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Source: Acta Chiropterologica, 5(1) : 91-95

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: https://doi.org/10.3161/001.005.0108

Acta Chiropterologica, 5(1): 91–95, 2003
PL ISSN 1508-1109 © Museum and Institute of Zoology PAS

The effect of canine tooth wear on the diet of big brown bats (*Eptesicus fuscus*)

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The purpose of this study was to determine whether canine wear influences the diet of big brown bats (*Eptesicus fuscus*). We hypothesized that tooth wear reduces the ability to consume hard-bodied insects, such as beetles, and that older *E. fuscus* (those with worn canines) would thus include fewer beetles in their diet than younger individuals (those with less-worn canines) do. We examined 600 fecal pellets collected from 60 female bats captured at a single maternity colony in southeastern Alberta, Canada. The diets of two groups were similar in composition, despite considerable differences in canine wear. Diets were dominated by beetles (Coleoptera), which accounted for 30 to 40% of the identifiable food items. Younger bats included more beetles in their diet, although the difference was not statistically significant. The results suggest that older bats are still able to use their worn canines to effectively puncture hard exoskeleton, perhaps because of the angular shape of the worn teeth.

Key words: aging, canine wear, Chiroptera, insectivory, predation, senescence, teeth

Introduction

In many animals, foraging behavior changes as individuals age (e.g., Werner and Gilliam, 1984; Marchetti and Price, 1989; Yoerg, 1994). Among insectivorous bats, age-related shifts in both foraging habitat (Adams, 1996) and diet (Rolseth *et al*., 1994; Hamilton and Barclay, 1998) have been described, although these studies have focused on differences between young bats (i.e., one year old or less) and adults. Changes in foraging ecology may also occur as adult bats age.

Insectivorous bats have many morphological adaptations that allow them to capture and handle prey in flight and of these the teeth are crucial. Tooth shape greatly influences the force required to break up insects (Evans and Sanson, 1998). For example, insectivorous bats with sharp canines require less force to puncture exoskeletons at initial contact than individuals with blunted canines (Freeman and Weins, 1997). Therefore, tooth shape may limit bats to certain types of prey, as jaw structure does (Freeman, 1979). As bats age their teeth wear and this may influence the ability of older bats to consume certain prey, and be reflected in their diet.

For some species, such as the big brown bat (*Eptesicus fuscus*), beetles are important prey (Whitaker, 1995; Hamilton and Barclay, 1998). Beetles are relatively slow fliers and do not detect the echolocation calls of bats, thus making them easier to

capture than faster, more evasive prey. They also have relatively high levels of polyunsaturated fatty acids (PUFA — Schalk and Brigham, 1995). PUFA may be important with respect to the ability to use torpor (Frank, 1991; Geiser and Kenagy, 1993). If older bats with greater tooth wear are less able to eat beetles, there could be a direct link between foraging ability, use of torpor, and mortality. In other words, tooth wear might be a proximate mechanism for senescence in these bats.

The purpose of our study was to determine whether tooth wear influences the diet of *E. fuscus*. We predicted that if tooth wear reduces the ability to consume hard-bodied insects such as beetles, then older *E. fuscus* would include fewer beetles in their diet than younger individuals do. We specifically looked at canines because they are the primary tools for initiating food break-up, and producing and directing cracks in food items of bats (Freeman, 1992, 1998). Furthermore, canine wear is conspicuous and readily classified in the field using live bats.

Materials and Methods

We conducted field work during the summers of 1990 to 2001 at a single maternity colony in Medicine Hat, Alberta, Canada (50°02'N, 110°40'W). Each year we captured female *E. fuscus* in mistnets and recorded age (adult or juvenile), body mass, and reproductive condition. We banded individuals, including pups, on the forearm using plastic split-rings so that individuals could be recognized later. In addition, we evaluated wear of the upper canines using a tooth classification system devised for *E. fuscus* at our study site (Holroyd, 1993). Tooth class 1 corresponds to unworn, pointed canines. Tooth class 3 involves canines that are obviously rounded at the tips but not yet flattened, while tooth class 7 corresponds to the greatest amount of wear, involving canines with less than two-thirds of their original length (Fig. 1). We were able to assess general age categories (young versus old adults) of captured bats based on the tooth classes of known-aged individuals (i.e., those banded as pups — R. M. R. Barclay, unpublished data). Known-aged individuals with tooth class 3 were 2–3 years old (young adults; $n = 14$), while individuals with tooth class 7 were at least seven years old (old adults; $n = 9$).

We collected fecal samples from bats assigned tooth class 3 and 7 equally throughout the summer months and analyzed them according to the techniques of Whitaker (1988). We excluded bats with tooth classes 1 and 2 because most of these bats are subadults which have a diet different from that of adults (Hamilton and Barclay, 1998). We also excluded bats assigned tooth classes 4–6 to maximize the difference in tooth wear between the two age groups. We softened feces in 70% ethanol, teased them apart with dissecting needles and examined them under a dissecting microscope. We identified insect remains to order by direct comparisons with whole insects collected at the study site and by the use of reference guides (Whitaker, 1988; Shiel *et al*., 1997).

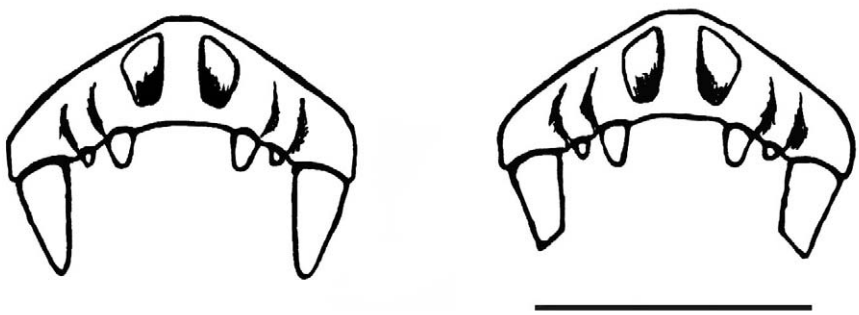

Fig. 1. Comparison of the canine teeth of an *Eptesicus fuscus* with tooth code 3 (left) and 7 (right). The drawing on the left was made from a live individual captured at the study site, while the drawing on the right was made from a skull deposited in the University of Calgary Museum of Zoology [UCMZ(M) 2002.001]. Bar equals 5 mm

To avoid bias, fecal samples were coded to conceal which age class each sample belonged to. For each pellet, we visually estimated the percent volumes of constituent prey (Whitaker, 1988). To compare the composition of prey types eaten by the two age groups, data from all the pellets of an individual were combined to produce an overall percent volume of each prey type for each bat. To determine whether older bats feed less on hard-bodied prey than younger bats, we compared the percent volumes of Coleoptera for the two age groups using a one-tailed Mann-Whitney test with $\alpha = 0.05$. A non-parametric test was necessary as the data were not normally distributed, even after transformation.

Results

We examined 10 pellets from each of 60 female big brown bats. Each age group was composed of 30 individuals and had a similar capture distribution from June through August. The diet was similar for the two groups (Table 1). The most abundant taxon in the diet was Coleoptera, comprising over a third of the volume. Trichopterans and lepidopterans were also important prey, each forming approximately 20% of the volume. Dipterans, hymenopterans, neuropterans, and hemipterans were less abundant. Mites (Arachnida: Acari), fur, mist-net material, and fibers from the cloth holding bags were other items found in fecal pellets, but were not included in analyses.

Table 1. Mean ± SE percent volume of the identifiable prey types in the diet of female *Eptesicus fuscus* with tooth codes 3 (young bats) and 7 (older bats). In each case the number of samples examined was equal to 30

Prey	% Volume	
	Young bats	Older bats
Coleoptera	38.8 ± 6.92	30.9 ± 6.50
Lepidoptera	15.7 ± 3.85	21.8 ± 5.40
Diptera	8.2 ± 1.81	5.2 ± 1.24
Trichoptera	19.6 ± 4.69	21.5 ± 5.57
Hymenoptera	5.5 ± 0.71	4.4 ± 0.62
Neuroptera	5.9 ± 0.78	5.4 ± 0.88
Hemiptera	6.2 ± 0.33	10.8 ± 1.48
Total	100.0	100.0

On average, younger bats consumed a greater quantity of beetles, although there was no significant difference between the two age groups (one-tailed Mann-Whitney test, $U = 406.5$, $d.f. = 59$, $P = 0.53$).

Discussion

In this study, coleopterans were the main prey in the diet of both young and old adult *E. fuscus*. Trichoptera and Lepidoptera were other important dietary items. This is consistent with previous studies on the diet of *E. fuscus* in Alberta (Brigham and Saunders, 1990; Hamilton and Barclay, 1998).

We hypothesized that differences in tooth wear would influence the chewing and prey-handling abilities of the two age classes, resulting in differential use of beetles. Although young bats consumed more beetles than older bats, the difference was not significant. This is surprising, considering that sharp canines are more efficient at initiating cracks in hard food items than are blunt canines (Freeman and Weins, 1997). However, canines of insectivorous bats have additional features that may aid in breaking up food items. The canines of *E. fuscus* have multiple sharp edges and are positioned so that there is a continuous sharp edge at the tooth-food interface (Freeman, 1992). Edged canines increase the likelihood of cracks forming in a solid (Freeman, 1998). In addition, the canines wear at an angle (Fig. 1) rather than simply rounding off, and this may allow older bats to puncture and crack beetle exoskeletons effectively. Similar maintenance of angularity occurs as the teeth of gorillas (*Gorilla gorilla*) wear (Unger and Williamson, 2000). Older *E. fuscus* may also be able to break-up hard exoskeletons by investing more energy or time in mastication. Another possibility is that *E. fuscus* may break up food with other teeth. Molars may have

the shape necessary to fracture food items (Strait, 1993; Evans and Sanson, 1998; Freeman, 1998) and may compensate for the inefficiency of blunt canines. This may increase handling time and energy investment, but could yield diets of similar composition. However, Hall (1957) found that the molars of *E. fuscus* wear faster than the canines. No matter what the wear patterns of *E. fuscus* teeth are, our data suggest that tooth wear does not significantly impair the ability of older bats to capture and ingest beetles. Indeed, as canines wear, gape effectively increases and this may allow capture of larger prey by older bats.

While edged canines may explain older bats' ability to penetrate beetle prey, blunt tips may still limit their ability to efficiently masticate and digest food. Excessive tooth wear is associated with production of larger food particles in some mammals (e.g., koalas *Phascolarctos cinereus* — Lanyon and Sanson, 1986; kangaroos *Macropus* spp. — McArthur and Sanson, 1988). Larger particles yield a decreased surface area for enzymatic breakdown and thus lower an animal's ability to obtain energy from food (McLeod and Minson, 1969; Kay and Sheine, 1979). Thus, tooth wear may influence the amount of energy available to insectivorous bats during the later stages in life. Further investigation comparing particle size of the diet between age classes in bats would support or nullify this hypothesis.

Acknowledgements

We are grateful to S. Holroyd, I. Hamilton, and L. Wilkinson for collecting fecal samples in the field. We thank D. MacKinnon and the Medicine Hat Public Board of Education for granting access to roost sites to conduct this study, and P. W. Freeman for suggesting pertinent literature. Valuable comments on earlier drafts of this paper were provided by D. Solick, L. Hollis, T. Luszcz, J. Wilson, M. Brigham and two anonymous reviewers. This study was supported by grants from the Natural Sciences and Engineering Research Council of Canada and the University of Calgary to R. M. R. Barclay.

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Received 03 October 2002, accepted 19 December 2002