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PREY USE BY EASTERN SCREECH-OWLS: SEASONAL VARIATION IN CENTRAL KENTUCKY AND A REVIEW OF PREVIOUS STUDIES

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ABSTRACT.—We examined prey use by Eastern Screech-Owls (*Otus asio*) in central Kentucky and reviewed the results of previous studies. Invertebrates and mammals were the most common prey in central Kentucky, with mammals and birds contributing the most biomass. Although prey use by screech-owls varied among other locations, small mammals or birds always contributed the most biomass. In central Kentucky and at other locations, invertebrates were frequently used during the breeding season. However, the small size of invertebrates limited their contribution to total prey biomass. Although capable of killing prey with masses greater than 100 g, screech-owls typically used much smaller prey ($\bar{x}$ = 28.3 g). The mean mass of prey taken by screech-owls during the breeding period ($\bar{x}$ = 24.6 g) was lower than during the non-breeding period ($\bar{x}$ = 31.8 g), a result of the increased availability and use of smaller prey (e.g., invertebrates) during the breeding period.

Presas cazadas por tecolotes de la especie *Otus asio*: variación estacional en Kentucky central, y una revisión de estudios previos

EXTRACTO.—Hemos examinado el uso de las presas por tecolotes *Otus asio* en Kentucky central, y hemos revisado los resultados de estudios anteriores. Mamíferos e invertebrados fueron las presas más comunes en Kentucky central. La biomasa estuvo compuesta en su mayoría por mamíferos y aves. Aunque las presas del *O. asio* variaron según los sitios de caza, los pequeños mamíferos y las aves siempre contribuyeron mayormente a la biomasa. En Kentucky central y en otros sitios, los invertebrados fueron frecuentemente cazados durante la estación de reproducción; sin embargo, la pequeña dimensión de éstos limitó su contribución a la biomasa de presa total. Aunque tienen capacidad para matar presas con una masa de más de 100 g de peso, estos tecolotes cazaron presas típicamente más pequeñas ($\bar{x}$ = 28.3 g). La masa media de la presa cogida por el *O. asio* durante el período reproductor ($\bar{x}$ = 24.6 g) fue menor que la de la presa del período no reproductor ($\bar{x}$ = 31.8 g). Esto es resultado del aumento en la disponibilidad de presas más pequeñas (e.g., invertebrados) durante el período de reproducción.
[Traducción de Eudoxio Paredes-Ruiz]

Although Eastern Screech-Owls (*Otus asio*) are among the most widespread raptors in eastern North America (Johnsgard 1988), relatively few data are available concerning their food habits (Marti and Hogue 1979). Most studies have been conducted in the northern United States and most authors have only reported the percentage of occurrence of each prey category. Using frequency data to draw conclusions about the relative importance of various prey may be misleading. Although such data may provide information about the relative impact a raptor has upon prey species, biomass determination may give a more accurate evaluation of the relative importance of prey species to the raptor (Marti 1987).

The objective of our study was to examine prey use, both in terms of occurrence and biomass, by Eastern Screech-Owls. We provide information concerning prey use in central Kentucky and compare our results with those published previously. Data from previous studies were reanalyzed, converting occurrence data into biomass data, so that occurrence and biomass data could be compared. We sought to determine the extent to which prey use by screech-owls varied with geographic location and with time of year.

METHODS AND MATERIALS

Prey Use by Screech-Owls in Central Kentucky. We determined prey use by identifying the remains of prey in pellets (N = 351) and nest debris (N = 9 nests), and by identifying cached items. Pellets and nest debris were collected from nests and roost sites at the Central Kentucky Wildlife Management Area, Madison County, Kentucky, between September 1985 and August 1986. Pellets were

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collected from open roost sites either on or one day after the day of use. Prey remains in nests and nest boxes were collected only when the site was vacant. Nest debris was collected from each nest site in May 1986 after young owls left the nest.

We identified and quantified most vertebrates using skulls and most invertebrates using head capsules. Some mammals and birds were identified using hair and feathers, and these prey were quantified by assuming the fewest possible number of individuals (e.g., feathers from one species were assumed to represent one individual). Crayfish remains in pellets were highly fragmented so we assumed that a pellet containing crayfish contained one individual. All prey items were identified to the lowest possible taxonomic category. We used Chi-square analyses to test for differences in frequency of use of different prey (invertebrates, fish, amphibians, birds and mammals), and to test for differences in prey use between the breeding (March through August) and non-breeding periods (September through February).

Estimating the Mass of Prey Items. The mass of some prey was estimated by weighing individuals captured on or near our study area (e.g., several invertebrates and several species of salamanders). Most estimates, however, were taken from the literature (Craighead and Craighead 1956, Burt and Grossenheider 1964, Carlander 1969, Barbour and Davis 1974, Marti 1974, Clench and Leberman 1978, Trautman 1981, Steenhof 1983, Dunning 1984, Kellner and Ritchison 1985). When the mass of a species or group was presented as a range (e.g., Burt and Grossenheider 1964), we used the midpoint as the estimated mass. The mass of some prey (e.g., unidentified thrush) was estimated based on the masses of closely related species (e.g., the mean mass of all thrush species). Although the mass of prey may vary with sex, age, and geographical location, it was not possible to adjust for these variables. Thus, the same estimate of mass was used for all individuals of a particular prey species or category, regardless of the geographic location of the study. The mass of some prey items was potentially (i.e., for older individuals) greater than that of an adult screech-owl (e.g., bluegill *Lepomis macrochirus* and Norway Rat *Rattus norvegicus*). We assumed that screech-owls would not take a prey item with a mass larger than their own (mean = 167 g for males and 194 g for females; Henny and VanCamp 1979) and assigned these potentially large prey items a mass of 150 g.

Terminology. Previous investigators have examined seasonal variation in prey use by screech-owls, however, these investigators have delimited seasons in different ways. We divided the year into two periods: breeding (March through August) and non-breeding (September through February). Thus, the breeding period includes the "nesting season" (Craighead and Craighead 1956, VanCamp and Henny 1975) and "spring" (Duley 1979), while the non-breeding period includes the "winter" (Craighead and Craighead 1956, Duley 1979), "fall and winter" (VanCamp and Henny 1975), and the "late fall and winter" (Cahn and Kemp 1930).

RESULTS

Prey Use by Screech-Owls in Central Kentucky. Pellets, nest debris, and nest boxes yielded 671 prey items (Table 1). The number of prey items from the five prey groups (invertebrates, fish, amphibians, birds, and mammals) varied significantly ($\chi^2 = 865.7$, df = 4, $P < 0.0001$), with invertebrates and mammals being most numerous. Crayfish and beetles were the most common invertebrate prey. Short-tailed shrews (*Blarina brevicauda*), voles (*Microtus* spp.), and mice (*Peromyscus* spp.) were the most common mammalian prey. Mammals contributed the most biomass (65.9%), followed by birds (19.8%) and invertebrates (12.8%; Table 1).

Prey use varied significantly by period ($\chi^2 = 27.95$, df = 4, $P < 0.0005$), with more mammals taken by screech-owls during the non-breeding period and more invertebrates taken during the breeding period (this study; Table 2). Birds, fish, and amphibians were taken in similar frequencies during the two periods. Mammals contributed more biomass during the non-breeding (75.5%) than the breeding period (61.6%; Table 2). Despite being the most common prey during the breeding period (63.5% of all prey), invertebrates contributed only 15.5% of the total prey biomass (Table 1). During the non-breeding period, invertebrates contributed 7.7% of the total prey biomass (this study; Table 2).

Prey Use by Screech-Owls: a Review. Information concerning prey use was obtained from eleven studies (Table 2). Six were conducted in the northern part of the screech-owl's range (Ohio, Wisconsin, Illinois, New York and two in Michigan), four in the middle (Missouri, Tennessee and two in Kentucky), and only one in the southern part (Arkansas). These studies reported a total of 4917 prey items, including 20 species of mammals, 73 species of birds, 1 species of reptile, 8 species of amphibians, and 9 species of fish. Although most invertebrates were not identified to species, 35 families and genera were reported as screech-owl prey. Among the major prey groups, mammals (60.9%) were taken most frequently, followed by invertebrates (22.9%) and birds (14.4%; Table 2). Mammals (73.7%) and birds (19.5%) contributed the most biomass (Table 2). Invertebrates made up only 1.7% of the prey biomass (Table 2).

Rodents (93.6%) were the most frequently taken mammalian prey of screech-owls, followed by insectivores (6.1%) and bats (0.2%). Voles (*Microtus* spp., 69.2% of rodent prey) and mice (*Peromyscus* spp., 17.4% of rodent prey) were the most common rodent prey of screech-owls. Most avian prey were passerines (95.3%), largely in the families Emberi-

Table 1. Prey used by Eastern Screech-Owls in central Kentucky.

PREY	OCCURRENCE		BIOMASS	
	N	%	GRAMS	%
Mammals				
Blarina brevicauda	49	7.3	1127.0	11.2
Cryptotis parva	7	1.0	42.0	0.4
Unident. shrew	3	0.3	54.0	0.5
Pipistrellus subflavus	1	0.1	5.0	<0.1
Glaucomys volans	2	0.3	128.0	1.3
Reithrodontomys humulis	1	0.1	12.0	0.1
Peromyscus leucopus	3	0.3	66.0	0.7
Peromyscus spp.	39	5.8	858.0	8.5
Microtus pennsylvanicus	17	2.5	629.0	6.3
Microtus ochrogaster	12	1.8	516.0	5.1
Microtus spp.	28	4.2	1120.0	11.1
Rattus norvegicus	1	0.1	150.0	1.5
Mus musculus	11	1.6	209.0	2.1
Unident. cricetid/murid	39	5.8	1092.0	10.8
Unident. rodent	18	2.7	630.0	6.3
Mammal subtotal	231	34.5	6638.0	65.9
Birds				
Cyanocitta cristata	5	0.7	435.0	4.3
Sialia sialis	2	0.3	64.0	0.6
Turdus migratorius	1	0.1	77.0	0.8
Unident. warbler	1	0.1	10.0	0.1
Quiscalus quiscula	2	0.3	228.0	2.3
Cardinalis cardinalis	6	0.9	264.0	2.6
Pipilo erythrophthalmus	3	0.4	123.0	1.2
Unident. passerine	17	2.5	680.0	6.8
Unident. bird	2	0.3	112.0	1.1
Bird subtotal	39	5.8	1993.0	19.8
Amphibians				
Unident. salamander	1	0.1	3.5	<0.1
Rana spp.	1	0.1	30.0	0.3
Fish				
Notropis chrysocephalus	9	1.3	117.0	1.2
Amphibian/fish subtotal	11	1.6	150.5	1.5
Insects				
Acrididae	26	3.9	39.0	0.4
Tettigoniidae	2	0.3	3.0	<0.1
Unident. orthopteran	2	0.3	2.0	<0.1
Carabidae	30	4.5	6.0	<0.1
Scarabaeidae	2	0.3	0.6	<0.1
Tenebrionidae	2	0.3	1.2	<0.1
Unident. coleopteran	123	18.3	36.9	0.4
Pentatomidae	2	0.3	0.4	<0.1
Apidae	3	0.4	1.2	<0.1
Noctuidae	2	0.3	2.0	<0.1
Unident. insect	11	1.6	16.5	0.2

Table 1. Continued.

PREY	OCCURRENCE		BIOMASS	
	N	%	GRAMS	%
Crustaceans				
Astacidae				
Cambarus spp.	10	1.5	65.0	0.6
Unident. crayfish	172	25.6	1118.0	11.1
Arachnids				
Unident. spider	1	0.1	0.5	<0.1
Gastropods				
Polygridae	2	0.3	0.8	<0.1
Invertebrate subtotal	390	58.1	1293.1	12.8
Overall total	671	100.0	10 074.6	100.0

Table 2. Summary of prey use by Eastern Screech-Owls.

		PERCENT OCCURRENCE				PERCENT BIOMASS					
LOCATION[a]	PERIOD[b]	MAMMALS	BIRDS	INVERTS.	FISH, AMPHIBIANS, AND REPTILES	MAMMALS	BIRDS	INVERTS.[c]	FISH, AMPHIBIANS, AND REPTILES	PREY ITEMS	METHOD[d]
Michigan-1	NB	91.9	7.7	0.4	0	89.8	10.2	*	0	235	P
Michigan-1	B	46.2	16.9	36.9	0	62.2	29.9	7.9	0	65	P
Michigan-2	Sept.-May	99.3	0.3	0.4	0	99.5	0.4	0.1	0	1549	P
Wisconsin	all	68.6	26.3	2.2	2.9	71.6	18.0	0.4	10.0	137	P
New York	B	6.1	36.1	48.4	9.4	27.1	45.0	7.9	20.0	213	C, P, O
Ohio	B	30.4	64.8	0.8	4.0	27.1	59.8	0.1	13.0	477	C
Ohio	NB	60.3	26.5	2.5	10.7	50.5	29.3	0.3	19.8	121	C
Illinois	NB	92.2	7.8	0	0	89.6	10.4	0	0	128	P
Missouri	all	92.4	7.0	0.4	0.2	92.1	7.7	*	0.2	497	P
Kentucky-1	all	14.7	14.8	70.5	0	39.1	56.4	4.5	0	244	S, P
Kentucky-2	B	29.0	5.6	63.5	1.9	61.6	21.0	15.5	1.9	203	P, C
Kentucky-2	NB	49.3	5.9	43.8	1.0	75.5	16.1	7.7	0.7	468	P, C
Tennessee	B	16.5	63.7	9.9	9.9	10.8	68.2	0.6	20.4	91	C
Tennessee	NB	4.2	72.9	6.2	16.7	1.9	65.1	0.5	32.5	48	C
Tennessee	all	4.7	1.2	93.1	1.0	49.8	15.2	18.7	16.3	407	S
Arkansas	all	8.8	8.8	76.5	5.9	18.5	57.3	12.4	11.8	34	S
Overall		60.9	14.4	22.9	1.8	73.7	19.5	1.7	5.1	4917	

[a] References = Michigan-1, Craighead and Craighead 1956; Michigan-2, Wilson 1938; Wisconsin, Errington 1932; New York, Allen 1924; Ohio, VanCamp and Henny 1975; Illinois, Cahn and Kemp 1930; Missouri, Korschgen and Stuart 1972; Kentucky-1, Brown 1989; Kentucky-2, this study; Tennessee, Duley 1979; Arkansas, Hanebrink et al. 1979.

[b] NB = non-breeding period, B = breeding period, and all = all year.

[c] * = less than 0.1%.

[d] C = cached prey, P = pellets, O = direct observation, S = stomach contents.

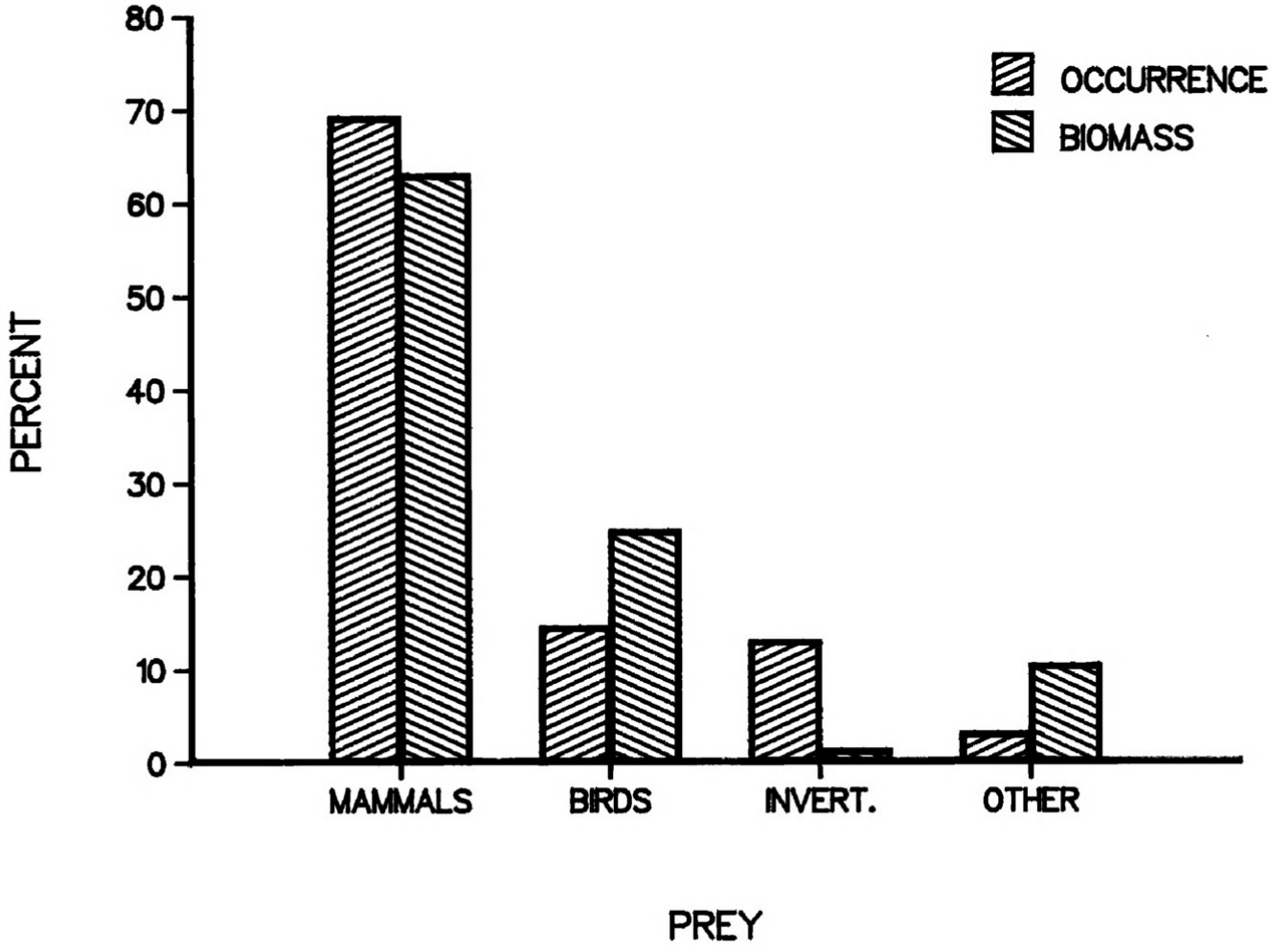

Figure 1. Prey use (N = 735) by Eastern Screech-Owls during the non-breeding period using data derived from several studies.

zidae (47.3% of passerines), Muscicapidae (12.1% of passerines) and Passeridae (9.6% of passerines). The most common invertebrate prey were crayfish (24%), moths and butterflies (26.6%), beetles (23.8%), and crickets and grasshoppers (15.3%).

Several investigators have reported seasonal variation in prey use by screech-owls (Table 2). Craighead and Craighead (1956) found that screech-owls in Michigan used mammalian prey almost exclusively during the non-breeding period but used a variety of prey (mammals, birds, and invertebrates) during the breeding period (Table 2). On the basis of cached prey, VanCamp and Henny (1975) found that small mammals were the most common prey of screech-owls during the non-breeding period (October–February) while birds were the most common prey during the breeding period (March–June; Table 2). VanCamp and Henny (1975) also examined seasonal variation in the diet of screech-owls in the northeastern United States and Ontario, Canada, using stomach content data. Analysis revealed that 61% of the screech-owl stomachs collected during April through November contained arthropod (primarily insect) remains while only 18% of the stomachs collected during December through March contained arthropod remains.

For all studies providing seasonal data combined (Allen 1924, Cahn and Kemp 1930, Craighead and Craighead 1956, VanCamp and Henny 1975, Duley 1979, this study), the most common prey (both in frequency of occurrence and biomass) during the non-breeding period were mammals (Fig. 1) while the most common prey during the breeding period were birds (Fig. 2). Invertebrates were preyed upon more frequently during the breeding period (33.3% of all prey; Fig. 2) than during the non-breeding

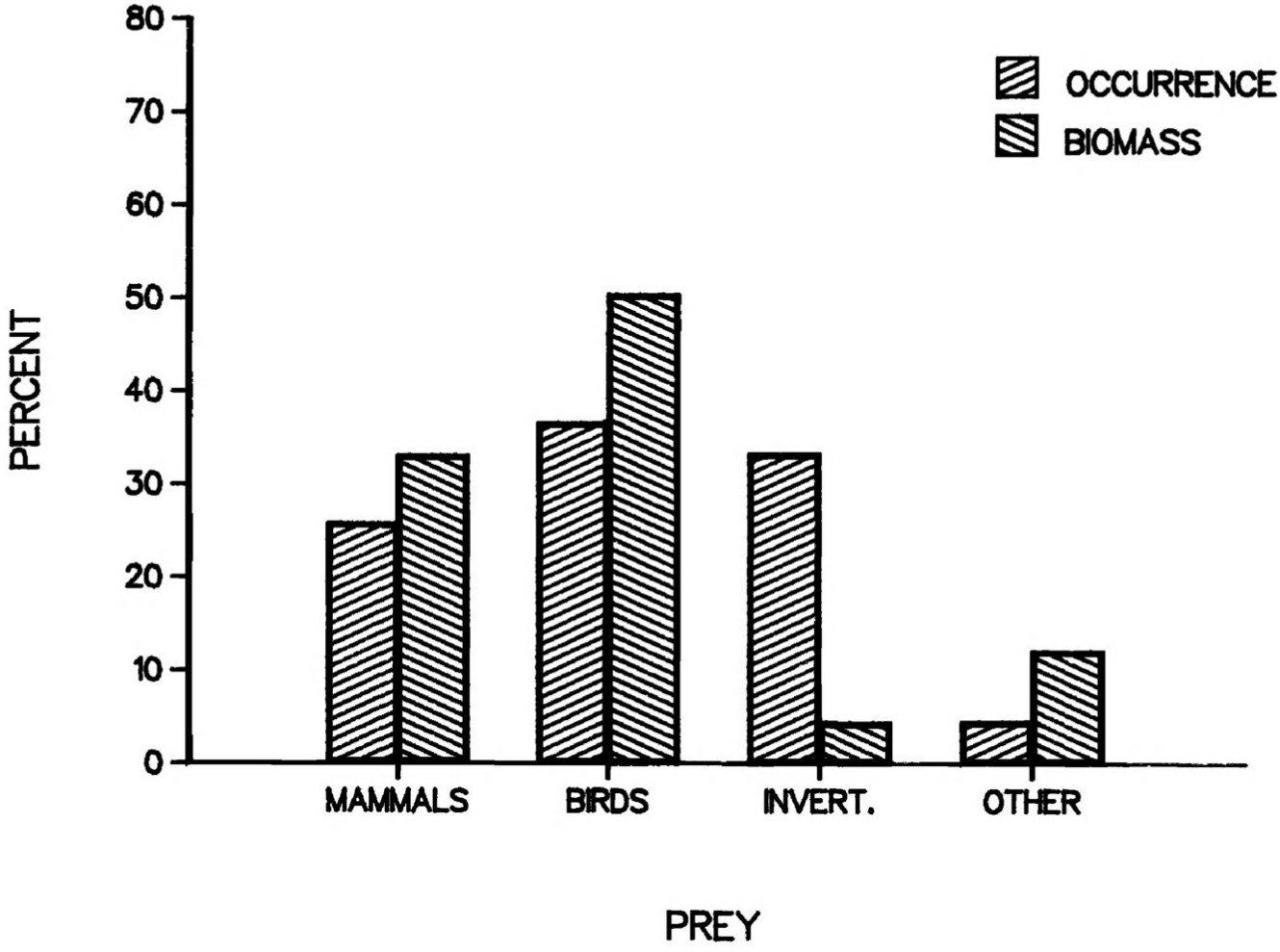

Figure 2. Prey use (N = 1314) by Eastern Screech-Owls during the breeding period.

period (Fig. 1), but only accounted for 4.4% of total prey biomass (Fig. 2).

Prey use by screech-owls varied with location (Table 2), however, differences in methodology and the time and duration of studies were probably responsible for some of this variation. Among studies using similar methods (examining pellets and cached prey) and timing (all or most of the year), mammals were predominant at both northern (Wisconsin, Errington 1932; Michigan, Craighead and Craighead 1956; Ohio, VanCamp and Henny 1975) and more southern (Missouri, Korschgen and Stuart 1972; Tennessee, Duley 1979; Kentucky, this study) locations (Table 2). These studies also suggest that birds were used more frequently by screech-owls at northern locations and invertebrates more frequently further south. However, these results were due largely to just two studies (VanCamp and Henny 1975, this study). Other differences between locations were also apparent. For example, few invertebrates were used by screech-owls in Missouri (Korschgen and Stuart 1972) while many were used by screech-owls in central Kentucky (this study; Table 2).

The mean mass of all prey (N = 4917) taken by screech-owls was 28.29 ± 0.33 (SE) g. During the non-breeding period, the mean mass of screech-owl prey (N = 735) was 31.77 ± 0.88 g. During the breeding period, the mean mass of prey (N = 1314) taken by screech-owls was 24.61 ± 0.90 g. The mean mass of prey items in each of the major prey groups was 34.27 ± 0.26 g for mammals (N = 2992), 38.23 ± 1.02 g for birds (N = 708), 31.50 ± 6.93 g for amphibians (N = 34), 106.34 ± 7.81 g for fish (N = 56), and 2.12 ± 0.05 g for invertebrates (N = 1126). The mean mass for fish is relatively high because six of nine species reported as prey are po-

tentially larger than screech-owls and, therefore, were assigned a mass of 150 g.

DISCUSSION

Prey use by Eastern Screech-Owls may vary with season and location, but our results indicate that small mammals and birds contribute the most biomass. Invertebrates were sometimes taken more frequently than other prey (e.g., Allen 1924, VanCamp and Henny 1975, Duley 1979, Brown 1989, this study), however, the small size of most invertebrates limited their contribution to total prey biomass.

Invertebrates were taken more frequently by screech-owls during the breeding period than during the non-breeding period (Craighead and Craighead 1956, VanCamp and Henny 1975, Duley 1979, this study). Increased use of invertebrates by screech-owls during the breeding period may be due to increased availability at this time. Screech-owls at northern locations also took birds more frequently during the breeding period (e.g., Allen 1924, Craighead and Craighead 1956, VanCamp and Henny 1975). No seasonal variation in the number of birds in the diet of screech-owls was found in either Kentucky (this study) or Tennessee (Duley 1979). Increased use of birds by screech-owls during the breeding period at northern locations may be due to the increased availability of birds plus the reduced availability of other prey. Craighead and Craighead (1956:289) reported that "meadow mice and all other prey species, with the exception of the small-bird group, reached a period of minimum population density in spring" in Michigan. VanCamp and Henny (1975:18) suggested that the breeding period of screech-owls in northern Ohio was "timed to take advantage of the spring migration of small birds." Prey availability may fluctuate less at more southern locations, with ectotherms more likely to be available throughout the year. Thus, screech-owls further south (e.g., Kentucky and Tennessee) may not be as dependent on the influx of small birds that occurs during spring migration.

Differences in methodology were responsible for some of the variation reported in prey use by screech-owls. For example, birds were the most frequent prey of screech-owls during the breeding period in northern Ohio (VanCamp and Henny 1975) while invertebrates were the most frequent prey of screech-owls during the breeding period in New York (Allen 1924). However, VanCamp and Henny (1975) described food habits based solely on prey cached in nest boxes, while Allen (1924) used cached prey, pellets, and direct observations. Screech-owls rarely cache small prey items like invertebrates (VanCamp and Henny 1975), explaining the apparent near absence of invertebrates in the diet of screech-owls in northern Ohio. Similarly, Duley (1979) reported few invertebrates (less than 10% of all prey items) in the diet of screech-owls when examining cached prey but found many invertebrates (more than 90%) when using stomach content analysis (Table 2).

Some differences in prey use between locations may be due to differences in prey availability. For example, although screech-owls rarely preyed on crayfish at other locations (see references in Table 2), we found that crayfish were frequently used by screech-owls in central Kentucky. Our study site is a low, poorly drained area (see Belthoff 1987 for a description of the area) supporting large numbers of terrestrial crayfish (*Cambarus* spp.) (pers. observation).

Our overall estimate of the mean mass of prey used by Eastern Screech-Owls was 28.3 g, and mean prey mass was lower for the breeding period than for the non-breeding period. Based on previous studies of screech-owl food habits, Marti and Hogue (1979) estimated a mean prey mass of 38.1 g. Differences in estimates of the mass of prey items may have contributed to this difference. In addition, however, we used data from more recent studies conducted in the southern United States (Duley 1979, Hanebrink et al. 1979, this study). These studies revealed greater use of smaller prey (invertebrates) by screech-owls than previous studies and, as a result, our overall estimate of mean prey mass was lower. Similarly, our estimate of mean prey mass was lower during the breeding period than the non-breeding period because of an increased use of invertebrates.

Although capable of killing prey with masses greater than 100 g, our results indicate that Eastern Screech-Owls typically use much smaller prey. Similarly, Marti and Hogue (1979) found that captive screech-owls offered lab mice of various sizes usually selected smaller prey over larger. There are several reasons why screech-owls may select smaller prey: 1) more small prey species are available, 2) smaller prey are likely younger and more vulnerable, 3) capturing larger prey may require greater energy expenditure if such prey escape more often, 4) risk of injury may be greater with larger prey, and 5) sit-and-wait predators like screech-owls expend lit-

tle energy in searching and may be able to afford to take smaller, easier prey (Marti and Hogue 1979).

Our results indicate that Eastern Screech-Owls use a wide variety of prey, with vertebrates predominant in terms of biomass, and, furthermore, that prey use varies with time of year. These conclusions, however, are based largely on studies conducted at northern locations, many of which focused on prey use by screech-owls during the non-breeding period, when owls roost in natural or artificial boxes and prey remains are easier to locate. In addition, techniques used to examine prey use by screech-owls may overemphasize the importance of certain types of prey. Studies of prey use by screech-owls relying more on either stomach content analysis or direct observation and conducted during the breeding period and in the southern part of their range may yield different results.

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