Food Habits of the Coyote in Tennessee

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Abstract: During 1981–1984, digestive tracts of 262 coyotes (*Canis latrans*) from Tennessee were examined for food items, and data were assessed in relation to sex, age, seasonal, annual, and spatial variation. Foods with highest percent occurrence were rodent, persimmon (*Diospyros virginia*), rabbit (*Sylvilagus* spp), and white-tailed deer (*Odocoileus virginianus*). There were no differences between sexes and for foods eaten, and only persimmon varied significantly among age classes. Seasonal variation was found for rodent, insect, reptile and amphibian, opossum (*Didelphis virginiana*), and persimmon. Livestock, insect, and grass varied across years. Little spatial variation in food use was detected, and examination of environmental data with percent occurrence of food items revealed no associations.

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Little information has been accumulated from coyotes in the southeastern United States. Since the species has recently expanded its range into this region (Gipson 1978), knowledge of food habits is important. Many food-related studies have been conducted (Sperry 1941, Korschgen 1973, Gipson 1974, Bekoff 1977); however, limited information is available concerning feeding activities east of the Mississippi River in the southeastern United States. The purposes of this study were to identify coyote food items in Tennessee and to assess spatial variability in food use.

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Methods

During 1981–1984, digestive tracts of 262 (121 males, 123 females, 18 unknown sex) coyotes were collected and examined. Most were provided by hunters, trappers, and Tennessee Wildlife Resource Agency personnel. Sex was recorded for each specimen, and animals were aged (males, females, unknown sex) as to class I (<8 months, $N = 5, 8, 0$) class II (8 to 13½ months, $N = 41, 29, 3$), class III (22 to 45 months, $N = 38, 29, 10$), or class IV (≥46 months, $N = 13, 14, 1$) following Gier (1968) and Nellis et al. (1978). Digestive tracts were removed and stored frozen for later examination (Korschgen 1969). Analyses were based only on digestive tracts that contained food (40 were empty). Data were recorded on the basis of presence or absence. Hair samples were identified following Moore et al. (1974) and a reference collection of known samples housed in the Department of Biology, Memphsis State University. Counties or regions in Tennessee from which specimens were examined and sample sizes for males (given first), females (given second), and unknown sex (given third) were as follows: (1) Benton—8, 11, 4; (2) Carroll—3, 2, 0; (3) Cheatham—0, 3, 0; (4) Chester—1, 2, 0; (5) Clay—1, 0, 0; (6) Cumberland—1, 0, 0; (7) Davidson—1, 0, 0; (8) Dyer—1, 0, 0; (9) Fayette—14, 10, 1; (10) Hardeman—18, 13, 0; (11) Hardin—2, 0, 0; (12) Haywood—12, 4, 0; (13) Henderson—1, 1, 0; (14) Humphreys—1, 0, 0; (15) Lauderdale—3, 1, 0; (16) McNairy—2, 2, 0; (17) Madison—5, 5, 0; (18) Meigs—0, 2, 0; (19) Montgomery—0, 1, 0; (20) Obion—0, 1, 4; (21) Perry—0, 1, 0; (22) Robertson—1, 3, 0; (23) Shelby—17, 11, 1; (24) Stewart—1, 2, 0; (25) Tipton—6, 9, 3; (26) Warren—1, 0, 0; (27) Weakley—1, 0, 0; (28) Williamson—1, 1, 0; (29) Wilson—1, 1, 0; (30) western Tennessee—6, 11, 2; (31) middle Tennessee—0, 1, 0. Geographic location of each county is provided in Figure 1. County or region for each coyote were given in Lee (1986). Coyotes were collected over different years in the following numbers (males, females, unknown sex): 1981—11, 12, 8; 1982—41, 26, 4; 1983—35, 34, 3; 1984—22, 26, 0. Also, coyotes were taken over different seasons (those of the calendar year) in the following numbers (males, females, unknown sex): winter—72, 62, 9; spring—11, 11, 3; summer—3, 2, 0; autumn—23, 22, 3. Season of harvest was unknown for 1 animal. Because it was not possible to examine specimens at harvest time, and Gier (1968) showed that foods present in coyote stomachs for more than 5 hours were not accurate indicators of proportional intake, food volumes were not recorded.

Contingency table analyses were employed to test for differences in food items by sex, age, season, and year. A series of contingency table tests were used to determine variant groups. The Chi-square statistic was utilized as a measure of significance ($P \leq 0.05$). To increase sample sizes for analyses, sexes were combined for comparisons after it was established that no differences ($P > 0.05$) existed between males and females. Samples relating to seasons and age classes for individual years were also pooled. Contingency table tests included 14 characters (food items; Table 1).

To increase sample sizes for multivariate analyses, variant groups (within each

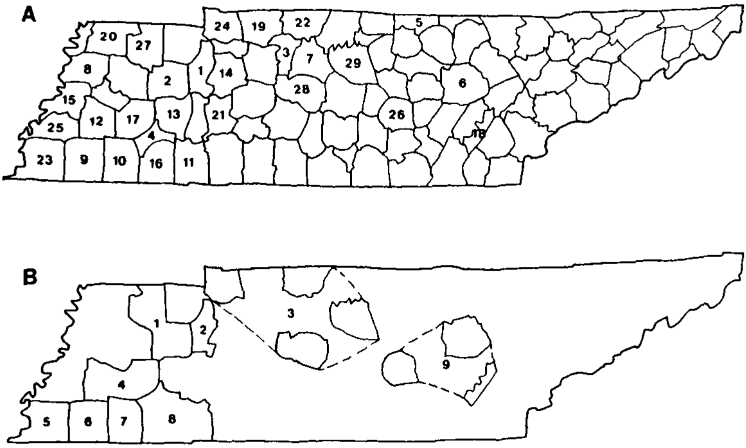

Figure 1. Sample localities used in a food habits study of the coyote in Tennessee. A: Counties from which coyotes were collected. B: Localities used in a multivariate statistical assessment of coyote food habits. Numbers correspond to those given in the text for counties and regions.

Table 1. Percent occurrence of individual food items by sex for coyotes examined from Tennessee.

Food item	Male	Female	Unknown sex	Average across groups
Animal				
Rodent	36.7	62.2	66.7	39.2
Rabbit	27.5	30.6	26.7	28.8
White-tailed deer	28.4	26.5	20.0	27.0
Livestock	16.5	17.3	13.3	16.7
Insect	9.2	17.3	6.7	12.6
Nongame bird	11.0	11.2	6.7	10.8
Game bird	7.3	2.0	0.0	4.5
Reptile and amphibian	1.8	2.0	0.0	1.8
Shrew	0.0	3.1	0.0	1.4
Opossum	0.9	0.0	0.0	0.5
Vegetation				
Persimmon	28.4	38.8	20.0	32.4
Other vegetation	22.0	31.6	20.0	26.1
Grass	20.2	16.3	53.3	20.7
Miscellaneous	10.1	10.2	6.7	9.9

character) were removed from pooled data. Invariant characters were not included in multivariate analyses following Sneath and Sokal (1973). This reduced the 14 character set to 9 in the multivariate assessment; reptile and amphibian, shrew, grass, and opossum were characters omitted. To test for spatial variation among food items, counties with less than 3 specimens were clustered with an adjacent or close county, usually within the same physiographic region, and treated as a single locality. Final localities (Fig. 1) and sample sizes were as follows: (1) Carroll and Weakley counties, 3; (2) Benton County 10; (3) middle Tennessee, 5; (4) Haywood and Madison counties, 5; (5) Shelby County, 9; (6) Fayette County, 7; (7) Hardeman County, 4; (8) Chester, McNairy, and Hardin Counties, 4; (9) eastern Tennessee, 3. The data matrix for multivariate analysis included 66 coyotes.

To meet assumptions of normality and homoscedasticity, percentages of occurrence for the 9 variables were arc sine transformed (Berenson et al. 1983), and variances were stabilized using a Bartlett correction factor for 100.0 or 0.0% (Green and Suchey 1976). Multivariate analyses were performed using NT-SYS (Numerical Taxonomic System) programs of Rohlf et al. (1982). Raw data were summarized into 3 dimensions by nonmetric multidimensional scaling. Projection of localities were prepared from these summarized data. A minimally connected network was computed in the original character space and used to connect most similar localities in the 3-dimensional plot. Interpretation of the position of the localities on the 3-dimensional model was derived from comparisons of values in the original raw data matrix.

Association of food items and selected environmental variables were examined by comparing a distance matrix of the percent occurrence of food items with a distance matrix of the environmental data (Mantel 1967 , Sokal 1979). Matrices were derived using NT-SYS (Rohlf et al. 1982) and were listed in Lee (1986). Environmental data included were latitude, longitude, actual evapotranspiration (a measure of net primary productivity, Rosenzweig 1968), mean January precipitation, mean July precipitation, mean January temperature, and mean July temperature. Actual evapotranspiration values were obtained from Thornthwaite Associates (1964). Other variables were taken from the U.S. Department of Commerce (1973).

Results

Fourteen foods were recorded (Table 1). There were no differences between sexes of coyotes for foods eaten ($P > 0.05$). Among age classes, only persimmon varied ($P = 0.028$). Seasonal variation was found for frequency of rodent ($P = 0.041$), insect ($P < 0.001$), reptile and amphibian ($P = 0.012$), opossum ($P = 0.049$), and persimmon ($P < 0.001$). Annual variation was significant for livestock ($P = 0.030$), insect ($P = 0.006$), and grass (Poaceae, $P < 0.001$).

Of animal foods, rodents were found in the greatest number of coyotes. Most common were hispid cotton rat (*Sigmodon hispidus*), deer mouse (*Peromyscus* spp.), and vole (*Microtus* spp.). In addition, woodchuck (*Marmota monax*), Old

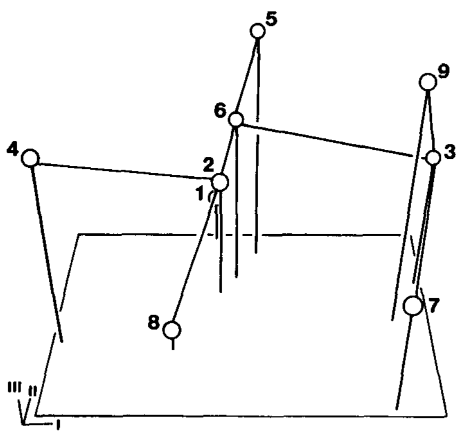

Figure 2. Projection of localities onto the first 3 dimensions derived from the nonmetric multidimensional scaling of 9 characters (food items) recorded for Tennessee coyotes. Numbers correspond to those given in the text for counties and regions.

World rat (*Rattus* spp.), and squirrel (*Sciurus* spp.) were verified. Other mammals included rabbit, white-tailed deer, livestock, opossum, and short-tailed shrew (*Blarina* spp.). The identifiable nongame birds were common flicker (*Colaptes* spp.) and cardinal (*Cardinalis cardinalis*). Game birds included wild turkey (*Meleagris gallapavo*) and northern bobwhite (*Colinus virginianus*); domestic chicken was grouped with gamebirds for analyses. The most common insect was grasshopper (*Melanoplus* spp.).

Vegetation was grouped into 3 categories (grass, persimmon, and other vegetation). Grass and persimmon were the most common vegetation. Other vegetation consisted of items rarely taken.

In the multivariate analysis, a final stress (a measure of goodness of fit) of 0.077 was obtained when the original distance matrix was reduced to a 3-dimensional matrix (Lee 1986). An $r = 0.940$ was determined when the original distance matrix and reduced distance matrix were compared. Thus, there was little distortion in distances when reducing the original 9-dimensional character matrix to 3 dimensions. The 3-dimensional plot is presented as Figure 2.

In general, the position of the localities on dimension I (Fig. 2) was influenced by livestock, rabbit, and bird. Variation along dimension I separated coyotes with high percent occurrence for livestock and low for rabbit and bird (localities 3, 9, 7; positioned to the right of the model) from those with the opposite condition (locality 4; positioned to the left). Animals representing most localities grouped toward the center of the model, indicating similarity in percent occurrences of food items. Dimension II (Fig. 2) was principally dominated by the percent occurrence of persimmon. Coyotes from localities toward the front of the model (4, 7, 8) had high values for persimmon while those to the back (1, 5) had low values.

For the most part, dimension III was influenced by the percent occurrence of livestock and insect. Animals from localities represented by low sticks (8, 1) have high occurrence for insect and low occurrence for livestock. Coyotes with the opposite condition are represented by localities with high sticks (9, 3, 7, 5). It is evident that there are exceptions to the generalizations derived for dimensions I-III; however, patterns exist. Examination of environmental data with percent occurrence of food items revealed no association ($P \geqslant 0.05$).

Discussion

The coyote has been shown by a number of investigators (e.g., Sperry 1941, Gier 1975) to be an extremely versatile scavanger and predator. Gipson (1974) summarized 5 studies relating to the food habits of coyotes in their original range and reported that rabbits and rodents were most important. Other studies conducted in the newly colonized area (western Tennessee—Smith and Kennedy 1983, Mississippi and Alabama—Wooding et al., 1985) of the southeastern United States reported similar findings. This study indicated that a feeding strategy which included a high use of rodents and rabbits was maintained by coyotes in the newly colonized area.

White-tailed deer and livestock were among the most economically important food items of coyotes found in Tennessee. Bekoff (1977) reported that there is little evidence that coyote predation is a primary limiting factor on big game populations or domestic livestock, and Korschgen (1973) concluded that coyotes do not prey heavily on livestock. The average percent occurrence reported in this study for white-tailed deer was higher than the 13% reported for western Tennessee by Smith and Kennedy (1983) but similar to the 30% (percent occurrence in stomachs) reported by Wooding et al. (1985) for Mississippi and Alabama. Since most coyotes examined were collected during autumn and winter and several digestive tracts contained remains of internal organs, it is probable that scavenging of wounded deer or remains of field-dressed deer accounted for the high percentage of deer in our study.

Our average percent occurrence for livestock is lower than the 35.2% reported for western Tennessee (Smith and Kennedy 1983) but similar to the 19.0% reported for Mississippi and Alabama (Wooding et al. 1985). It was difficult to separate carrion from predator-killed animals; therefore, these results should be interpreted with caution.

Smith and Kennedy (1983) reported the percent occurrence of insects in coyote samples as 14.8 (similar to our 12.6), but they did not elaborate on the types of insects. Wooding et al. (1985) found insects in 39.0% and 37.9% of the stomachs and scats examined, respectively. Grasshoppers were the most common insect taken. There is widespread utilization of insect by coyotes at varying levels. Birds also seem to be a consistent component of the coyote diet. Other animal foods (reptile and amphibian, shrew, and opossum) eaten by coyotes in Tennessee probably reflected their opportunistic nature.

Because persimmons rarely occur west of central Oklahoma, this item represents a new food for coyotes in the east parts of its range. While other types of plant material (other vegetation) had a high occurrence, no individual item predominated. These findings differ from Smith and Kennedy (1983) but are consistent with Wooding et al. (1985). Grass has been eaten by coyotes in several areas; however, only Best et al. (1981) has suggested investigating its nutritional value to coyotes. The role of grass as a food item for the coyote is unclear. In this study, grass was found in several stomachs (20.7%), while Smith and Kennedy (1983) reported no use of grass. Differences are probably due to larger sample sizes of the present study. Wooding et al. (1985) reported grass in 11.0% (stomachs) and 10.9% (scats).

Our data support Sperry (1941), Korschgen (1957), Gipson (1974), and Bekoff (1977) that have noted no differences between diets of males and females. However, little attempt has been made to examine food use across age classes. In this study, only persimmons varied across age classes (juvenile animals taking more persimmons than other classes). Overall, results of this study follow those reported in previous investigations (Sperry 1932, Ozoga and Harger 1966, Bekoff 1977, Bowyer et al. 1983) whieh indicate a seasonal shift in the use of several foods.

Only a few studies (Korschgen 1957, Clark 1972, Gipson and Sealander 1976) have addressed annual variation in coyote food habits. Although varying somewhat in percent occurrence, principle foods appeared to remain as important items across years in our study; however, 2 primary foods (livestock and insect) did vary. Livestock predation by coyotes varied regionally, and harvest pressure and control measures varied by year. However, insects showed variable annual emergence patterns, and coyote use of insects may have varied with availability.

Coyotes from localities represented in this study were similar in percent occurrences for most foods. Results of the multivariate analysis indicated coyotes from the majority of localities clustered toward the center of the model (Fig. 2). This grouping indicated that most coyotes tended to take similar foods, probably reflecting opportunistic feeding. Gipson (1974) indicated differences in food items across 4 physiographic regions in Arkansas. Similar tests across all physiographic regions in Tennessee are not yet possible because of the sparse numbers of coyotes. The fact that no relationships were determined between food items and selected environmental factors further indicated a homogeneous food resource in the regions studied.

Overall, the coyote has been shown by a number of investigators (e.g., Murie 1940, Sperry 1941, Gier 1975) to be a versatile scavenger and predator. Opportunistic feeding habits have not been lost in the southeastern coyote. This opportunistic nature of feeding is likely to be a major factor in the success of the species in the Southeast. Since variation across years does exist for some food items, long-term studies are recommended for understanding the coyote in the Southeast.

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