Mammals of Southern Clermont County, Ohio, With Notes on the Food Habits of Four Species of Bats[1]

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ABSTRACT. The mammals of wood and openland habitats adjacent to the Ohio River were sampled during May, June, July, and October 1984 using mist nets and live, pit, and snap traps. Four species of bats were netted; 13 species of large mammals, or their sign, were observed; and eight species of small mammals were trapped. Snap trap and live trap success was greatest in red cedar upland and immature upland forests, respectively. Pit trap success was greatest in recently disturbed areas. Species diversity was greatest for all three trap methods in recently disturbed areas. Food habitats of bats were determined via fecal analysis. Moths and beetles were the primary prey of 12 red bats; big brown bats ate beetles. A juvenile hoary bat, the first recorded from Clermont County, ate largely lacewings; an eastern pipistrelle was more of a generalist, eating moths, beetles, flies, caddisflies, leaf hoppers, and ants.

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INTRODUCTION

Few studies have addressed the occurrence, abundance, and diversity of small mammals in upland habitats adjacent to the Ohio River. Land use on the Ohio River's floodplain varies from agricultural, open land, and small tracts of riparian forest to developed (i.e., urban, industrial, and residential). Lateral to the floodplain are steeply cut, typically forested banks. Uplands are forested, farmed, or open with scattered residences.

This study documents the occurrence of mammalian species, the food habits and habitat use by bats, and the effectiveness of small mammal trapping methods in habitats adjacent to the Ohio River. Of special concern was the potential presence of *Myotis sodalis* (Indiana bat) and *Myotis grisescens* (gray bat), two species on the U.S. Fish and Wildlife Service's list of endangered species. Information on the occurrence of these and other bat species in Ohio is also limited (Gottschang 1981).

MATERIALS AND METHODS

STUDY AREA. The 243-ha study area is in southern Clermont County, Ohio (Fig. 1) immediately adjacent to the Zimmer Power Plant which is being converted from a nuclear to a coal-fired facility. This area is a series of steep hills and valleys, adjacent to the Ohio River, with an average elevation of approximately 259 m (msl). The area lies only a few miles within the limits of the Illinoian glacial advance. Consequently, the topography is intermediate between the mountains of the southeast and flat rolling farm lands of the northwest. The study area is within the Central Lowland physiographic province, till plain section.

Study site vegetation was typed as: I-recently disturbed, such as powerline rights-of-way and cultivated fields; II-red cedar (*Juniperus virginiana*)-dominated upland forest; III-disturbed second-growth upland forest, with most large trees removed in the last 15 to 20 years; IV-immature second-growth upland forest, that was less recently logged and had a more closed canopy; V-mature second-growth upland forest; VI-immature second-growth terrace forest, located along Little Indian Creek and Ohio River floodplains; and VII-immature second-growth floodplain forest (Fig. 1).

BAT CAPTURE AND FECAL ANALYSIS. Mist netting was conducted during May, June, and July with procedures described by Brack et al. (1984); nets were open from dusk until 2400 or later, frequently until dawn. A total of 30 net-nights of effort was expended at 14 locations along Little Indian Creek and its tributaries. Multi-tiered nets were suspended over the stream, closing off the entire flight space from the stream surface to canopy closure. All nets were hung in type VI and VII habitats. Net sites were about 0.5 km apart. When caught, bats were kept individually in bags for 1.5 to 2.0 h to allow for defecation. When removed they were banded and weighed, and the sex, age, and reproductive condition noted. Feces handling and analysis followed the procedures of Brack and LaVal (1985). A dietary diversity index (DDI; MacArthur 1972) was calculated for samples by species, sex, and age. The equation for the index is: $DDI = 1/\Sigma P_i^2$, where the P_i are the proportions of insect orders in the diet. This index value is often interpreted as the number of orders of insects equally represented in the diet.

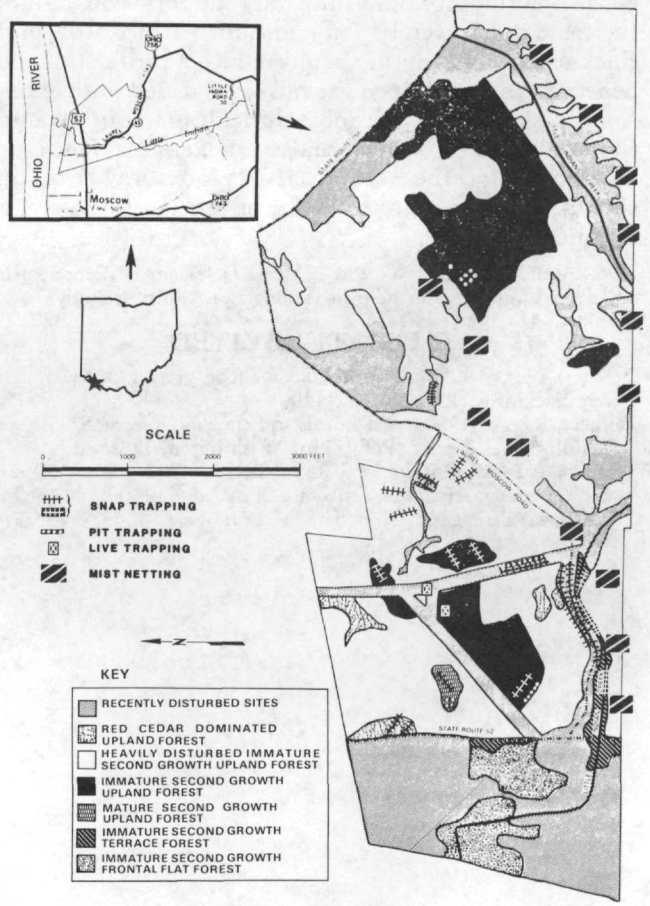

FIGURE 1. The study area in southern Clermont County, Ohio. Vegetation types and trapping locations are shown within the project area.

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Bat captures by time and height were analyzed with the chi-square (X^2) test. Height intervals corresponded to the three foliage layers of temperate deciduous forests: herbaceous, subcanopy, and canopy (MacArthur and MacArthur 1961). Times of capture were separated into four approximately equal periods throughout the night.

SMALL AND LARGE MAMMAL SAMPLING. Small terrestrial mammals were sampled during May, June, and October, 1984 with snap traps, Sherman live traps, and pit traps. Snap traps were baited with peanut butter and rolled oats and spaced approximately 1 m apart in traplines in habitats I, II, III, IV, V, and VI (Fig. 1). Live traps were pre-baited with peanut butter, rolled oats, and sunflower seeds for 2 or 3 d prior to trapping in habitats I and IV. Fifty traps were placed on a 5 × 10 grid, with traps spaced at 10-m intervals. Pit traps (size #20 cans) were sunk flush into the ground along naturally occurring obstacles such as logs or roots, or fitted with hardware cloth drift fences. The cans were half filled with 10% formalin. Pit traps were placed in habitats I, IV, and VI, and sampled for days or weeks. A species diversity index, equal to $1/\Sigma P_i^2$, was determined for each capture method for each habitat (MacArthur 1972). In the equation, P_i is the proportion of all individuals that belong to the ith species. The index is most easily interpreted as the number of equally represented species. Trap success was calculated as the percent of traps capturing mammals.

The presence of large mammals was confirmed through sightings, sign, road kills, and by questioning residents.

RESULTS

BAT CAPTURE. The capture of 17 *Lasiurus borealis* (red bat) was distributed randomly throughout the night ($X^2 = 4.21$; $P = 0.24$), but was greatest in the subcanopy ($X^2 = 16.63$; $P = 0.00$). From 12 of these, 104 fecal pellets were collected and food habits determined (Table 1). Three juveniles ate predominantly coleopterans: Scarabaeidae parts were identified twice and Carabidae once. A coleopteran flight wing measuring 10.7 × 4.5 mm was also found. Adult males ate predominately lepidopterans, although parts from six other insect orders were identified. A single pregnant female ate coleopterans and lepidopterans only. In the combined diet of all *L. borealis*, lepidopterans, coleopterans, homopterans, dipterans, and neuropterans each comprised over 6% of the diet. The DDI for this species ranged from 2.00 to 6.25, and averaged 5.81 for the combined group (Table 1).

Three fecal pellets from a male juvenile *Lasiurus cinereus* (hoary bat) contained the remains of neuropterans, lepidopterans, and coleopterans. This bat was caught at 0315 in the subcanopy layer. The only *Pipistrellus subflavus* (eastern pipistrelle) caught was taken from the canopy layer at 2210. This pregnant female had eaten prey from six orders of insects (Table 1).

Six *Eptesicus fuscus* (big brown bat) were caught; 49 fecal pellets were collected from four individuals (Table 1). All ate katydids (Orthoptera: Tettigoniidae). However, the three lactating females ate predominately coleopterans, including families Scarabaeidae (identified in five fecal pellets), Carabidae (two pellets), and Curculionidae (one pellet). The principal prey of an adult male was hymenopterans (99%). The combined DDI (3.86) for this species was low in relation to the others. Two bats were caught in the canopy and four in the subcanopy ($X^2 = 4.00$; $P = 0.14$), and capture continued throughout the night ($X^2 = 4.64$; $P = 0.20$)

LARGE AND SMALL MAMMALS. A *Glaucomys volans* (southern flying squirrel) was caught in a mist net while volplaning. An additional 12 species of mammals, predominantly large, were found but not trapped from the project area. *Odocoileus virginianus* (white-tailed deer), *Urocyon cinereoargenteus* (gray fox), *Vulpes vulpes* (red fox), *Procyon lotor* (raccoon), *Mephitis mephitis* (striped skunk), *Sciurus niger* (fox squirrel), *Sciurus carolinensis* (gray squirrel), *Marmota monax* (woodchuck), *Sylvilagus floridanus* (eastern cottontail), and *Didelphis virginiana* (opossum) were observed. Residents of the area indicated that *Mustela vision* (mink) has been trapped from the project area in recent years. Their sign, and that of *Scalopus aquaticus* (eastern mole), were observed. As evidenced from frequency of encounters, white-tailed deer and woodchuck were the most abundant herbivores; gray squirrel were common. Raccoon and gray fox were the common carnivores.

Eight species of small mammals were trapped in six habitats by the three capture methods (Table 2). Snap trap capture success was greatest in red cedar upland forest (Type II); live trap success was greatest in immature upland forest (IV); and pit trap success was highest in recently disturbed areas (I). Overall, live trapping was most successful (13.3%) and yielded the greatest diversity of mammals (3.9). Species diversity was greatest in recently disturbed areas (I) for all three trapping methods. Three species, *Microtus pennsylvanicus* (meadow vole), *Peromyscus leucopus* (white-footed mouse), and *Blarina brevicauda* (short-tailed shrew), were caught by each trapping method. Only *P. leucopus* was caught in all habitats trapped, but this species was most abundant in habitat types II, III, IV, and VI. *Tamias striatus* (eastern chipmunk) was caught only in live traps in immature upland forest (IV). *Mus musculus* (house mouse) was

TABLE 1

Diet by percent volume of bats caught in Clermont County, Ohio, May–July, 1984. Samples were combined by sex (Male = M, Female = F) and age (Adult = A, Juvenile = J). Adult females were further designated by reproductive condition (Pregnant = P, Lactating = L).

Species	Sex/ Age	No. bats	No. pellets	Lepidoptera	Coleoptera	Diptera	Trichoptera	Homoptera	Hymenoptera	Neuroptera	Orthoptera	DDI*
L. borealis	F/J	3	31	4.2	89.4	1.7	0.0	0.3	0.3	1.6	0.0	5.77
	F/P	1	7	39.3	60.7	0.0	0.0	0.0	0.0	0.0	0.0	2.00
	M/A	8	65	57.0	3.8	13.1	0.4	15.3	0.4	9.2	0.0	6.25
	Total	12	104	42.3	29.9	9.0	0.3	10.3	0.3	6.5	0.0	5.81
L. cinereus	M/J	1	3	16.7	15.0	0.0	0.0	0.0	0.0	68.3	0.0	3.00
P. subflavus	F/P	1	7	7.9	15.7	20.7	10.0	40.0	5.7	0.0	0.0	6.00
E. fuscus	F/L	3	31	0.0	88.5	0.0	0.0	1.2	0.9	0.0	6.5	3.27
	M/A	1	18	0.0	0.0	0.0	0.0	0.0	99.0	0.0	1.0	2.00
	Total	4	49	0.0	66.4	0.0	0.0	0.9	25.4	0.0	5.1	3.86

*Dietary diversity index

TABLE 2

Small mammal catch by trapping method and habitat during 1984 in Clermont County, Ohio. Tabular values include number of trap nights, percent success, species captured, and diversity.

		Snap trap		Live trap		Pit trap	
Habitat*	Species**	Nights	Catch	Nights	Catch	Nights	Catch
I	M.p.	1360	2	150	6	600	7
	M.t.		0		0		1
	S.c.		0		1		0
	P.l.		0		1		1
	Z.h.		0		1		1
	M.m.		1		0		0
	B.b.		3		3		4
	% Success		0.4		8.0		2.3
	Diversity		2.6		3.1		2.9
II	M.p.	415	3	0		0	
	S.c.		1				
	P.l.		6				
	% Success		2.4				
	Diversity		1.5				
III	P.l.	350	2	0		0	
	% Success		0.6				
	Diversity		1.0				
IV	M.p.	525	1	150	0	466	0
	P.l.		10		17		0
	B.b.		0		4		2
	T.s.		0		7		0
	% Success		2.1		18.7		0.4
	Diversity		1.2		2.2		1.0
V	P.l.	100	1	0		266	0
	B.b.		0				1
	% Success		1.0				0.4
	Diversity		1.0				1.0
VI	P.l.	300	1	0		0	
	% Success		0.3				
	Diversity		1.0				
TOTAL		3050		300		1332	
	% Success		1.0		13.3		1.3
	Diversity		2.1		3.9		2.9

*I = recently disturbed; II = red cedar upland; III = disturbed upland; IV = immature upland; V = mature upland; VI = immature terrace.

**M.p. = *Microtus pennsylvanicus;* M.t. = *Microtus pinetorum;* S.c. = *Synaptomys cooperi;* P.l. = *Peromyscus leucopus;* Z.h. = *Zapus hudsonius;* M.m. = *Mus musculus;* T.s. = *Tamias striatus;* B.b. = *Blarina brevicauda.*

caught only in snap traps, and *Microtus pinetorum* (woodland vole) only in pit traps. The latter two species and *Zapus hudsonius* (meadow jumping mouse) were caught only in recently disturbed areas (I). A single *Synaptomys cooperi* (southern bog lemming) was live-trapped in a recently disturbed area; another was snap-trapped in the red cedar upland (II).

DISCUSSION

BATS. No threatened or endangered bats were caught. *Myotis sodalis* has been recorded from Clermont County (Gottschang 1981), but this capture and others reported by Barbour and Davis (1969) may represent captures during migration. In general, the study area's physiography was quite different from that used by well studied nursery colonies of this species in Indiana (Humphrey et al. 1977, Cope et al. 1974, Brack 1983). The only Ohio *M. grisescens* recorded was an individual shot over the Ohio River (Gottschang 1981). This species is cavern-dwelling, and the nearest known colonies are in Kentucky (Brady et al. 1982) and Indiana (Brack et al. 1984).

Captures of *L. borealis* were predominately in the subcanopy. Insects (e.g. Diptera, Trichoptera, Plecoptera, and Ephemeroptera) requiring an aquatic habitat for the majority of their life cycle were plentiful above Little Indian Creek and its tributaries. However, they were not eaten, indicating that the subcanopy space over the creeks was used as a travel corridor and not for foraging, similar to the findings of Brack et al. (1984) and Brack (1985). The diet of this species was similar to that found by Ross (1967) and Whitaker (1972).

On two occasions *L. borealis* were observed at dusk feeding high over the canopy along a forest-field interface, supporting the foraging observations of LaVal et al. (1977), LaVal and LaVal (1979), and Mumford and Whitaker (1982). Once an apparent agonistic encounter ended in one bat being chased from the occupied foraging area of another. On 25 July, while a juvenile was in a bag, another *L. borealis* made audible noises from nearby. As the juvenile was released, another *L. borealis* flew toward it and was caught. Unfortunately, it escaped as the net was lowered. In contrast to night-long captures, Kunz (1973) found captures skewed towards early evening in Iowa.

The diet of the single *P. subflavus* captured was variable, similar to reports by Whitaker (1972), LaVal and LaVal (1980), and Brack (1985). *Lasiurus cinereus* is uncommon in Ohio (Gottschang 1966), and the present capture represents a Clermont County record. The diet of this juvenile male differed from that reported by Ross (1967) and Black (1972, 1974) who reported that lepidopterans were the major food item of this species. Conversely, Brack et al. (1984) and Brack (1985) found that lepidopterans frequently are not a major portion of its diet. The jaw and skull morphology of *L. cinereus* are robust, indicative of a diet containing proportionately more hard foods (Freeman 1981).

Coleopterans were the principal dietary items of the four *E. fuscus*, similar to results of past studies (Black 1974, Whitaker 1972, LaVal and LaVal 1980). In contrast to previous published studies (Kunz 1973, Brack et al. 1984, Brack 1985), this study provides no evidence of spatial or temporal resource partitioning in this species.

SMALL MAMMALS. Snap trapping effort was greatest in Type I habitat (Table 2). Success was low but diversity was high. These areas, created only several years previous, were poorly developed. Trap success, ranging from 0.3 to 2.4% and averaging 1.0%, was comparable to that reported by Rose and Seegert (1982) in Kentucky (2.0%) and Illinois (3.9%); Rose and McKean (1980) in southern Indiana (2.5%); Rose (1982) in southern Indiana (3.1%); and Mumford and Whitaker (1982) throughout Indiana (0.4 to 13.6%).

Of the three trapping methods, live traps were the most efficient per trap night, caught the greatest number of species, and exhibited the greatest species diversity of catch. This success may have been due, in part, to prebaiting.

Pit trap success (1.3%) and species diversity (2.9) were intermediate between the other two trapping methods. In southern Indiana, Rose and McKean (1980) and Rose (1982) found that pit traps were more efficient than snap

traps in the capture of six and seven of 10 species, respectively. Overall, their success was less for pit traps (1.2%) than snap traps (2.5%) (Rose and McKean 1980). In western Kentucky and adjacent Illinois, only three of 10 species were caught more often in pit traps, and pit trap success (1.8%) was about one-half snap trap success (3.9%) (Rose and Seegert 1982).

Gottschang (1981) reported 17 species of rodents and three species of insectivores from Clermont County. In the present study, trapping was inappropriate for *Rattus norvegicus* (Norway rat). Well-developed grasslands were lacking and likely account for the absence of *Microtus ochrogaster* (prairie vole), *Peromyscus maniculatus* (deer mouse), and *Reithrodontomy humulis* (eastern harvest mouse). Habitat was also lacking for *Ondatra zibethicus* (muskrat) and *Castor canadensis* (beaver). Old field, favored by *Cryptotis parva* (least shrew), was absent from the study area.

CARNIVORA. Gottschang (1981) reported eight species of Carnivora from Clermont County. *Canis latrans* (coyote), *Mustela nivalis* (least weasel), and *Mustela frenata* (long-tailed weasel) were not observed during this study.

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