97 ^{NS}	3.76***	1.22 ^{NS}	3.51***	2.00*	4.02***
Miscellaneous	0.87 ^{NS}	1.76 +	0.00 ^{NS}	1.43 ^{NS}	0.48 ^{NS}	0.96 ^{NS}

*** P < 0.001 ** P < 0.01 * P < 0.05 + P < 0.10 . NS P > 0.10

However, percent occurrence in both spring and summer differed significantly from autumn (Table 2). The remains of eight (1%) birds and nine (1%) reptiles were found in coyote feces; neither showed significant seasonal variation.

The occurrence of mammalian remains in feces was significantly higher than the occurrence of vegetation or arthropods (Table 3). No significant difference occurred in percentages of vegetation or arthropods in coyote scats found during winter and spring (Table 3). Remains of rodents, marsupials, carnivores, ungulates and vegetation occurred in feces throughout the year. Occurrences of lagomorphs, chiropterans, arthropods, reptiles and birds were seasonal (Table 1).

The mean number of coyotes observed per transect for each season was: spring ($\bar{x} = 0.76$, $SD = 0.15$, $N = 41$), summer ($\bar{x} = 1.16$, $SD = 0.40$, $N = 106$), autumn ($\bar{x} = 1.22$, $SD = 0.78$, $N = 109$) and winter ($\bar{x} = 0.91$, $SD = 0.19$, $N = 31$). A *t*-test revealed no significant differences ($P > 0.10$) in the number of coyotes observed between any seasonal pairings.

DISCUSSION

The occurrence of some foods consumed by coyotes has been estimated from analysis of undigested residues in scats (Holle, 1978; Johnson and Hansen, 1978; Litvaitis and Shaw, 1980), suggesting a relationship between foods ingested and their remains in feces. Seasonal variation in the percent occurrence of food items in coyote feces raises the possibility that these predators fed opportunistically on East Mesa. Quantitative data on food abundance were not measured, but qualitative observations indicated that changes in the diet of coyotes paralleled the seasonal occurrence of some foods. Moreover, the intensity of predation may not be proportional to the availability of prey; the condition of prey (Mech and Frenzel, 1971), as well as their ability to elude capture, may influence rates of predation (Peterson, 1977).

The frequency of plant remains in scats was greatest in summer and autumn when manzanita berries, chokecherry and holly-leaved cherry occurred on East Mesa. Coyote feces had the highest frequency of grasses during spring; this corresponded with the germination and growth of these plants. Percent occurrence of arthropods, largely grasshoppers and beetles, increased during spring and summer, which appeared to coincide with the emergence of these insects.

The diet of coyotes consisted primarily of mammals, although fluctuations in the frequency of these prey items did occur. The largest number of mammalian food items were present during summer and autumn, which may relate to the poor physical condition of mammals during that period due to prolonged dryness and little vegetation growth. The lowest number of mammalian foods in coyote feces occurred during winter. Perhaps the decrease of rodents relates to their reduced availability because of hibernation or lessened activity. Mule deer remains in feces were most frequent in summer; this may relate to vulnerability of fawns as reported by Salwasser (1974). Percent occurrence of all mammals in food items was highest in winter when seasonal changes may have reduced the availability of fruits, arthropods and reptiles.

The feeding behavior of coyotes may be opportunistic in areas where a complex biota exists (Clark, 1972). Opportunistic feeding suggests that seasonal fluctuations of food items in the diet of coyotes should coincide with availability and that coyote

TABLE 3. — Comparison of the three major food groups found in coyote scats using chi-square values

	Spring	Summer	Autumn	Winter	Total
Mammalia-Arthropoda	29.88***	48.02***	90.42***	12.02***	116.28***
Mammalia-vegetation	22.09***	47.86***	8.58**	14.70***	85.69***
Vegetation-Arthropoda	0.54 ^{NS}	8.69**	50.07***	2.25 ^{NS}	45.63***

*** $P < 0.001$

** $P < 0.01$

NS $P > 0.10$

numbers should not fluctuate with changes in preferred prey. Coyotes on East Mesa may be opportunistic feeders in regard to mammals, vegetation and arthropods. Seasonal changes in frequency of these food items in coyote feces followed observed patterns of availability. The lack of significant changes in the number of coyotes observed between seasons during which food habits shifted significantly further suggests these predators fed opportunistically.

Acknowledgments.—James Geary granted permission to conduct research in Cuyamaca Rancho State Park and arranged for the necessary collecting permits. Randy Rabb and M. Curto assisted with the fieldwork. We thank K. D. Curry and R. E. Barry for their assistance in the preparation of this manuscript.

We are indebted to P. Meyers for providing hair samples, from the Museum of Zoology's mammal collection at the University of Michigan from which we made most of our reference slides.

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SUBMITTED 25 FEBRUARY 1982

ACCEPTED 21 MAY 1982