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Fall and Winter Food Habits of Bobcats (*Lynx rufus*) in Iowa

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The bobcat (*Lynx rufus*) is a widely distributed native felid of North America but nearly disappeared from Iowa due to habitat loss and unregulated harvest that occurred during the century after European settlement. Bobcats are repopulating the state and are now relatively common in southern Iowa. This study was part of a research project to understand the ecology of the species in Iowa's landscape so that conservation plans could be established. We determined food habits by the examination of stomach contents from 100 bobcat carcasses that were accidentally killed in traps, killed by automobiles, or radio-marked individuals found dead during 2002 to 2006 across southern Iowa. We found the remains of cottontail rabbits (*Sylvilagus floridanus*) in 60%, mice (*Peromyscus* spp.) and voles (*Microtus* spp.) in about 20%, and fox squirrels (*Sciurus niger*) in nearly 15% of the stomachs. Deer occurred more frequently in the diet of adult bobcats (17%), especially males, than it did in the diet of juveniles (3%) and the small quantity and type of remains suggested that it was often taken as carrion. Evidence of birds appeared in 2% of the stomachs. These results are very consistent with dietary studies elsewhere in the species range. All of the primary mammalian prey taken by bobcats are abundant and widely-distributed in the forest-grassland edge habitats in which bobcats were most commonly located, suggesting that prey availability will not be a limiting factor to bobcat populations in Iowa.

INDEX DESCRIPTORS: bobcat, food habits, Iowa, *Lynx rufus*, protected species.

The bobcat is the most widely distributed native felid in North America. The species occupies a wide variety of habitats ranging from dense forests to deserts across the 48 contiguous United States and into central Mexico. Historically, bobcats were found throughout Iowa, but the species had nearly disappeared due to large-scale habitat loss and unregulated harvest that occurred during the century after European settlement of the Corn Belt region of the Midwest (Anderson and Lovallo 2003). Although bobcats were probably never extirpated in Iowa, the species was listed as Endangered in 1977 when the first state threatened and endangered classification was completed (Bowles et al. 1998). Sighting, incidental trapping, and automobile deaths of bobcats in Iowa increased during the 1990's and the Department of Natural Resources changed the status to Protected (with no harvest permitted) in 2003 (Koehler 2006). Bobcats are now relatively common in southern Iowa and may be sparsely distributed elsewhere across the state (Gosselink and Clark 2006).

Bobcats evolved as generalist carnivores that hunt alone, opportunistically stalking and ambushing prey (Hansen 2007). They are almost exclusively carnivorous, usually consuming prey shortly after it is killed. Bobcats will cache all or part of larger prey by covering it with litter. Large prey such as deer (*Odocoileus virginiana*) may be consumed as carrion. Bobcats most frequently take prey that range up to 5 or 6 kg. Food habits studies consistently show that rabbits and hares dominate bobcat diets in most regions. In the Midwest, cottontail rabbits (*Sylvilagus floridanus*) are important, by far the most prevalent prey in a Nebraska study (76%) (Bischof 2002) but much less prevalent in an Illinois study (23%) (Woolf and Nielsen 2002). Tree squirrels (*Sciurus* spp.), mice (*Peromyscus* spp.) and voles (*Microtus* spp.) are also regularly consumed, although there is regional variation in the relative importance of all mammalian prey depending on availability (Anderson and Lovallo 2003, Hansen 2007). For example, in Illinois mice and squirrels were found in 21% and 19% of the stomachs examined, respectively (Woolf and Nielsen 2002). Larger rodents, such as muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*), may also be found, but will vary with region (Larivière and Walton 1997). Woolf and Nielsen (2002) found opossum (*Didelphis virginiana*) to be the most frequently eaten predator. Bobcats generally consume all parts of most small- to medium-sized prey and it has been reported that they are able to digest a large fraction of the bones of cottontails and squirrels consumed (Hansen 2007).

White-tailed deer (*Odocoileus virginianus*) are found to be an important food source for northern and northeastern populations (Anderson and Lovallo 2003, Hansen 2007), especially in winter. Although most researchers believe that much of the consumed deer is carrion that is available from deaths caused by starvation, road-kill, or hunter losses, bobcats can kill deer (Hanson 2007). Adult males consume deer more often that adult females and juveniles. In Nebraska, deer occurred in 7.5% of stomachs analyzed (Bischof 2002).

Although conservationists sometimes express that predation by bobcats on both game and nongame birds could be as significant as predation by domestic cats (Lepczyk et al. 2004), birds generally comprise $<5\%$ of the diet of bobcats (Anderson and Lovallo 2003). Galliformes have been found to be the most frequent taxa of birds consumed by bobcats, but passerines are also consumed opportunistically. In the Illinois study (Woolf and Nielsen 2002) birds were found in 10% of stomachs examined. Reptiles, fish, and insects may also be considered prey, but these

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groups only appear incidentally in the diet (Larivière and Walton 1997). Plant material may appear in bobcat stomachs, either ingested incidentally from the digestive tracts of prey or intentionally ingested to assist digestion (Hansen 2007).

The predominant prey species of bobcats are all abundant in the grassland-forest edge habitats of Iowa. During extensive study of habitat selection by bobcats in southern Iowa, Koehler (2006) found that bobcat home ranges most often included forest and grassland areas, and activity was often focused where these habitat types occurred together. Intensive telemetry also revealed that bobcats were frequently located in riparian forests with dense understory vegetation. Cottontail rabbits are abundant in these habitats throughout the agricultural regions of the Midwest (Swihart and Yahner 1982, Mankin and Warner 1999). Forest edge is also a common habitat for *Peromyscus* spp. (M'Closkey and Fieldwick 1975, Kirkland and Layne 1989, Hayslett and Danielson 1994). Fox squirrels (*Sciurus niger*), the most common tree squirrel in south central Iowa, tend to occupy open forest edges and prefer small wooded areas (Nixon et al. 1978, Nixon and Hansen 1987). *Microtus* spp. are abundant in grasslands with dense herbaceous cover (Birney et al. 1976, Hayslett and Danielson 1994), including hayfields, ungrazed pastures and Conservation Reserve Program (CRP) fields that are widespread, especially in southern Iowa (Natural Resources Conservation Service 1997).

In 2003, the Iowa Department of Natural Resources, in cooperation with Iowa State University, began a study of the population and landscape ecology of bobcats in Iowa (Gosselink and Clark 2006, Tucker et al. 2008). This study of the diet of bobcats was a natural extension of the broad objective to understand habitat use of bobcats in Iowa (Tucker et al. 2008) to understand if prey utilization was consistent with habitat selection.

METHODS

We determined food habits by examining stomach contents from bobcat carcasses that were accidentally trapped or found dead (primarily from road-kill) and submitted for necropsy (Gosselink and Clark 2006). We selected a sample of 100 animals that were collected from 2002 to 2006 throughout the primary range of the bobcat across southern Iowa (Gosselink and Clark 2006).

We dissected stomachs from thawed carcasses, excising the alimentary tract at the opening of the esophagus into the stomach and at the pylorus. Stomachs and contents were weighed to the nearest gram and presence of parasites noted. We washed stomach contents with water through a size 35 mesh sieve until runoff was clear and wet contents were weighed to the nearest gram. In an effort to compare the biomass of prey consumed by various sex and age classes, we dried contents to calculate dry/wet ratios (Neale 1996). We dried contents in an oven on low heat (15–20 C) for approximately 48 hours, and weighed to the nearest gram and stored in plastic containers for identification.

Large parts of prey such as identifiable appendages, tails, skull fragments, teeth, long bone fragments, and feathers were used to identify contents macroscopically and separated from large quantities of hairs. The remaining hair was placed in a dissection tray and a 5% sample was randomly selected using a 1×1 cm mesh grid to determine the relative amounts of prey species. We made temporary mounts of hairs using the methods described by Moore et al. (1974) and identified them following the keys provided by Moore et al. (1974). We also compared hairs to known hair samples of Iowa mammals that were taken from the collections maintained by Iowa State University. We also identified skull fragments and teeth with the aid of keys (Jones and Manning 1992) and by comparison to the collections.

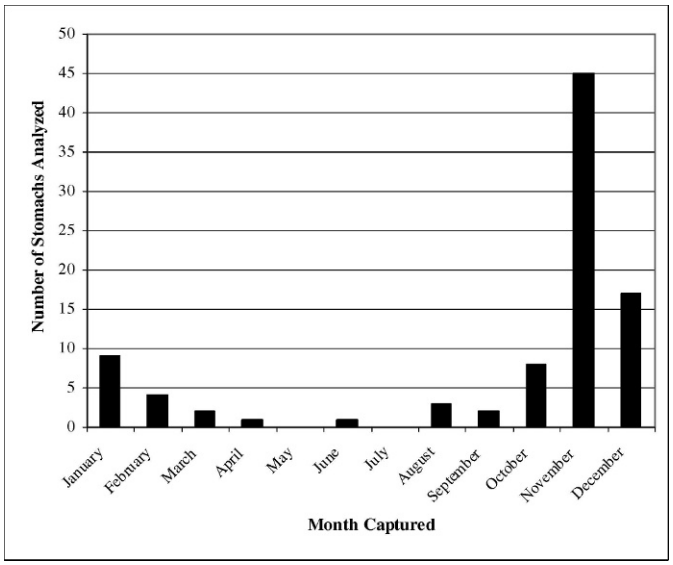

Fig. 1. Sample distribution by month of bobcat stomachs collected in Iowa from 2002 to 2006.

In our study area, two species of *Peromyscus* (*P. maniculatus* and *P. leucopus*) and two species of *Microtus* (*M. pennsylvanicus* and *M. ochrogastor*) are known to occur (Bowles 1975). Although we could distinguish the species using hair characteristics we considered these species of small mammals functionally equivalent in the diet of bobcats. In the results that follow, "mice" refers collectively to *Peromyscus* and "voles" refers collectively to *Microtus*.

We report the percentage of bobcat stomachs in which a prey species occurred among the contents. We used the Fisher's exact test to determine significance when comparing frequencies among sex and age classes to account for the small expected counts in some categories.

RESULTS

We sampled stomachs from 35 adult male, 35 adult female, 15 juvenile male and 15 juvenile female bobcats. We included all of the samples collected, although most of the stomachs analyzed were from bobcats collected between October and March (Fig. 1). So the diets that we report realistically represent the Fall/Winter season as defined by Tucker et al. (2008). Carcasses came from 28 counties across southern Iowa, with a greater proportion from southwestern compared with southeastern Iowa. A majority of the bobcats sampled were killed by accidental trapping (54) and automobile collision (21) incidents. One death resulted from a gunshot and 24 were collected with an unknown cause of death.

The uncertain association between easily digested stomach contents like muscle and the more persistent items like bone and hair deterred us from attempting to estimate biomass of each prey type consumed (Neale 1996). The stomachs we sampled contained an average of 275 wet g of prey (Table 1) and the mean ratio of mass of dry contents/mass of wet contents was 0.250 (SE = 0.01, n = 94). The largest volume of contents was hair but bone and muscle were evident in all stomachs. Although

Table 1. Mass distribution of carcasses, stomachs including contents, and contents of stomachs of bobcats collected in Iowa, 2001–2006.

Mass	Sample Size	Mean	SE
Carcass (kg)	94	8.03	0.302
Stomach (g)	99	348.11	23.53
Wet Contents (g)	95	275.40	23.17
Dry Contents (g)	95	72.14	6.56

we sampled the hair to partition the remains by species, we could not reliably determine biomass proportions. We often could reliably account for individuals by counting jaws and bones.

Remains of cottontail rabbits were found in about 60% of the stomachs, mice and voles in about 20%, and fox squirrels in 15% of stomachs (Figs. 2 and 3), although these proportions varied somewhat among sex and age classes. Generally adult male and adult female bobcats consumed prey at about the same frequency with the exception that adult males ate significantly more deer than adult females (Fig. 2, Fisher's exact test $P = 0.01$). Despite the absence of squirrel and deer in the stomachs of juvenile male bobcats (Fig. 3) the observed variation did not indicate statistically significant differences. Although it appears that juvenile bobcats (sexes combined) more frequently ate mice and voles compared with adult bobcats (30% versus 16%) (Figs. 2 and 3), the difference was not significant (Fisher's exact test $P = 0.12$). Conversely, it also appears that juvenile bobcats ate squirrels less frequently than did adult bobcats (7% versus 17%) (Figs. 2 and 3), but the observed difference was not significant (Fisher's exact test $P = 0.11$). However, stomachs of adult bobcats (sexes combined) more frequently contained deer (17%) than did those of juvenile bobcats (3%, Figs. 2 and 3, Fisher's exact test $P = 0.05$).

With the exception of deer, apparently most prey was consumed entirely. In the 60 stomachs in which we found rabbit, 57 contained evidence of a single rabbit and 3 contained evidence of two rabbits. In every case when we found squirrel, it was evidence of a single individual. However we often found the intact carcass of mice and voles. The mean number of mice and voles consumed was 2.4 (SE = 0.46), although the mode was 1 and the maximum was 9.

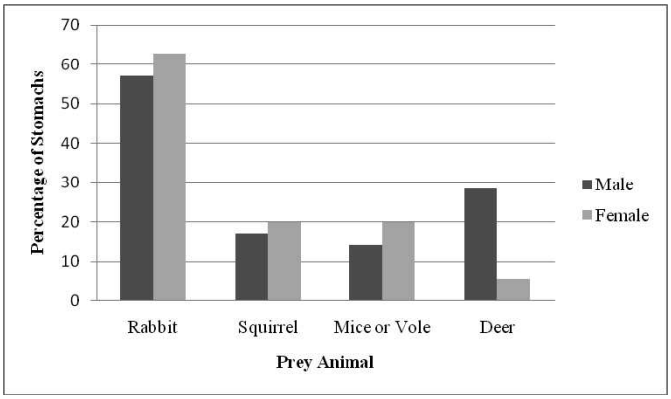

Fig. 2. Proportions of stomachs of adult male (n_m = 35) and female (n_f = 35) bobcats containing various prey species in southern Iowa, 2001 to 2006.

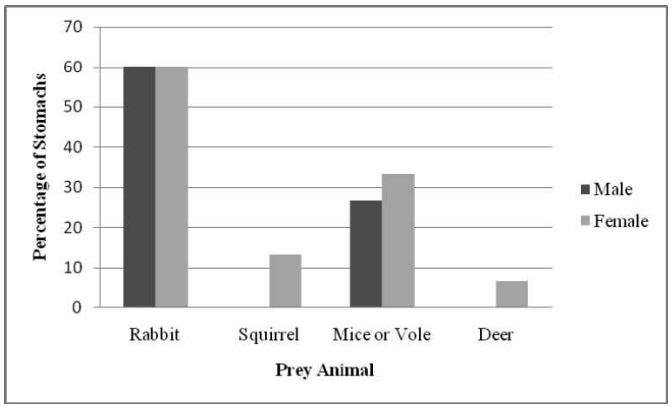

Fig. 3. Proportion of stomachs of juvenile male (n_m = 15) and female (n_f = 15) bobcats containing various prey species in southern Iowa, 2001 to 2006.

We also found that bobcats had consumed muskrat (2 stomachs), beaver (2 stomachs), wild turkey (*Meleagris gallopavo*) (1 stomach), shrew (*Sorex spp.*) (2 stomachs) and Northern Harrier (*Circus cyaneus*) (1 stomach). We found more than trace amount of plant material in only 2 of 100 stomachs.

We found parasites in 41 of 100 stomachs, with as much as 19 g wet weight in one stomach. *Physaloptera praeputialis*, a roundworm, was the most common and was found in 35 stomachs. *Toxocara cati* roundworms and unidentified tapeworms were both found in 4 stomachs.

DISCUSSION

Bobcats in Iowa preyed predominantly on mammals, particularly cottontail rabbits, squirrels and other small rodents. These results are consistent with other studies throughout the range (Anderson and Lovallo 2003). But we found a much higher percentage of stomachs with cottontail rabbits compared with findings from Illinois (Woolf and Nielsen 2002), which could be attributed to more mature forest habitat than the interspersed forest, grassland, and cropland of southern Iowa. The frequency of prey types consumed by bobcats is very similar to that reported in Nebraska (Bischof 2002).

Although we do not have estimates of availability, the major prey items taken by bobcats are all abundant and widely-distributed in Iowa (Bowles et al. 1998). Cottontail rabbit surveys (Bogenschutz and Monen 2006) have apparently remained about at the historical average counts during the last 10 years and the highest counts were reported from southcentral and southwestern Iowa. Although chipmunks (*Tamias striatus*) are abundant in forests and ground squirrels (*Spermophilus tridecemlineatus*) are abundant along grassland edges in Iowa, the absence of these species from the stomachs we sampled might be attributed to the fact that both species hibernate and therefore would have been relatively unavailable during November through January when most of the bobcats were collected. Because our collections focused on Fall and Winter, the study does not provide clear conclusions about the frequency of predation by bobcats on nesting birds like ring-necked pheasants (*Phasianus colchicus*) and wild turkey. We also were not able to determine whether there was any seasonal variation in the evidence of deer in the bobcat diet, as might be predicted when carrion would be especially available after the deer hunting season. Given that bobcats are consuming abundant and common prey species that are associated with the forested and grassland habitats that are

selected for home range areas (Tucker et al. 2008) these data provide another element to suggest that local habitat quality in Iowa is not limiting to bobcats.

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