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The Diet of Big Brown Bats (*Eptesicus fuscus*) in Relation to Insect Availability in Southern Alberta, Canada

Abstract

The purpose of this study was to determine if bats preferentially select certain prey types by comparing the diet of big brown bats (*Eptesicus fuscus*) with insect samples collected at the sites where the bats were captured. We analyzed 135 fecal pellets collected from 14 bats captured in Writing-On-Stone Provincial Park, near Milk River, Alberta, Canada (49° 05'N, 111° 37'W). We used a combination of sticky, Malaise, and whirligig traps to sample the insect prey available to the bats. Despite the predominance of dipterans in insect trap samples, more than 65 percent of the diet of *E. fuscus* consisted of coleopterans even though beetles constituted less than 2 percent of the insects in the trap samples. Less than 10 percent of the bat's diet consisted of dipterans. We conclude that although our sampling methods were biased, foraging by *E. fuscus*, although probably selective, is flexible, and can vary with the size and type of prey available.

Introduction

Our present knowledge of the foraging behaviour of most species of insectivorous bats does not allow us to answer the question, "Do individuals preferentially select different prey types?" Prey selection could reflect any combination of energetic considerations predicted by optimal foraging theory (Stephens and Krebs 1986), detection constraints imposed by echolocation call design (Barclay 1985), limitations on habitat use determined by wing morphology and flight style (Norberg and Rayner 1987, Aldridge and Rautenbach 1987), or diet variation as a result of differences in prey availability between sites. To further our understanding of prey selection by bats, diet data for the same bat species from different locations and measures of prey availability in those locations are needed.

In this paper we present data on the diet of big brown bats (*Eptesicus fuscus*) from southern Alberta, and we compare bat diet with the availability of insect prey measured at the same site. The diet of *E. fuscus* has been reported from a number of localities in North America (Hamilton 1933; Ross 1967; Whitaker 1972; Black 1972, 1974; Whitaker *et al.* 1977, 1981), but in only one instance has diet of this species and prey availability been measured simultaneously (Brigham 1988).

Study Area

Fecal pellets and insect samples were collected from bats caught in or near Writing-On-Stone Provincial Park near Milk River, Alberta (49° 05'N, 111° 37'W). The Park spans the Milk River valley and includes parts of several major coulee systems. The area is centered in Alberta's semi-arid, mixed grassland region, and is characterized by low precipitation, low humidity, strong winds and hot summers. The main river valley is flanked on both sides by steep sandstone cliffs and hoodoo formations. A variety of habitats including riparian (dominated by western cottonwood (*Populus deltoides*)), coulee and upland are present (Saunders 1989).

Materials and Methods

Fourteen bats were captured in mist nets on six nights during June and July, 1988. The bats, captured as they foraged in coulee systems adjacent to the Milk River, were kept in cotton bags for a minimum of one hour after which fecal samples were collected. Most feces are voided during the first hour after capture (Warner 1985). We determined the diet for 13 individuals using 10 pellets randomly selected from each bat's feces. One individual produced only five pellets, all of which were analyzed. For each pellet examined, we estimated the percentage volume of each identifiable insect Order with a 6x to 30x dissecting microscope. The frequency of occurrence in the diet was defined as the percentage of pellets in which an insect Order was found.

Insect abundance was measured on five of the six nights that bats were captured. We used one or more traps or trap types on any given night. These included three sticky traps, two Malaise traps and a whirligig trap (Kunz 1988). We used these different traps because of their availability to us and the nature of the sampling sites. The whirligig trap was dependent on a source of electricity and could not be used in remote locations. All insect traps were placed within 100 m of the nets used to capture the bats. The sticky traps were hung 0.5, 1.0 and 1.5 m from the ground and the Malaise traps were placed on the ground. The nets on the whirligig trap sampled insects flying at 0.5 and 3.5 m from the ground. We observed the bats feeding at dusk in the area of nets and insect traps, but it was impossible to determine what proportion of their total foraging time was spent in the area. Brigham (1988) and Brigham and Fenton (1986) showed that the range of foraging sites used on a given night by radio-tagged *E. fuscus* may be concentrated at a single predictable location or scattered among numerous unpredictable locations. Therefore, we do not know if the bats foraged near the traps in our study area for the whole night on a regular basis or for only a short period of time on an irregular basis.

To estimate the relative abundance of each insect Order, we summed the number of individual insects of each Order caught by the traps on a given night.

Results

The results of the diet analysis show that coleopterans dominated the diet of *E. fuscus* in terms of both volume and frequency (Table 1), despite the fact that only 1.9 percent of the insects captured in the traps were beetles (Table 2). Lepidopterans (moths) and hemipterans (bugs) were the only other insect Orders contributing more than 10 percent to the dietary volume during the dates we sampled. Dipterans (flies) constituted 79.3 percent of the insects captured by the traps, but made up only 7.7 percent of the volume of the diet of *E. fuscus*. No other insect Order constituted more than 10 percent of the trap samples.

Using the same method of analysis as Swift *et al.* (1985) we found no significant correlation between prey availability and diet on any of the four nights when insects were caught (Spearman rank r_s = 0.21, —0.42, —0.48, and —0.40 for 20 June, 7 July, 16 July and 25 July respectively; $p > 0.05$ in each case). These results indicate that the diet composition of *E. fuscus* does not reflect insect availability as measured by our traps, but suggests either selective feeding by the bats or differential vulnerability of prey types to capture.

Discussion

Our results concur with the findings of Hamilton (1933), Ross (1967), and Whitaker (1972) in suggesting that beetles are the most important dietary item in this species. Potential beetle preference is reinforced by the results of our insect sampling as beetles were relatively rare in our traps (although see below). In contrast, however, in the two localities closest to our study area where the diet of *E. fuscus* has been described, the predominate prey items were moths (Whitaker *et al.* 1977) and caddisflies respectively (Brigham 1988). Together, these data indicate that labelling *E. fuscus* as a beetle strategist (sensu Black 1974) is inappropriate. We suggest this species would be better described as being

TABLE 1. Summary of percent frequency (F) and volume (V) of insect Orders found in the diet of *Eptesicus fuscus*. Lep. represents lepidopterans; Col. coleopterans; Hem. hemipterans; Dip. dipterans; and Tri. trichopterans.

Date	# bats	Lep.		Col.		Hem.		Dip.		Tri.		other	
		F	V	F	V	F	V	F	V	F	V	F	V
2 June	4	65.7	45.4	54.2	32.8	2.8	0.3	40.0	20.3	0.0	0.0	8.6	1.1
20 June	4	12.5	6.5	77.5	61.5	37.5	25.4	10.0	6.0	2.5	0.2	0.0	0.0
7 July	2	0.0	0.0	100	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16 July	1	0.0	0.0	100	97.0	0.0	0.0	0.0	0.0	10.0	3.0	0.0	0.0
25 July	1	40.0	16.0	40.0	25.0	80.0	55.0	10.0	2.0	0.0	0.0	10.0	2.0
31 July	2	5.0	1.0	30.0	26.0	75.0	70.0	5.0	3.0	0.0	0.0	0.0	0.0
total	14	24.4	15.1	66.6	54.5	28.9	22.1	14.8	7.7	1.5	0.2	3.0	0.4

TABLE 2. Summary of the number of each insect Order found in trap samples. Insect Order abbreviations are the same as in Table 1.

Date	trap	Lep	Col	Hem	Dip	Tri	other
2 June	sticky	0	0	0	0	0	0
20 June	sticky	4	1	0	1	1	0
7 July	sticky	3	0	0	13	0	2
	Malaise	1	0	0	13	0	3
16 July	sticky	2	0	0	7	0	0
	Malaise	0	0	0	2	0	0
25 July	sticky	2	0	0	14	0	4
	w-gig	11	4	0	157	1	15
Total	number	23	5	0	207	2	24
	percent	8.8	1.9	0.0	79.3	0.8	9.2

capable of eating hard-bodied insects such as beetles (e.g., Freeman 1981), although not restricted to eating them.

In both this study and that of Brigham (1988), *E. fuscus* did not select prey relative to availability. Brigham (1988) found that *E. fuscus* did not eat chironomids (midges), despite these being the most abundant insect at his study site. Small insects such as chironomids or dipterans may not be available as a result of detection constraints for *E. fuscus* (Barclay 1985). It is likely that the predominance of caddisflies (body length > 5 mm) in the diet of *E. fuscus* in Brigham's (1988) study reflected the fact that they were the only relatively large insect regularly available.

Our data are more difficult to interpret. Saunders (1989) found that both *Myotis lucifugus* and *M. volans*, sympatric with *E. fuscus* at Milk River, ate both dipterans and lepidopterans. The diet of these species was much more in accordance with the insect availability measures than our data for *E. fuscus*. Saunders (1989) found that dipterans caught in the whirligig trap were relatively small (2 mm), but the moths were generally larger than 10 mm in body length. If prey size, and hence detectability, influences prey selection by bats, the limited selection of flies is explained. However, if prey size is the only important criteria, we would have expected moths to constitute a greater proportion of the diet of *E. fuscus* than did the coleopterans.

Although a variety of different traps have been designed to collect insects, our results illustrate the biases inherent in all insect sampling devices (Southwood 1978, Kunz 1988). Most traps are either prone to catching certain insect types, or have limited success in catching large or fast-flying insects. Graham (1969) concluded that whirligig traps generally take a random sample except for mosquitoes which are attracted, while Juillet (1963) found that these traps caught few large beetles. Juillet (1963) showed that Malaise traps caught relatively few insects and were biased against catching coleopterans and hemipterans. Heathcote (1957) found that sticky trap shape was also important, with cylindrical traps like those used in our study being the most efficient. However, since sticky traps partly make use of wind to catch insects, the airflow pattern at the sampling site can greatly influence sampling efficiency. Juillet (1963) found that sticky traps catch smaller insects than Malaise traps and that they are inefficient at catching large insects. He concluded that of the three types, whirligig traps were the least biased. This agrees with Saunders (1989), who suggested that the whirligig trap caught the most representative sample of insects available to foraging bats. As noted however, the drawback to this trap is the need for a power source. Swift *et al.* (1985) used a suction trap which is also relatively unbiased (Southwood 1978), but also requires a source of power (Kunz 1988). We suggest that future studies concurrently measuring diet and prey availability should use more than one type of insect sampling device, preferably including a whirligig or suction trap which seem to collect the most representative samples.

It is almost certain that our sampling methods (especially the sticky and Malaise traps) underestimated the actual availability of the large, strong flying coleopterans eaten by *E. fuscus* and were biased toward the smaller, weaker flying dipterans. However, even after accounting for the sampling problems, our results, when compared with Brigham's (1988) data where insects were sampled using only a whirligig trap (the same trap as in this study), suggest that prey availability can influence selection by *E. fuscus*. Even our whirligig trap rarely caught beetles, which were the preferred prey type of *E. fuscus*. We conclude, therefore, that foraging by this species, although probably selective, is flexible, and can vary with the size and type of prey available.

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Literature Cited

Aldridge, H. D. J. N., and I. L. Rautenbach. 1987. Morphology, echolocation and resource partitioning in insectivorous bats. J. Anim. Ecol. 56:763-778.

Barclay, R. M. R. 1985. Long- versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and consequences for prey selection. Can. J. Zool. 63:2507-2515.

Black, H. L. 1972. Differential exploitation of moths by the bats *Eptesicus fuscus* and *Lasiurus cinereus*. J. Mammal. 53:598-601.

__________. 1974. A north temperate bat community: structure and prey populations. J. Mammal. 55:138-157.

Brigham, R. M. 1988. The influence of morphology, prey detection system, and prey availability on the foraging behaviour of aerial insectivores. York University, North York, Ontario. Ph.D. Thesis.

Brigham, R. M. and M. B. Fenton. 1986. The influence of roost closure on the roosting and foraging behaviour of *Eptesicus fuscus* (Chiroptera: Vespertilionidae). Can. J. Zool. 64:1128-1133.

Freeman, P. W. 1981. Correspondence of food habits and morphology in insectivorous bats. J. Mammal. 62:166-173.

Graham, P. 1969. A comparison of sampling methods for adult mosquito populations in central Alberta, Canada. Quaestiones Entomologique. 5:217-261.

Hamilton, W. J. Jr. 1933. The insect food of the big brown bat. J. Mammal. 14:155-156.

Heathcote, G. D. 1957. The optimal size of sticky aphid traps. Plant Path. 6:104-107.

Juillet, J. A. 1963. A comparison of four types of traps used for capturing insects. Can. J. Zool. 41:219-223.

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Kunz, T. H. 1988. Methods for assessing prey availability for insectivorous bats. *In* T. H. Kunz (ed.) Ecological and Behavioral Methods for the Study of Bats. Smithsonian Press, Washington, D.C. Pp. 191-210.

Norberg, U. M., and J. M. V. Rayner. 1987. Ecological morphology and flight in bats (Mammalia:Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. Phil. Trans. R. Soc. London B. 316:335-427.

Ross, A. 1967. Ecological aspects of the food habits of insectivorous bats. Proc. West. Foundation Vert. Zool. 1:205-263.

Saunders, M. B. 1989. Resource partitioning between little brown bats (*Myotis lucifugus*) and long-legged bats (*Myotis volans*) in southern Alberta. University of Calgary, Calgary, Alberta. M.Sc. Thesis.

Southwood, T. R. E. 1978. Ecological Methods. Chapman and Hall, London.

Stephens, D. W., and J. R. Krebs. 1986. Foraging Theory. Princeton University Press. Princeton, New Jersey.

Swift, S. M., P. A. Racey, and M. I. Avery. 1985. Feeding ecology of *Pipistrellus pipistrellus* (Chiroptera: Vespertilionidae) during pregnancy and lactation. II Diet. J. Anim. Ecol. 54:217-225.

Warner, R. M. 1985. Interspecific and temporal dietary variation in an Arizona bat community. J. Mammal. 66:45-51.

Whitaker, J. O. Jr. 1972. Food habits of bats from Indiana. Can. J. Zool. 50:877-883.

Whitaker, J. O. Jr., C. Maser, and L. E. Keller. 1977. Food habits of bats of Western Oregon. Northw. Sci. 51:46-55.

Whitaker, J. O. Jr., C. Maser, and S. P. Cross. 1981. Food habits of Eastern Oregon bats, based on stomach and scat analysis. Northw. Sci. 55:281-292.