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FOOD HABITS OF BOBCATS IN INDIANA

Cassie M. Hudson, Scott A. Johnson[1], **Beth J. Geboy** and **Heather D. Walker**: Indiana Department of Natural Resources, 5596 East State Road 46, Bloomington, IN 47401, USA

ABSTRACT. The food habits of bobcats (*Lynx rufus*) have been reported throughout North America but there are few published accounts from the midwestern United States where conversion of native habitats to agricultural use prompted historic declines in regional populations. We determined food habits of bobcats in Indiana by examining the stomach contents of 159 carcasses obtained primarily from collisions with vehicles and trap-related mortalities in 38 counties between 1990 and 2010. Thirty-eight stomachs were either empty or had only vegetation or woody debris. Mammalian prey was found in 94.2% of the remaining stomachs, whereas avian remains were present in 14 stomachs (11.6%). Leading prey items consumed year-round were eastern cottontail rabbits (*Sylvilagus floridanus*; 35.5% occurrence), small mammals (e.g., *Microtus* spp., *Peromyscus* spp.; 26.4% occurrence), and tree squirrels (e.g., *Sciurus niger*, *S. carolinensis*; 15.7% occurrence). White-tailed deer (*Odocoileus virginianus*) and muskrat (*Ondatra zibethicus*) were consumed exclusively in fall-winter, but seasonality of other prey species was not observed. Frequencies of most foods varied between sexes and among age classes but differences were not statistically significant. Bobcats in Indiana exploited a wide array of mammalian prey consistent with other studies throughout North America, and principal food items (e.g., rabbits, small mammals, sciurids) were equally as important in other midwestern states where diet has been assessed.

Keywords: Bobcat, diet, food habits, Indiana, lagomorphs, *Lynx rufus*

INTRODUCTION

Bobcats (*Lynx rufus*) are the most common and widely distributed felid endemic to North America (Anderson & Lovallo 2003). The species' historical range is vast, encompassing the continental United States and extending from central Mexico north into British Columbia (Young 1958; Hall 1981). Bobcats inhabit diverse environments (e.g., coniferous and broadleaf forests, grasslands, savannahs, deserts) as evidenced by their extensive geographic distribution. As opportunistic predators, the abundance and stability of available prey populations influence their use of habitats (Litvaitis et al. 1986; Koehler & Hornocker 1989). Their food habits have been described from different regions of North America (Rollings 1945; Pollack 1951; Progulske 1955; Fritts & Sealander 1978; Bailey 1979; Jones & Smith 1979; Maehr & Brady 1986; Knick 1990). Bobcats, as all Felidae, are obligate carnivores and prefer prey items weighing between 700 g and 5.5 kg (Rosenzweig 1966). As a whole, mammals comprise the bulk of their diet, and multiple sources (see reviews in Rolley 1987 and Anderson & Lovallo 2003) report lagomorphs (e.g., *Lepus* spp., *Sylvilagus* spp.) to be a common food item rangewide. Principal prey species, however, vary regionally: medium-sized rodents (e.g., *Neotoma* spp., *Sigmodon* spp.) dominate diets in southern states (Kight 1962; Beasom & Moore 1977; Miller & Speake 1978; Jones & Smith 1979) and white-tailed deer (*Odocoileus virginianus*) become more important at northern latitudes (Marston 1942; McCord 1974). Small mammals (e.g., *Microtus* spp., *Peromyscus* spp.) are regularly consumed and were the leading prey of bobcats in southern Illinois (Woolf & Nielsen 2002).

Bobcat populations in the midwestern United States experienced widespread regional declines due to unregulated take and conversion of native habitats to anthropogenic land uses, largely extensive row-crop agriculture, following European settlement (Erickson et al. 1981; Hamilton & Fox 1987; Rolley 1987). Published accounts of the species' food habits from this altered landscape are limited to Illinois (Woolf & Nielsen 2002) and Iowa (Brockmeyer & Clark 2007). Whitaker &

[1] *Corresponding author:* Scott A. Johnson, 812-334-1137 (phone), 812-339-4807 (fax), sjohnson@dnr.IN.gov.

Mumford (2009) provide the only known data from Indiana bobcats in which they describe the stomach contents of three individuals. Our purpose is to provide a comprehensive assessment of the food habits of bobcats in Indiana. We document principal prey items and seasonal variation in food consumption and compare our findings with studies conducted throughout the bobcat's range.

METHODS

Bobcat carcasses were collected from September 1990 through March 2010. Stomachs were removed by cutting the distal end of the esophagus and anterior portion of the duodenum and contents were emptied onto trays for examination. Most items were identified macroscopically but a dissecting microscope was often used to differentiate among cricetids. Each item was identified to the lowest level we were able to confirm, and diet was assessed using percent occurrence and percent volume. Due to small sample sizes, taxonomically and guild-related species were combined into prey groups (e.g., *Sciurus* spp., small mammals) for analysis. The number of individuals of each item present was noted when possible. The volume of each item in stomachs was estimated visually if > 1 item was present. Each sample was assigned to one of two intervals to determine seasonal variation: spring-summer (1 April to 30 September) or fall-winter (1 October to 31 March). Bobcats were aged as juveniles (< 1 year), yearlings (1–2 years), or adults (> 2 years) based on tooth eruption patterns (Jackson et al. 1988), the presence of an open apical root foramen, or cementum annuli analysis of a lower canine (Matson's Laboratory, LLC; Milltown, Montana). We used chi-square (X^2) analyses to compare frequencies among sexes, age classes, and seasons.

RESULTS

Sample effort.—A total of 159 bobcat carcasses (40 adult males, 32 adult females, 22 yearling males, 19 yearling females, 20 juvenile males, 20 juvenile females, and five males and one female of undetermined age) were collected from 38 (41.3%) of 92 Indiana counties. Most originated from the southern half of the state, including 83 (52.2%) from seven counties (Gibson, Greene, Lawrence, Martin, Pike, Posey, Warrick) in southwestern Indiana

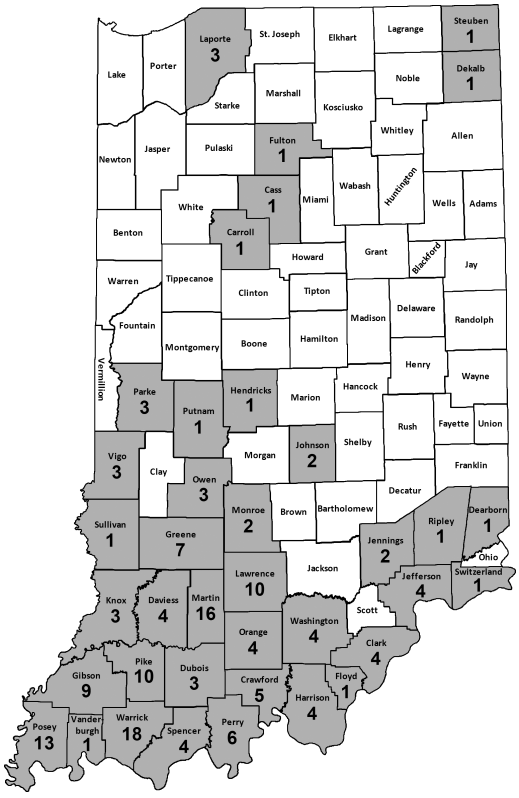

Figure 1.—Number of bobcat carcasses (n = 159) by county examined for stomach contents in Indiana, September 1990 through March 2010.

(Fig. 1). Only eight samples, all of which were collected during fall-winter, came from six counties in the northern half of the state. Sources of carcasses included bobcats that had been struck by vehicles (n = 123), incidentally killed in traps legally set for other furbearers (n = 26), illegally shot (n = 6), struck by a train (n = 1), and died from undetermined causes (n = 3). Samples were unevenly distributed throughout the year with most (81.1%; n = 129) obtained during fall-winter months (Fig. 2). Although our study spanned nearly 20 years, most carcasses (81.1%; n = 129) were collected during the 42-month period from October 2006 through March 2010.

Thirty stomachs (18.9%), which included eight from spring-summer and 22 from fall-winter, were empty and excluded from further analysis. We omitted eight additional stomachs that contained only vegetation or woody debris that was likely ingested inciden-

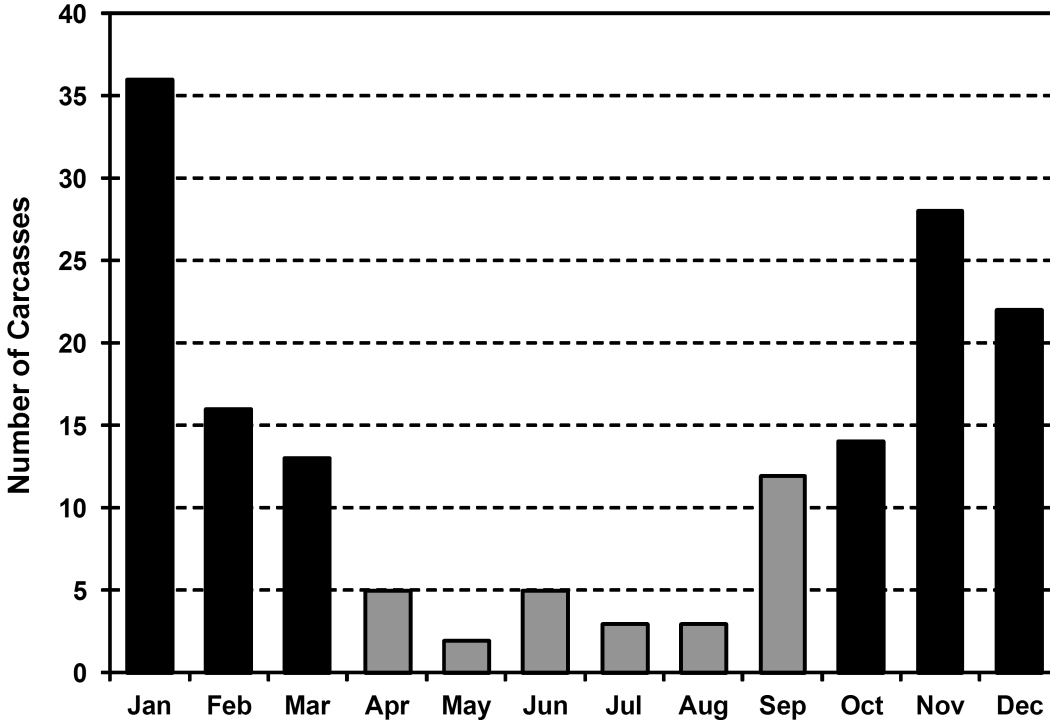

Figure 2.—Number of bobcat carcasses (n = 159) by month examined for stomach contents in Indiana, September 1990 through March 2010. Black bars denote fall-winter samples; gray bars denote spring-summer samples.

tally or consumed in trap-related mortalities. Thus, our final analysis is based on 121 carcasses composed of 64 males and 57 females, including 58 adults, 31 yearlings, 28 juveniles, and four not aged. Of these, 20 were obtained during spring-summer and 101 were obtained during fall-winter.

Prey items.—Mammalian prey comprised the bulk of the bobcat's diet in Indiana and was found in 94.2% (n = 114) of the stomachs (Table 1). Avian remains were present in 14 stomachs (11.6%). We found no evidence of other taxa (e.g., reptiles, amphibians, fish, insects). Although frequency of most species or prey groups appeared to vary between sexes (Fig. 3), the differences were not significant (X^2 = 2.73, df = 5, P = 0.74). There were no statistically significant age-related differences (X^2 = 10.82, df = 8, P = 0.21) among prey groups that were consumed by all three age classes (Fig. 4).

The eastern cottontail rabbit (*Sylvilagus floridanus*) was the most common food item in our study (Table 1). Overall, rabbit remains were found in 43 stomachs (35.5%) that comprised an average of 32.0% of the total volume and were the only prey animal in 27 stomachs (22.3%). Small mammals, as a group, were the second most prevalent food item; they were present in 32 stomachs (26.4%) that comprised an average of 18.3% of the total volume and were the only prey group in 20 (16.5%) stomachs. *Microtus* spp. and *Peromyscus* spp. were the most commonly taken small mammals, which included the prairie vole (*M. ochrogaster*), woodland vole (*M. pinetorum*), and white-footed mouse (*P. leucopus*). The meadow jumping mouse (*Zapus hudsonius*), southern bog lemming (*Synaptomys cooperi*), and Soricidae (shrews) were also identified. Sciurids (i.e., *Sciurus niger*, *S. carolinensis*) were found in 19 stomachs (15.7%) with a mean of 13.4% of the total volume. They were the only prey group found in 11 stomachs (9.1%). White-tailed deer was present in 15 stomachs (12.4%), of which 13 (86.7%) contained exclusively deer remains; percent volume averaged 11.5%. Muskrat

Table 1.—Contents of bobcat stomachs collected in Indiana, 1990–2010. Spring-Summer defined as April through September; Fall-Winter defined as October through March. Small mammals include *Peromyscus* spp., *P. leucopus*, *Microtus* spp., *M. ochrogaster*, *M. pinetorum*, *Zapus hudsonius*, *Synaptomys cooperi*, Soricidae (shrews), and unidentified small mammals. Sciurids include *Sciurus niger*, *S. carolinensis*, and unidentified sciurids. Birds include *Anas platyrhynchos*, *Fulica americana*, *Otus asio*, unidentified passerines, and unidentified birds.

Species or prey group	Spring-Summer (n = 20)		Fall-Winter (n = 101)		Combined (n = 121)	
	Percent occurrence	Mean percent volume	Percent occurrence	Mean percent volume	Percent occurrence	Mean percent volume
Mammals	95.0	93.5	94.1	92.4	94.2	92.6
Sylvilagus floridanus	45.0	41.9	33.7	30.0	35.5	32.0
Small mammals	25.0	13.7	26.7	19.2	26.4	18.3
Sciurids	35.0	28.0	11.9	10.5	15.7	13.4
Odocoileus virginianus	0.0	0.0	14.9	13.7	12.4	11.5
Ondatra zibethicus	0.0	0.0	5.9	5.4	5.0	4.5
unidentified mammal	10.0	10.0	14.9	13.5	14.0	12.9
Birds	10.0	6.5	11.9	7.6	11.6	7.4

(*Ondatra zibethicus*) was found in six stomachs (5.0%), all of which were adults, and was the only prey species in five (83.3%) of those samples. Mammalian remains that could not be identified to species or prey group because of their advanced stage of digestion were found in 17 stomachs (14.0%). Birds, as a group, were an occasional food of bobcats in Indiana. Remains, typically feathers, were present in 14 stomachs (11.6%) that comprised an average of 7.4% of the total volume. Passeriformes were the most common taxa among birds, although waterfowl (e.g., *Anas platyrhynchos*, *Fulica americana*) and a Strigiformes (i.e., *Otus asio*) were also noted.

Excluding stomachs with either deer or unidentifiable mammalian remains (n = 30), 65 of 91 stomachs (71.4%) contained a single species or prey group (e.g., small mammals, sciurids). Twenty-five additional stomachs (27.5%) had two prey groups whereas only one contained parts from three different groups (rabbit, small mammals, passerine). Number of individuals in each stomach averaged 1.7 ± 1.4 but most (64.8%) contained a single individual regardless of species or prey group. All stomachs that had squirrel remains (n = 19) contained only one individual. Similarly, 41 of 43 stomachs (95.3%) with rabbit parts had evidence of a single rabbit. In contrast, 22 of 32 (68.8%) stomachs that contained small mammals had > 1 individual ($\bar{x}$ = 2.6 ± 1.9; range = 1–8).

Seasonal variation.—Bobcats in Indiana consumed all species or prey groups in both seasons, except white-tailed deer and muskrat which were found only in stomachs from fall-winter months (14.9% and 5.9% of the seasonal sample, respectively; Table 1). There were no statistically significant differences (X^2 = 3.77, df = 3, P = 0.29) among prey groups that were consumed year-round, although sciurids and rabbits were present in a higher percentage of the stomachs in spring-summer than fall-winter (Table 1).

DISCUSSION

Our results are similar to many of the food habit studies that have been conducted throughout the geographic range of the bobcat. Mammals dominated the diet in Indiana and our three leading prey items (i.e., rabbits, small mammals, sciurids) were equally important in other midwestern states (Woolf & Nielsen 2002, Brockmeyer & Clark 2007). Cottontail rabbits were the principal prey in Indiana and lagomorphs (i.e., rabbits, hares, jackrabbits) have been the top food item for bobcat populations that inhabit vastly different North American environments (Korschgen 1957; Nussbaum & Maser 1975; Epperson 1978; Fritts & Sealander 1978; Bailey 1979; Story et al. 1982; Parker & Smith 1983; Litvaitis et al. 1986; Brockmeyer & Clark 2007). Rabbits comprised a smaller portion of the total diet in Indiana (35.5% occurrence) compared to studies in other midwestern and central plains states including Nebraska (68%, Epperson 1978), Iowa (60%, Brockmeyer & Clark 2007), and Missouri

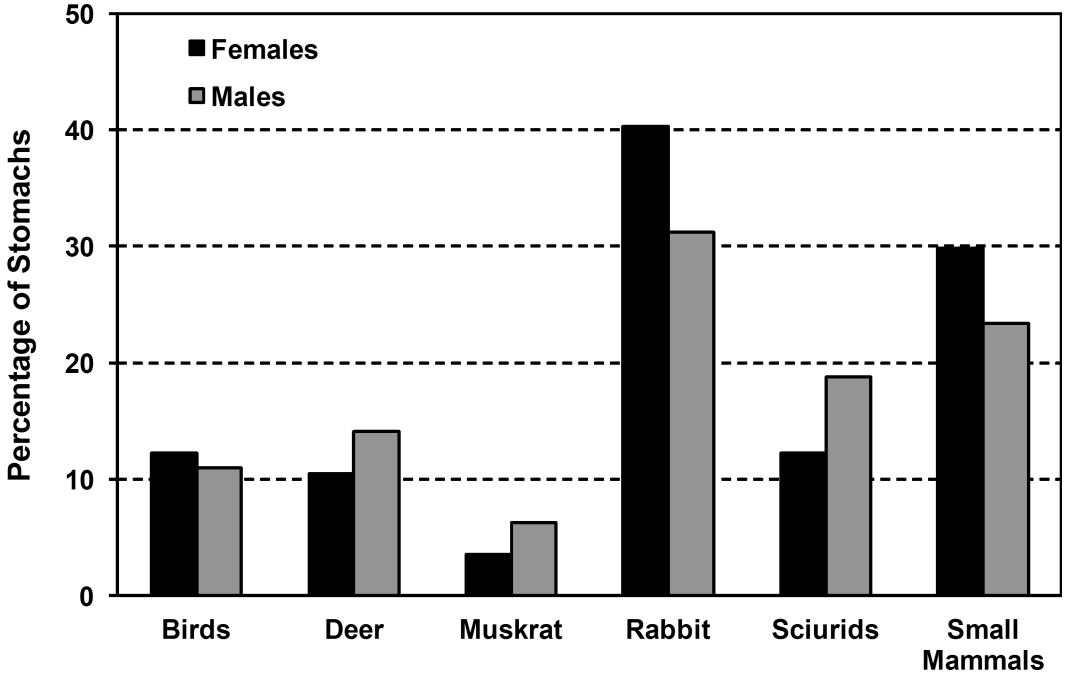

Figure 3.—Percentage of stomachs of female (n = 57) and male (n = 64) bobcats containing multiple species or prey groups in Indiana, September 1990 through March 2010.

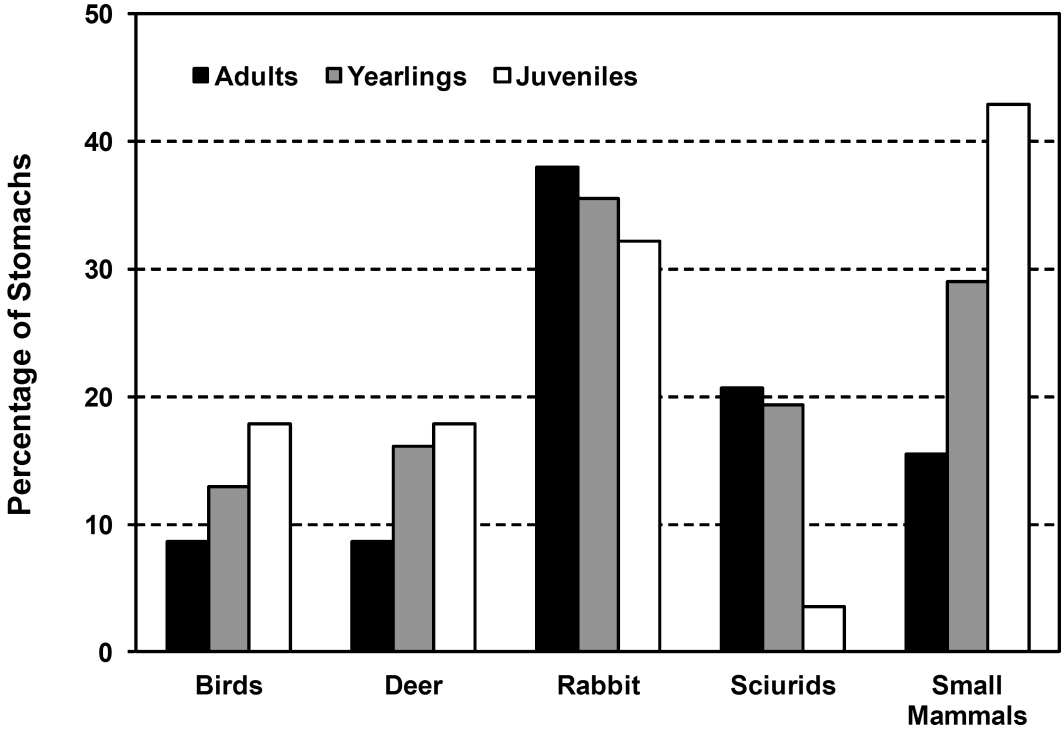

Figure 4.—Percentage of stomachs of adult (n = 58), yearling (n = 31), and juvenile (n = 27) bobcats containing multiple species or prey groups in Indiana, September 1990 through March 2010.

(52.2%, Korschgen 1957). Conversely, occurrence of rabbits in the diet of Indiana bobcats was greater than that reported in neighboring Illinois (22.7%, Woolf & Nielsen 2002).

Collectively, small mammals are a consistent element of bobcat diets and they comprised a relatively important prey group in Indiana (26.4% occurrence). Occurrence of small mammals in our study was slightly greater than reported for populations in Arkansas, (21.3%, Fritts & Sealander 1978) and Iowa (~20%, Brockmeyer & Clark 2007) whereas higher frequencies were noted in Idaho (*Microtus* spp. seasonal occurrence 40.0% and 65.2%, Koehler & Hornocker 1989), Illinois (32.8%, Woolf & Nielsen 2002), and Tennessee (*M. pinetorum* 27.3%, Story et al. 1982). *Microtus* spp. was frequently consumed although small mammals, as a group, provide little sustenance individually compared to larger items. Story et al. (1982) suggested voles are either easily captured or bobcats have developed efficient hunting strategies to warrant their pursuit. Our data support this contention and parallel data reported by Woolf & Nielsen (2002) in that most stomachs with small mammals (68.8% in Indiana, 51.9% in Illinois) commonly contained multiple individuals.

Frequency of tree squirrels in the diet of bobcats varies geographically and is uncommon or absent from arid southwestern sections of their range (Beasom & Moore 1977; Jones & Smith 1979; Delibes & Hiraldo 1987). Consumption of squirrels in Indiana (15.7% occurrence) was within the range (15–25%) reported for populations that occupy more forested areas (Progulske 1955; Korschgen 1957; Fritts & Sealander 1978; Litvaitis et al. 1984) including fragmented woodlands characteristic of midwestern landscapes (Woolf & Nielsen 2002; Brockmeyer & Clark 2007). Birds occur in most diet studies but typically constitute a minor component because they are usually active during the day which limits contact with primarily nocturnal predators (Tewes et al. 2002). Avian remains were found in 11.6% of bobcat stomachs in Indiana, similar to that reported in Illinois (10.1%, Woolf & Nielsen 2002) but considerably greater than Iowa (~2%, Brockmeyer & Clark 2007).

Previous studies (Fritts & Sealander 1978; Litvaitis et al. 1984) hypothesized age-related differences in bobcat diets may be due to inexperience, inadequate hunting skills, or variation in body mass that influences optimal prey size. Moreover, the diet of juveniles may be influenced by their mother, particularly for philopatric individuals that still occupy their natal range. Although differences were not significant, we found small mammals, an abundant and easily captured prey item, in the stomachs of more juveniles than adults (42.9% versus 15.5%). Conversely, adult bobcats preyed on tree squirrels, which probably demand advanced hunting skills, more frequently than juveniles (20.7% versus 3.6%). Similar age-related patterns for these two prey groups were reported from Iowa (Brockmeyer & Clark 2007).

Remains of white-tailed deer were found in a higher percentage of juveniles (17.9%) and yearlings (16.1%) than adults (8.6%), which differs from Litvaitis et al. (1984) and Brockmeyer & Clark (2007) in which juveniles consumed deer less often than older individuals. Bobcats are known to kill ungulates (Marston 1942; McCord 1974; Bailey 1979; Koehler & Hornocker 1989; Labisky & Boulay 1998), but the majority of deer eaten by bobcats is believed to represent carrion left from hunt-related losses, offal from field-dressed deer, road-kills, or winter starvation. Smaller and less experienced juveniles may be more apt than adult bobcats to take advantage of carrion, particularly in winter when other prey may be unavailable or less abundant. Although the few spring-summer samples limited our ability to detect seasonal differences in diet, only deer and muskrat were restricted to the fall-winter season. Further, 10 of the 15 stomachs (66.7%) with deer remains were collected from mid-November through December, a period that coincides with deer firearms season in Indiana.

The type and variety of prey consumed by bobcats are influenced by prey availability (Anderson & Lovallo 2003). It was not practical, however, to evaluate prey availability in our study because data were collected throughout the state during a 20-year span. As a result, spatial and temporal variation in prey populations was unknown as was their potential to influence bobcat habitat use. Food, however, was not believed to limit increases in bobcat populations in Illinois (Woolf & Nielsen 2002) or Iowa (Brockmeyer & Clark 2007), and results from our study support this premise. Overall, bobcats in Indiana exploited a wide array of prey consistent with earlier studies, particularly

those conducted in midwestern states, and their diet did not vary based on sex, age class, or season. Primary prey species occur throughout Indiana and are common or abundant in suitable habitats (Simon et al. 2002, Whitaker & Mumford 2009). Most of our samples originated from southwest Indiana (Fig. 1) where the landscape is characterized by riparian woods and forested tracts interspersed among early-stage vegetation (e.g., grassy fields, shrubby areas, reclaimed strip mines) and cultivated fields. The mixture of open and forested habitats in this region likely supports a diverse and plentiful prey base needed to sustain viable bobcat populations in Indiana.

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