Western North American Naturalist

Volume 67 | Number 1 Article 2

3-27-2007

Diets of sympatric bobcats and coyotes during years of varying rainfall in central Arizona

Ted McKinney
Arizona Game and Fish Department, Research Branch, Phoenix, Arizona

Thorry W. Smith
Arizona Game and Fish Department, Research Branch, Phoenix, Arizona

Western North American Naturalist 67(1), © 2007, pp. 8–15

DIETS OF SYMPATRIC BOBCATS AND COYOTES DURING YEARS OF VARYING RAINFALL IN CENTRAL ARIZONA

Ted McKinney[1,2] and Thorry W. Smith[1]

ABSTRACT.—We collected fecal samples (scats) of sympatric bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) between 2000 and 2003 in a 53,600-ha area of the Upper Sonoran Desert in central Arizona. Our objective was to investigate composition, diversity, and overlap of diets of bobcats and coyotes in relation to varying rainfall in the Sonoran Desert of central Arizona. In general, bobcats ate more rodents than did coyotes, and coyotes ate more lagomorphs, large prey, and fruit/seeds than did bobcats. Composition of bobcat diets was independent of differences among years in annual rainfall and seasonal rainfall during summer–autumn (May–October) and winter–spring (November–April). Composition of coyote diets also was independent of drought conditions among years during summer–autumn, but coyotes ate more large prey and fewer rodents during years with winter–spring drought. Seasonally, bobcats ate more rodents than did coyotes in summer–autumn and winter–spring, whereas coyotes ate more lagomorphs than did bobcats during winter–spring, and more large prey and fruit/seeds in both seasons. Coyotes ate more large prey and lagomorphs during winter–spring, when seasonal rainfall was higher, and more fruit/seeds in summer–autumn, when seasonal rainfall was lower. Diversity of diets was consistently higher for coyotes than for bobcats, and increased for bobcats but not for coyotes during winter–spring drought and during higher seasonal rainfall in winter–spring. Overlap of diets between predators was independent of rainfall levels. We suggest that bobcats in the Sonoran Desert are more selective, specialized predators and that coyotes are more generalist, opportunistic predators. We hypothesize that, although diversity of bobcat food items and composition of coyote diets differ with varying rainfall in the Sonoran Desert, patterns of feeding strategy are independent of seasonal differences in precipitation and effects of drought, and bobcats and coyotes partition food resources independently of varying rainfall.

Key words: Arizona, bobcats, coyotes, diets, drought, rainfall, seasons, Sonoran Desert.

Bobcat (*Lynx rufus*) and coyote (*Canis latrans*) populations are sympatric over much of their range in North America, and diets of these 2 species have been studied extensively in various geographic regions. Bobcats and coyotes are believed to be obligate and facultative carnivores, respectively (Ballard et al. 2001). Bobcats are specialized in their diets (Anderson 1987, Litvaitis and Harrison 1989), but whether they are opportunistic or selective predators is controversial (Anderson 1987, Delibes and Hiraldo 1987, Delibes et al. 1997). Coyotes are thought to be more generalist, opportunistic predators (MacCracken and Hansen 1987, Arjo et al. 2002), although some prey selection has been suggested (Windberg and Mitchell 1990, Hernández et al. 1994, Patterson et al. 1998).

Regional differences in diets of bobcats and coyotes might be expected to reflect differences in availability of food resources (Witmer and DeCalesta 1986, Anderson 1987, Theberge and Wedeles 1989, Delibes et al. 1997, Anderson and Lovallo 2003). Relative abundance of predators and alternative prey, as well as weather variables, might influence diets (Beasom and Moore 1977, Leopold and Krausman 1986, Gese et al. 1988). Rainfall is unpredictable and variable in arid and semiarid regions of the southwestern United States (McKinney et al. 2001, Marshal et al. 2002, 2005), and it influences forage availability and abundance of food resources for bobcats and coyotes (Beatley 1969, Reichman and Van De Graaff 1975, Whitford 1976, Jones and Smith 1979, Brown and Heske 1990). Diets of bobcats in southern Texas were influenced by the interaction between rainfall and vegetation (Beasom and Moore 1977). Drought in southern Texas might have contributed to lower consumption of ungulates and increased consumption of lagomorphs by bobcats and coyotes (Leopold and Krausman 1986). In comparison, diets of bobcats in Arizona's Sonoran Desert appeared independent of

[1]Arizona Game and Fish Department, Research Branch, 2221 W. Greenway Road, Phoenix, AZ 85023.
[2]E-mail: tmckinney@azgfd.gov

relative abundance of lagomorphs and rodents during a period of above-average rainfall (Jones and Smith 1979).

Little information is available regarding composition, diversity, and overlap of diets of bobcats and coyotes in relation to environmental variables in desert habitats of southwestern North America (Ortega 1987, Hernández et al. 1994, Delibes et al. 1997). Thus, information concerning diets of sympatric bobcats and coyotes in deserts of the Southwest could provide insights into mechanisms that facilitate coexistence of the species. Our objective was to investigate composition, diversity, and overlap of diets of bobcats and coyotes in relation to varying rainfall in the Sonoran Desert of central Arizona.

STUDY AREA

We conducted this study between January 2000 and December 2003 on a 53,600-ha area of the Upper Sonoran Desert (Brown 1994) in the Mazatzal Mountains, 65 km northeast of Phoenix, Arizona. The study area encompassed the 24,600-ha Four Peaks Wilderness Area, which occupied the eastern half of the site. Elevation ranged from 457 m to 2317 m, and primary vegetation communities were Sonoran Desert scrub, semidesert grassland, and interior chaparral (Cunningham and Ballard 2004). Drought conditions prevailed from 1994 to 1999, and average temperatures were about 10°C in winter and 30°C in summer (McKinney et al. 2001). Mammalian predators in the area included bobcats, black bears (*Ursus americanus*), coyotes, gray foxes (*Urocyon cinereoargenteus*), and mountain lions (*Puma concolor*). Ungulates included mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), collared peccary (*Pecari tajacu*), desert bighorn sheep (*Ovis canadensis*), and feral burros (*Equus asinus*). Cattle were removed from the study area between mid-2000 and early 2001, and by 2002 also were reduced to low levels on contiguous grazing allotments (USDA Forest Service, unpublished data).

METHODS

Total monthly rainfall between 1975 and 2003 was measured at the Mormon Flat and Stewart Mountain Dams, located on the Salt River at the southern boundary of the study area. We defined drought as <75% of long-term average (Thurow and Taylor 1999). Rainfall data were compiled annually (January–December) and seasonally in winter–spring (November–April) and summer–autumn (May–October), based on seasonal patterns (McKinney et al. 2001).

We evaluated diets through analyses of fecal samples (scats). We collected scats of bobcats and coyotes by searching along canyon bluffs and slopes, dry washes, ridges, livestock trails, and occasionally while driving limited wilderness access roads (<20 km). Because we searched continually throughout the study area, we considered the scats we collected to be a representative sample of those produced. We placed scats individually in plastic bags and held them at ambient temperatures <1 month before analysis. In most instances we were unable to determine relative ages of the scats, but median persistence of unprotected scats of wild canids and captive coyotes and bobcats away from roads in the Sonoran Desert was 14 days (Sanchez et al. 2004), suggesting that scats we collected were generally ≤1 month old.

We identified scats to species based on size, form, odor, and presence of tracks and scrapes at the collection site (Murie 1954, Danner and Dodd 1982, Fedriani et al. 2000, Thornton et al. 2004). Because feces of canids can be misidentified, we assigned scats ≥21 mm in diameter to coyotes, and further differentiated scats of foxes on the basis of long, tapered ends and strong odor (Danner and Dodd 1982, Fedriani et al. 2000). We thoroughly dissected air-dried scats by hand (Spaulding et al. 2000), sorted remains of food items, and identified remains of vertebrates by comparing scat contents to a reference collection of mammalian bone, hair, and tooth fragments developed by the Arizona Game and Fish Department and following Moore et al. (1974). We macroscopically identified remains of birds (feathers), reptiles (claw and skin remnants), and fruit or seeds in scats.

We divided remains of food items into 7 categories to evaluate diets: large prey (deer, collared peccary, cattle), lagomorphs, rodents, birds, reptiles, fruit/seeds, and invertebrates. We calculated percent occurrence of food items in scats (number of occurrences of each food item * 100 / total number of occurrences of all food items) for each predator by year and season. We compiled results of fecal analyses annually (January–December) and seasonally

TABLE 1. Annual (January–December), summer–autumn (May–October), and winter–spring (November–April) rainfall, 2000–2003. Percentages of long-term averages (1975–2003, Mazatzal Mountains, AZ) are given in parentheses.

	Rainfall (cm)			
Periods	2000	2001	2002	2003
Annual	29.6 (84.3%)	29.5 (84.0%)	12.9 (36.8%)	25.5 (72.6%)
Summer–autumn	18.9 (140.0%)	5.8 (43.0%)	5.6 (41.5%)	3.4 (25.2%)
Winter–spring	9.8 (44.5%)	20.7 (94.1%)	5.7 (25.9%)	18.9 (85.9%)

in winter–spring (November–April) and summer–autumn (May–October), corresponding with seasonal patterns of rainfall. We calculated diet overlap and diversity indices between years and seasons. Overlap indices can range from 0 (no overlap) to 1 (complete overlap), and diversity indices can range between 0 and n (n = number of food categories; Litvaitis and Harrison 1989). We evaluated composition, diversity, and overlap of predator diets using food items that occurred in at least 5% of the scats of either carnivore during annual or seasonal periods (Siegel and Castellan 1988). We tested for differences in diet composition among years and seasons using chi-square contingency tables (Siegel and Castellan 1988) and tested for differences in occurrence of individual food items between seasons using chi-square analyses (Yates correction factor) or the Fisher exact test for 2×2 contingency tables (Zar 1996).

RESULTS

Average rainfall was 35.1 cm annually (January–December 1975–2003), 13.5 cm during summer–autumn (May–October 1975–2003), and 22.0 cm during winter–spring (November–April 1975–2003). Drought conditions reflected in annual rainfall prevailed in 2002, and annual rainfall was slightly below 75% of long-term average in 2003; normal (≥75% of long-term average) annual rainfall occurred during 2 consecutive years (2000–2001). Drought also occurred in summer–autumn for 3 consecutive years (2001–2003), and during winter–spring in 2000 and 2002 (Table 1). On average, rainfall in winter–spring constituted about 62% of total seasonal rainfall between 2000 and 2003. In contrast to precipitation during winter–spring, composition, diversity, or overlap of predator diets had no clear association with levels of total annual rainfall or rainfall during summer–autumn.

We analyzed remains of food items for 320 bobcat and 622 coyote scats (Table 2). Among years (Table 2), bobcats ate more rodents than did coyotes ($\chi^2 = 17.16$, df = 3, $P < 0.001$), and coyotes ate more lagomorphs than did bobcats ($\chi^2 = 25.00$, df = 3, $P < 0.001$). Infrequent occurrence of remains of other food items in bobcat scats (Tables 2, 3) precluded statistical tests for differences among years between compositions of the diets of predators (Siegel and Castellan 1988). Seasonally, bobcats ate more rodents than did coyotes during summer–autumn ($\chi^2 = 47.96$, df = 1, $P < 0.001$), and coyotes ate more large prey (Fisher exact test: $P = 0.002$) and more fruit/seeds ($\chi^2 = 26.20$, df = 1, $P < 0.001$) than did bobcats (Table 3). During winter–spring, coyotes consumed more lagomorphs than did bobcats ($\chi^2 = 9.96$, df = 1, $P < 0.002$), and bobcats consumed more rodents than did coyotes ($\chi^2 = 121.05$, df = 1, $P < 0.001$).

Composition of bobcat diets (Tables 2, 3) did not differ among years ($\chi^2 = 6.19$, df = 6, $P < 0.25$) or between seasons ($\chi^2 = 3.20$, df = 3, $P < 0.50$). In contrast, composition of coyote diets (Tables 2, 3) differed among years ($\chi^2 = 83.29$, df = 18, $P < 0.001$) and seasons ($\chi^2 = 47.55$, df = 8, $P < 0.001$). Consumption of large prey by coyotes differed among years ($\chi^2 = 44.06$, df = 6, $P < 0.001$). Coyotes ate fewer rodents ($\chi^2 = 7.83$, df = 1, $P = 0.005$) and more large prey ($\chi^2 = 7.91$, df = 1, $P < 0.005$) during years with winter–spring drought in 2000 and 2002, compared with years of normal winter–spring rainfall in 2001 and 2003 (Tables 1, 2). Coyotes ate more large prey ($\chi^2 = 13.67$, df = 1, $P < 0.01$) and lagomorphs ($\chi^2 = 7.67$, df = 1, $P < 0.01$) during winter–spring than in summer–autumn, and they ate more fruit/seeds ($\chi^2 = 38.61$, df = 1, $P < 0.001$) during summer–autumn than in winter–spring (Table 3).

Diversity of food items eaten by coyotes was consistently higher than that of bobcats

TABLE 2. Total number of scats sampled, number of various food items, and percent occurrence of food items in scats of bobcats and coyotes, 2000–2003, Mazatzal Mountains, Arizona.

	Bobcat				Coyote			
	2000	2001	2002	2003	2000	2001	2002	2003
Total scats	92	49	101	78	91	174	237	120
Food items	113	53	112	85	115	212	310	161
Percent occurrence								
Deer	8.0	0	0	0	5.2	3.8	11.3	5.0
Collared peccary	0	1.9	0.9	1.2	5.2	4.2	8.1	1.9
Cattle	0.9	0	0	0	19.1	14.6	3.5	1.2
Lagomorph	15.0	17.0	21.4	9.4	20.0	22.6	26.5	18.6
Rodent	58.4	73.6	65.2	77.6	27.0	29.2	21.0	34.8
Bird	8.0	7.5	5.4	9.4	8.7	4.7	7.4	8.7
Reptile	0.9	0	2.8	0	1.7	2.4	2.3	0.6
Fruit/seed	7.1	0	4.5	2.4	13.0	18.9	18.7	23.0
Invertebrate	0.9	0	0	0	0	0	1.6	6.8

TABLE 3. Total number of scats sampled, seasonal number of various food items, and percent occurrence of food items in scats of bobcats and coyotes, Mazatzal Mountains, Arizona, 2000–2003.

	Summer–autumn		Winter–spring	
	Bobcat	Coyote	Bobcat	Coyote
Total scats	77	199	243	423
Food items	84	263	279	535
Percent occurence				
Deer	2.4	4.9	2.5	8.2
Collared peccary	0	2.3	1.1	6.9
Cattle	0	5.7	0.4	9.3
Lagomorph	15.5	16.3	16.2	26.2
Rodent	70.2	27.4	66.6	26.5
Bird	8.3	8.4	7.1	6.5
Reptile	1.2	2.7	1.1	1.5
Invertebrate	0	1.9	0.4	2.1
Fruit/seed	2.4	30.4	5.0	12.7

(Tables 4, 5). Diversity of food items eaten by bobcats, but not coyotes, tended to be higher during years with winter–spring drought and seasonally in winter–spring (Tables 1, 4, 5). Overlap between bobcat and coyote diets was independent of varying rainfall levels between seasons and among years, except that lowest overlap was apparent during severe drought in 2002 (Tables 1, 4, 5). Scats of bobcats and coyotes contained an average of 1.1 and 1.3 identifiable food items, respectively, among years and during seasons (Tables 2, 3).

DISCUSSION

Home ranges of bobcats and coyotes typically overlap spatially and temporally (Witmer and DeCalesta 1986, Major and Sherburne 1987, Thornton et al. 2004, Chamberlain and Leopold 2005), and competition between the species might occur in some ecosystems (Anderson and Lovallo 2003). We speculate that partitioning of food resources facilitates coexistence of bobcats and coyotes in Arizona's Sonoran Desert. Differences we observed between composition and diversity of diets of bobcats and coyotes might enhance sympatry (Fedriani et al. 2000, Neale and Sacks 2001, Thornton et al. 2004). Lagomorphs and rodents were primary prey of bobcats and coyotes, but bobcats ate more rodents than did coyotes, and coyotes ate more lagomorphs, fruit/seeds, and large prey than did bobcats. Overlap between diets of bobcats and coyotes was independent of drought during winter–spring and

TABLE 4. Indices of diet diversity and diet overlap for bobcats and coyotes, 2000–2003, Mazatzal Mountains, Arizona.

Indices	2000	2001	2002	2003
Diet diversity				
Bobcat (B)	2.67	1.74	2.11	1.61
Coyote (C)	4.46	4.48	4.83	4.55
Diet overlap (B × C)	0.59	0.48	0.43	0.51

TABLE 5. Seasonal indices of diet diversity and diet overlap for bobcats and coyotes, 2000–2003, Mazatzal Mountains, Arizona.

Indices	Summer–autumn	Winter–spring
Diet diversity		
Bobcat (B)	1.91	2.09
Coyote (C)	4.59	4.57
Diet overlap (B × C)	0.43	0.48

seasonal differences in rainfall; and diversity of coyotes diets consistently exceeded that of bobcat diets. Levels of overlap in composition of bobcat and coyote diets do not infer absence or existence of competition between the predators (Litvaitis and Harrison 1989), but interspecific competition may be less in southern areas of North America with milder climates and a more stable prey base than in northern areas, which experience seasonal restrictions in prey abundance (Neale and Sacks 2001, Thornton et al. 2004).

Numerous studies in desert habitats of the Southwest suggest that unpredictable rainfall affects forage production and abundance of potential prey of bobcats and coyotes. Rainfall in our study was higher during winter–spring than summer–autumn, and drought occurred in 2 of 4 years during winter–spring and 3 of 4 years during summer–autumn. Our findings indicated that diversity of bobcat food items and composition of coyote diets differed between seasons and between years of normal winter–spring rainfall and winter–spring drought, but measures of diets were independent of drought in summer–autumn. Composition of bobcat diets was independent of drought conditions during winter–spring, but higher diversity of food items during years with winter–spring drought suggests more opportunistic feeding when abundance and diversity of rodents likely are reduced during drought in desert communities (Reichman and Van De Graaff 1975, Whitford 1976, Jones and Smith 1979, Brown and Heske 1990).

Evidence of higher diversity of food items of bobcats during years with winter–spring drought and seasonally in winter–spring was not clearly apparent in differences in occurrence of food items in our study. Bobcats have been considered strict carnivores, although their diets in different regions often contain fruit (Litvaitis and Harrison 1989, Fedriani et al. 2000, Neale and Sacks 2001). Speculatively, differences in diversity of food items in our study might have reflected a tendency of bobcats to eat fewer rodents and more fruit/seeds and reptiles during winter–spring drought, and fewer rodent prey and more large prey, fruit/seeds, and invertebrates seasonally during winter–spring (Litvaitis and Harrison 1989, Neale and Sacks 2001). Reptiles occur most often in diets of bobcats in studies conducted south of 40°N latitude, and bobcats in southern latitudes might tend to eat fewer rodents and more reptiles during winter–spring (Delibes et al. 1997). Based on the same indices, diversity of bobcat diets (this study) during winter–spring was similar to that of bobcat diets in eastern Maine, but diversity during summer–autumn was lower in our study. Diversity of coyote diets during seasons in that region was consistently lower, and dietary overlap between predators was lower in winter–spring but similar in summer–autumn, compared to our results (Litvaitis and Harrison 1989).

Although bobcats appear to be specialized predators (Anderson 1987, Litvaitis and Harrison 1989), local and regional differences in prey availability likely affect their diets (Anderson and Lovallo 2003). Bobcats consume primarily lagomorphs in many areas (Anderson 1987, Anderson and Lovallo 2003), including regions of Utah/Nevada (Gashwiler et al. 1960), and the Sonoran (Delibes et al. 1997) and Chihuahuan (Delibes and Hiraldo 1987) Deserts in Mexico. In contrast, our results and others (Jones and Smith 1979, Maehr and Brady 1986, Thornton et al. 2004) support the contention that rodents tend to occur more often than lagomorphs in diets of bobcats in some desert areas and other more southern regions in North America. In general, rodents are believed to be more important prey than lagomorphs for bobcats in areas of the southern and western United States (Delibes et al. 1997). Relative availability of alternative prey might influence diets of bobcats in some arid and semiarid regions (Leopold and Krausman 1986, Delibes and Hiraldo 1987, Delibes et al. 1997), but consumption of lagomorphs and rodents by bobcats in central Arizona was independent of densities of these prey (Jones and Smith 1979).

Consumption of lagomorphs by coyotes among years was independent of drought during winter–spring, but coyotes ate less rodent prey and more large prey during years with winter–spring drought. Seasonally, coyotes ate more large prey and lagomorphs during winter–spring and ate more fruits/seeds during summer–autumn. Diversity of coyote diets was independent of winter–spring drought and seasonal rainfall patterns. Coyotes in desert areas possibly select for lagomorphs independently of their abundance but consume rodents in proportion to their availability (Hernández et al. 1994). Coyotes are thought to be generalist, opportunistic predators that consume prey largely in relation to availability (MacCracken and Hansen 1987, Windberg and Mitchell 1990). Composition of coyote diets likely tend to differ with seasonal variability of food resources in southern regions of milder climates (Leopold and Krausman 1986, Andelt et al. 1987, Ortega 1987, Hidalgo-Mihart et al. 2001), as well as in northern regions with greater seasonal limitations in prey availability (Andelt et al. 1987, Major and Sherburne 1987, Gese et al. 1988, Litvaitis and Harrison 1989, Koehler and Hornocker 1991).

Consistent with other studies (Litvaitis and Harrison 1989, Cypher and Spencer 1998, Fedriani et al. 2000), our measures of composition, diversity, and overlap of diets between predators did not identify small prey, fruits/seeds, or invertebrates to species level, possibly influencing results. However, consumptions of rodent species by bobcats and coyotes in California were positively correlated, indicating no evidence of prey partitioning by species (Neale and Sacks 2001). Because percent occurrence accounts for multiple food items in a scat (de Villa Meza et al. 2002), analyses using percent occurrence are justified in estimating what and relatively how much of food items are eaten (Corbett 1989, Hernández et al. 1994, Delibes et al. 1997). Thus, percent occurrence might provide a better indication of which food items are consumed than frequency of occurrence.

In summary, composition of diets differed less for bobcats than for coyotes in association with seasonal rainfall patterns and drought during winter–spring. Diversity of diets was consistently higher for coyotes than for bobcats, and it increased for bobcats but not for coyotes during winter–spring drought and during higher seasonal rainfall in winter–spring. Overlap of diets between predators was independent of rainfall levels.

Remaining consistent with studies in other regions (Anderson 1987, MacCracken and Hansen 1987, Litvaitis and Harrison 1989, Fedriani et al. 2000), we suggest that bobcats in the Sonoran Desert are more selective, specialized predators, whereas coyotes are more generalist, opportunistic predators. We hypothesize that, although diversity of bobcat food items and composition of coyote diets differ with varying rainfall in the Sonoran Desert, patterns of feeding strategy of these predators are independent of seasonal differences in precipitation and effects of drought, and bobcats and coyotes partition food resources independently of varying rainfall.

ACKNOWLEDGMENTS

The Federal Aid Wildlife Restoration Act, under Pittman-Robertson Project W-78-R of the Arizona Game and Fish Department, and the Arizona Desert Bighorn Sheep Society provided funding for this study. We thank J.R. Heffelfinger, M.L. Zornes, E.M. Anderson, and anonymous reviewers for insightful suggestions regarding earlier drafts of this manuscript.

LITERATURE CITED

ANDELT, W.F., J.G. KIE, F.F. KNOWLTON, AND K. CARDWELL. 1987. Variation in coyote diets associated with season and successional changes in vegetation. Journal of Wildlife Management 51:273–277.

ANDERSON, E.M. 1987. A critical review and annotated bibliography of literature on the bobcat. Special Report No. 62, Colorado Division of Wildlife, Denver.

ANDERSON, E.M., AND M.J. LOVALLO. 2003. Bobcat and lynx. Pages 758–786 *in* G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors, Wild mammals of North America. Johns Hopkins University Press, Baltimore, MD.

ARJO, W.M., D.H. PLETSCHER AND R.R. REAM. 2002. Dietary overlap between wolves and coyotes in northwestern Montana. Journal of Mammalogy 83:754–766.

BALLARD, W.B., D. LUTZ, T.W. KEEGAN, L.H. CARPENTER, AND J.C. DEVOS, JR. 2001. Deer-predator relationships: a review of recent North American studies with emphasis on mule and black-tailed deer. Wildlife Society Bulletin 29:99–115.

BEASOM, S.L., AND R.A. MOORE. 1977. Bobcat food habit response to a change in prey abundance. Southwestern Naturalist 21:451–457.

BEATLEY, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology 50:721–724.

BROWN, D.E. 1994. Biotic communities—southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City. 342 pp.

BROWN, J.H., AND E.J. HESKE. 1990. Temporal changes in a Chihuahuan Desert rodent community. Oikos 59: 290–302.

CHAMBERLAIN, M.J., AND B.D. LEOPOLD. 2005. Overlap in space use among bobcats (*Lynx rufus*), coyotes (*Canis latrans*) and gray foxes (*Urocyon cinereoargenteus*). American Midland Naturalist 153:171–179.

CORBETT, L.K. 1989. Assessing the diet of dingoes from feces: a comparison of 3 methods. Journal of Wildlife Management 53:343–346.

CUNNINGHAM, S.C., AND W.B. BALLARD. 2004. Effects of wildfire on black bear demographics in central Arizona. Wildlife Society Bulletin 32:928–937.

CYPHER, B.L., AND K.A. SPENCER. 1998. Competitive interactions between coyotes and San Joaquin kit foxes. Journal of Mammalogy 79:204–214.

DANNER, D.A., AND N.L. DODD. 1982. Comparison of coyote and gray fox scat diameters. Journal of Wildlife Management 46:240–241.

DELIBES, M., M.C. BLÁSQUEZ, R. RODRIGUEZ, AND S.C. ZAPATA. 1997. Seasonal food habits of bobcats (*Lynx rufus*) in subtropical Baja California Sur, Mexico. Canadian Journal of Zoology 74:478–483.

DELIBES, M., AND F. HIRALDO. 1987. Food habits of the bobcat in two habitats of the southern Chihuahuan Desert. Southwestern Naturalist 32:457–461.

DE VILLA MEZA, A., E.M. MEYER, AND G.L. GONZÁLEZ. 2002. Ocelot (*Leopardus pardalis*) food habits in a tropical deciduous forest of Jalisco, Mexico. American Midland Naturalist 48:146–154.

FEDRIANI, J.M., T.K. FULLER, R.M. SAUVAJOT, AND E.C. YORK. 2000. Competition and intraguild predation among three sympatric carnivores. Oecologia 125: 258–270.

GASHWILER, J.S., W.L. ROBINETTE, AND O.W. MORRIS. 1960. Foods of bobcats in Utah and eastern Nevada. Journal of Wildlife Management 24:226–229.

GESE, E.M., O.J. RONGSTAD, AND W.R. MYTTON. 1988. Relationship between coyote group size and diet in southeastern Colorado. Journal of Wildlife Management 52:647–653.

HERNÁNDEZ, L., M. DELIBES, AND F. HIRALDO. 1994. Role of reptiles and arthropods in the diet of coyotes in extreme desert areas of northern Mexico. Journal of Arid Environments 26:165–170.

HIDALGO-MIHART, M.G., L. CANTÚ-SALAZAR, C.A. LÓPEZ-GONZÁLEZ, E. MARTÍNEZ-MEYER, AND A. GONZÁLEZ-ROMERO. 2001. Coyote (*Canis latrans*) food habits in a tropical deciduous forest of western Mexico. American Midland Naturalist 146:210–216.

JONES, J.H., AND N.S. SMITH. 1979. Bobcat density and prey selection in central Arizona. Journal of Wildlife Management 43:666–672.

KOEHLER, G.M., AND M.G. HORNOCKER. 1991. Seasonal resource use among mountain lions, bobcats, and coyotes. Journal of Mammalogy 72:391–396.

LEOPOLD, B.D., AND P.R. KRAUSMAN. 1986. Diets of 3 predators in Big Bend National Park, Texas. Journal of Wildlife Management 50:290–295.

LITVAITIS, J.A., AND D.J. HARRISON. 1989. Bobcat-coyote niche relationships during a period of coyote population increase. Canadian Journal of Zoology 67:1180–1188.

MACCRACKEN, J.G., AND R.M. HANSEN. 1987. Coyote feeding strategies in southeastern Idaho: optimal foraging by an opportunistic predator? Journal of Wildlife Management 51:278–285.

MAEHR, D.S., AND J.R. BRADY. 1986. Food habits of bobcats in Florida. Journal of Mammalogy 67:133–138.

MAJOR, J.T., AND J.A. SHERBURNE. 1987. Interspecific relationships of coyotes, bobcats, and red foxes in western Maine. Journal of Wildlife Management 51:606–616.

MARSHAL, J.P., P.R. KRAUSMAN, AND V.C. BLEICH. 2005. Dynamics of mule deer forage in the Sonoran Desert. Journal of Arid Environments 60:593–609.

MARSHAL, J.P., P.R. KRAUSMAN, V.C. BLEICH, W.B. BALLARD, AND J.S. MCKEEVER. 2002. Rainfall, El Niño, and dynamics of mule deer in the Sonoran Desert, California. Journal of Wildlife Management 66:1283–1289.

MCKINNEY, T., T.W. SMITH, AND J.D. HANNA. 2001. Precipitation and desert bighorn sheep in the Mazatzal Mountains, Arizona. Southwestern Naturalist 46: 345–353.

MOORE, T.D., L.E. SPENCE, C.E. DUGNOLLE, AND W.G. HEPWORTH. 1974. Identification of the dorsal guard hairs of some mammals in Wyoming. Wyoming Game and Fish Department Bulletin 14:1–177.

MURIE, O.J. 1954. A field guide to animal tracks. Houghton Mifflin Co., Boston, MA. 374 pp.

NEALE, J.C.C., AND B.N. SACKS. 2001. Resource utilization and interspecific relations of sympatric bobcats and coyotes. Oikos 94:236–249.

ORTEGA, J.C. 1987. Coyote food habits in southeastern Arizona. Southwestern Naturalist 32:152–155.

PATTERSON, B.R., L.K. BENJAMIN, AND F. MESSIER. 1998. Prey switching and feeding habits of eastern coyotes in relation to snowshoe hare and white-tailed deer densities. Canadian Journal of Zoology 76:1885–1897.

REICHMAN, O.J., AND K.M. VAN DE GRAAFF. 1975. Association between ingestion of green vegetation and desert rodent reproduction. Journal of Mammalogy 56:503–506.

SANCHEZ, D.M., P.R. KRAUSMAN, T.R. LIVINGSTON, AND P.S. GIPSON. 2004. Persistence of carnivore scat in the Sonoran Desert. Wildlife Society Bulletin 32:366–372.

SIEGEL, S., AND N.J. CASTELLAN, JR. 1988. Nonparametric statistics for the behavioral sciences. 2nd edition. McGraw-Hill, New York. 399 pp.

SPAULDING, R., P.R. KRAUSMAN, AND W.B. BALLARD. 2000. Observer bias and analysis of gray wolf diets from scats. Wildlife Society Bulletin 28:947–950.

THEBERGE, J.B., AND C.H.R. WEDELES. 1989. Prey selection and habitat partitioning in sympatric coyote and red fox populations, southwest Yukon. Canadian Journal of Zoology 67:1285–1290.

THORNTON, D.H., M.E. SUNQUIST, AND M.B. MAIN. 2004. Ecological separation within newly sympatric populations of coyotes and bobcats in south-central Florida. Journal of Mammalogy 85:973–982.

THUROW, T.L., AND C.A. TAYLOR. 1999. Viewpoint: the role of drought in range management. Journal of Range Management 52:413–419.

WHITFORD, W.G. 1976. Temporal fluctuations in density and diversity of desert rodent populations. Journal of Mammalogy 57:351–359.

WINDBERG, L.A., AND C.D. MITCHELL. 1990. Winter diets of coyotes in relation to prey abundance in southern Texas. Journal of Mammalogy 71:439–447.

WITMER, G.W., AND D.S. DECALESTA. 1986. Resource use by unexploited sympatric bobcats and coyotes in Oregon. Canadian Journal of Zoology 64:2333–2338.

ZAR, J.H. 1996. Biostatistical analysis. 3rd edition. Prentice Hall, Upper Saddle River, NJ. 662 pp.

Received 1 June 2005
Accepted 17 May 2006