

Influence of Age, Sex and Time of Year on Diet of the Bobcat (*Lynx rufus*) in Pennsylvania

ABSTRACT.—Diet of the bobcat (*Lynx rufus*) in the mid-Atlantic region of the United States is poorly known. Age, sex and time of year are thought to influence bobcat prey selection, but accounts vary. We examined the contents of 85 bobcat stomachs taken from Pennsylvania during autumn and winter 2000–2002. White-tailed deer (*Odocoileus virginianus*) and rabbits (*Sylvilagus* sp.) occurred most frequently as prey. A larger percentage of female bobcats consumed lagomorphs (28%) than did males (12%; $P = 0.04$). More male bobcats consumed meso-mammals (14%), including raccoons and porcupines, than did females (2%; $P = 0.04$). Diet did not differ between bobcats < 2 y and bobcats ≥ 2 y. Variety of prey eaten was larger in autumn than in winter. Sexual differences in diet may be related to sexual dimorphism in this species and may help to effect interspecific niche partitioning. Winter weather reduces the availability of certain prey items in this region and may decrease the bobcat's ability to travel and hunt effectively.

INTRODUCTION

The diet of the bobcat (*Lynx rufus*) has been studied throughout much of North America (Anderson and Lovallo, 2003), including New England (Hamilton and Hunter, 1939; Pollack, 1951; Westfall, 1956; Litvaitis *et al.*, 1984) and the southeastern United States (Progulske, 1955; Story *et al.*, 1982; Maehr and Brady, 1986; Baker *et al.*, 2001). The primary foods of the bobcat in these areas are lagomorphs, small rodents and white-tailed deer. White-tailed deer are more commonly consumed in New England than in the Southeast; whereas small mammals are more commonly consumed in the Southeast (Anderson and Lovallo, 2003). With the exception of a study by Fox (1990), there is a paucity of information regarding the diet of the bobcat in the Mid-Atlantic States—including Virginia, West Virginia, Maryland, Delaware, Pennsylvania, New Jersey and New York.

The bobcat diet varies by age, sex and season (Anderson and Lovallo, 2003). Adult bobcats are larger and likely have greater hunting skills than younger bobcats, allowing them to prey upon more diverse and larger prey (Fritts and Sealander, 1978; Litvaitis *et al.*, 1984; Matlack and Evans, 1992). Similarly, sexual dimorphism of bobcats may allow males to be more efficient hunters of deer and other large mammals (Litvaitis *et al.*, 1984; Matlack and Evans, 1992). Finally, snow cover may limit both the bobcat's hunting range and the ability of white-tailed deer to escape predation by bobcats (Fritts and Sealander, 1978). Knowledge of the factors that can affect bobcat diet can aid in understanding intraspecific resource partitioning and habitat quality. We studied the diets of bobcats taken in Pennsylvania during autumns and winters of 2000–2001 and 2001–2002.

METHODS

We obtained 85 bobcat stomachs from road-killed ($n = 7$) and legally harvested ($n = 78$) animals from 17 counties in Pennsylvania. Date of death was collected from hunter surveys for harvested animals and was estimated for road-killed bobcats. Sex of bobcats was determined from gross examination. Age was determined using the cementum-annulus method (Crowe, 1972, 1975). Canine and molar teeth were extracted and sent to Matson's Lab, LLC (Milltown, MT) for analysis.

Volume of the stomachs was measured by water displacement before dissection. Prey items were determined macroscopically when possible. Bones, particularly jaws, were useful in identification. However, the primary method of prey identification was microscopic examination of hair cuticle patterns following the methods of Brunner and Coman (1974), except that acetyl acetate was used rather than Gelva for the cuticle impressions. Hairs were determined to species by comparing cuticle patterns to those in Adorjan and Kolenosky (1969), Brunner and Coman (1974) and a reference set in the zoological collections of Colgate University.

Bobcats were grouped according to sex and age. Each animal was placed in one of two age-groups reflecting phases in predatory ability (Fritts and Sealander, 1978): juvenile (< 2 y) and adult (≥ 2 y). Samples also were divided into two groups based on date of capture: 1 October to 31 November (autumn),

which is characterized as having no or little snow cover in most of Pennsylvania, and 1 December to 28 February (winter), which is characterized by heavier snow-cover. Mean monthly snowfall at Galeton, Potter County, during October and November of 2000 and 2001 was 1.7 cm; whereas mean monthly snowfall during December, January and February during the study period was 17.7 cm (NOAA National Climatic Data Center). Frequency and percent frequency were calculated for each prey item. Chi-square tests of independence were used to determine the dependence of diet composition on sex, age and time of year (Sokal and Rohlf, 1995). A *t*-test was used to compare stomach volumes of male and female bobcats.

RESULTS AND DISCUSSION

Of the 85 stomachs surveyed, 11 were empty. Empty stomachs were not considered in analyses. The most frequent mammal foods were white-tailed deer (*Odocoileus virginianus*, 41%), rabbits (*Sylvilagus floridanus* or *S. obscurus*, 22%) and deer mice (*Peromyscus* sp., 18%). All small mammal species (mammals <800 g) combined were found in 22% of stomachs. Unidentified birds were found in 31% of stomachs. We found a greater number of stomachs that contained deer and fewer that contained lagomorphs than Litvaitis *et al.* (1984) in New Hampshire. However, 41% of the stomachs and intestinal tracts of 88 bobcats in Maine contained white-tailed deer (Westfall, 1956) and evidence of deer was found in 32% of digestive tracts of bobcats from the New England states (Pollack, 1951). Like Matlack and Evans (1992), we found that small mammals were frequent foods of bobcats in our region. It has been suggested that small mammals may sustain bobcats while they continue to search for more energetically beneficial large prey (Powers *et al.*, 1989; Matlack and Evans, 1992). The fraction of our samples containing birds was high compared with samples from New England and the Southeast (Anderson and Lovallo, 2003).

Like Fritts and Sealander (1978), we found that diets of juvenile and adult bobcats were similar (Table 1). Contrary to Litvaitis *et al.* (1984), we found that a large proportion of juveniles had consumed deer. Because young bobcats are less adept at capturing large prey (Toweill, 1980), we assume that young bobcats were consuming deer as carrion provided by adult females (Bailey, 1974). We found no evidence of meso-mammals in the diets of juvenile bobcats, although our analysis was hampered by the small number of juveniles in our data set.

Mean (\pm sd) volume of stomachs of male bobcats (312 ± 243 ml³) was greater than volume of stomachs of female bobcats (190 ± 108 ml³; $t = -2.87$, $df = 72$, $P = 0.006$); however, proportion of stomachs containing >1 food item did not differ by sex ($G^2 = 0.814$, $df = 1$, $P = 0.3671$). Stomachs of females were more likely to contain evidence of lagomorphs, including *Sylvilagus* and *Lepus*, than stomachs of males ($G^2 = 4.34$; $df = 1$; $P = 0.0372$). Stomachs of males were more likely to contain evidence of meso-mammals, including raccoons and porcupines, than females ($G^2 = 4.04$; $df = 1$; $P = 0.0444$). Sexual dimorphism may play a role in mitigating intraspecific competition among bobcats with overlapping home ranges. Fritts and Sealander (1978) suggested that female bobcats take a larger number of smaller prey items than do males. This is consistent with the increased incidence of lagomorphs and decreased incidence of meso-mammals in the stomachs of females.

There was no difference in the proportions of male and female samples including deer ($P = 0.22$). Some authors have suggested that males may be better able to prey upon deer because of their larger size (Litvaitis *et al.*, 1984; Matlack and Evans, 1992). Similarity in consumption of deer by males and females in the present study may be due to the scavenging of carrion by females. We were unable to discriminate between deer consumed after scavenging and deer consumed after predation.

The inclusion of deer and rabbits in bobcat diets was high during both autumn and winter. Chipmunks (*Tamias striatus*) made up a greater portion of the bobcat diet during autumn than winter ($G^2 = 7.02$, $df = 1$, $P = 0.0081$) due to the period of hibernation in chipmunks. A greater proportion of stomachs collected during autumn had ≥ 1 food item than stomachs collected during winter ($G^2 = 6.55$, $df = 1$, $P = 0.0105$), suggesting a more diverse diet during autumn. These results may reflect higher prey diversity at that time or that snow cover limits the bobcats' ability to travel and hunt during winter. Toweill and Anthony (1988) also found that bobcats had a less diverse diet during winter than other seasons in Oregon. Powers *et al.* (1989) suggested that deer are an important food source for northern bobcats during winter because cached deer are easily accessible and have a high specific energy content. Deep snow may make deer more vulnerable to predation, and carrion may be more available during and after the deer hunting season. Thus, the use of deer by bobcats is typically higher in winter (Anderson

TABLE 1.—Number (% of total) of stomachs of bobcats collected in Pennsylvania containing each of 14 vertebrate foods by age class, sex and time of year. Juvenile animals were defined as <2 y old based on cementum annuli. Autumn was defined as 1 October–31 November; winter was defined as 1 December–28 February

Prey item	Age class		Sex		Season	
	Juvenile (n = 10)	Adult (n = 54)	Male (n = 38)	Female (n = 36)	Autumn (n = 35)	Winter (n = 33)
Large mammals						
<i>Odocoileus virginianus</i>	5 (50)	22 (41)	18 (47)	12 (33)	14 (40)	14 (42)
Meso-mammals						
<i>Didelphis virginianus</i>	0	1 (2)	2 (5)	0	1 (3)	1 (3)
<i>Erethizon dorsatum</i>	0	4 (7)	3 (8)	1 (3)	3 (9)	1 (3)
<i>Procyon lotor</i>	0	1 (2)	1 (3)	0	1 (3)	0
Lagomorphs						
<i>Lepus americanus</i>	0	1 (2)	0	1 (3)	1 (3)	0
<i>Sylvilagus</i> sp.	3 (30)	13 (24)	5 (13)	11 (31)	10 (29)	5 (15)
Small mammals						
<i>Blarina brevicauda</i>	1 (10)	0	0	1 (3)	1 (3)	0
<i>Clethrionomys gapperi</i>	2 (20)	2 (4)	1 (3)	3 (8)	2 (6)	1 (3)
<i>Microtus pennsylvanicus</i>	0	2 (4)	2 (5)	2 (6)	1 (3)	2 (6)
<i>Peromyscus</i> sp.	3 (30)	9 (17)	5 (13)	8 (22)	8 (23)	4 (12)
<i>Sciurus carolinensis</i>	1 (10)	1 (2)	1 (3)	2 (6)	1 (3)	1 (3)
<i>Tamias striatus</i>	2 (20)	3 (6)	1 (3)	4 (11)	5 (14)	0
<i>Tamiasciurus hudsonicus</i>	0	1 (2)	1 (3)	0	1 (3)	0
Unidentified birds	2 (20)	16 (30)	12 (32)	11 (31)	9 (26)	13 (39)

and Lovallo, 2003). Prey items, such as the chipmunk and deer mouse, which become less active during winter, may have shown seasonal shifts due to their changed availability as prey for bobcats.

We found that white-tailed deer and lagomorphs constituted the primary foods of the bobcat in Pennsylvania. Although both sexes frequently consumed deer, we found some evidence that males made more use of large prey items than females. This could lead to resource partitioning among sexes, especially during the warmer months when diet diversity and female nutritional needs are greatest.

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LITERATURE CITED

- ADORJAN, A. A. AND G. B. KOLENOSKY. 1969. A manual for the identification of hairs of selected Ontario mammals. Research Report (Wildlife) No. 90, Ontario Department of Lands and Forests. 64 p.
- ANDERSON, E. M. AND M. J. LOVALLO. 2003. Bobcat and lynx. *Lynx rufus* and *L. canadensis*, p. 758–786. In: G. A. Feldhamer, J. A. Chapman and B. C. Thompson (eds.). *Wild mammals of North America: biology, management, and conservation*, 2nd ed. Johns Hopkins Univ. press, Baltimore, Maryland.
- BAILEY, T. N. 1974. Social organization in a bobcat population. *J. Wildl. Manage.*, **38**:435–446.
- BAKER, L. A., R. J. WARREN, D. R. DIEFENBACH, W. E. JAMES AND M. J. CONROY. 2001. Prey selection by reintroduced bobcats (*Lynx rufus*) on Cumberland Island, Georgia. *Am. Midl. Nat.*, **145**:80–93.
- BRUNNER, H. AND B. J. COMAN. 1974. *The identification of mammalian hair*. Inkata Press, Melbourne, Australia. 173 p.

- CROWE, D. M. 1972. The presence of annuli in bobcat teeth cementum layers. *J. Wildl. Manage.*, **36**: 1330–1332.
- . 1975. Aspects of aging, growth, and reproduction of bobcats from Wyoming. *J. Mammal.*, **56**:177–198.
- FOX, L. B. 1990. Ecology and population biology of the bobcat, *Felis rufus*, in New York. M.Sc. Thesis, State University of New York College of Environmental Science and Forestry, Syracuse, New York. 184 p.
- FRITTS, S. H. AND J. A. SEALANDER. 1978. Diets of bobcats in Arkansas with special reference to age and sex differences. *J. Wildl. Manage.*, **42**:533–539.
- HAMILTON, W. J., JR. AND R. P. HUNTER. 1939. Fall and winter food habits of Vermont bobcats. *J. Wildl. Manage.*, **3**:99–103.
- LITVAITIS, J. A., C. L. STEVENS AND W. M. MAUTZ. 1984. Age, sex, and weight of bobcats in relation to winter diet. *J. Wildl. Manage.*, **48**:632–635.
- MAEHR, D. S. AND J. B. BRADY. 1986. Food habits of bobcats in Florida. *J. Mammal.*, **67**:133–138.
- MATLACK, C. R. AND A. J. EVANS. 1992. Diet and condition of bobcats, *Lynx rufus*, in Nova Scotia during autumn and winter. *Can. J. Zool.*, **70**:1114–1119.
- POLLACK, E. M. 1951. Food habits of the bobcat in the New England states. *J. Wildl. Manage.*, **15**:209–213.
- POWERS, J. G., W. W. MAUTZ AND P. J. PEKINS. 1989. Nutrient and energy assimilation of prey by bobcats. *J. Wildl. Manage.*, **53**:1004–1008.
- PROGULSKE, D. R. 1955. Game animals utilized as food by the bobcat in the southern Appalachians. *J. Wildl. Manage.*, **19**:249–253.
- SOKAL, R. R. AND F. J. ROHLF. 1995. Biometry: the principles and practice of statistics in biological research, 3rd ed. W. H. Freeman and Company, New York.
- STORY, J. D., W. J. GALBRAITH AND J. T. KITCHINGS. 1982. Food habits of bobcats in eastern Tennessee. *J. TN Acad. Sci.*, **57**:29–32.
- TOWEILL, D. E. 1980. Sex and age structure in Oregon bobcat populations. *Oreg. Dep. Fish Wildl. Info. Rep. Ser.*, Wildl. No. 80-1. 32 p.
- AND R. G. ANTHONY. 1988. Annual diet of bobcats in Oregon's Cascade Range. *Northwest Sci.*, **62**:99–103.
- WESTFALL, C. Z. 1956. Foods eaten by bobcats in Maine. *J. Wildl. Manage.*, **20**:199–200.

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