The significance of winter activity by the big brown bat (Eptesicus fuscus): the influence of energy reserves

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I tested the hypothesis that big brown bats (Eptesicus fuscus) found active during winter months may be forced into activity because of reduced energy reserves. I compared the masses and fat reserves of big brown bats found active with inactive (torpid) bats at a hibernaculum, throughout the winter. Active bats were significantly lighter that those in the hibernaculum during the same period. Active bats had significantly lower fat reserves and lean dry mass than inactive individuals. The majority of bats found active were lighter than the predicted mass of bats leaving hibernation in April. The forearm length of active individuals was significantly shorter than inactive bats. Inactive individuals lost mass throughout the winter while there was no significant correlation between the mass of active bats and the date of capture. The data are consistent with the hypothesis that bats may become active at a critically low energy reserve, possibly to find food.

Materials and methods

During the winters of 1984–1985 and 1985–1986, I used an advertising campaign to solicit reports of bats found active in the Ottawa area. Eptesicus fuscus hibernates in buildings (Fenton 1983) and previous experience had shown that throughout the winter some individuals arouse and could be observed and captured while flying in buildings. All captured individuals were sexed, banded on the forearm with aluminum bands, and weighed to the nearest 0.1 g using an Ohaus electronic balance. Their forearm lengths were measured to the nearest millimetre using Scala vernier scale calipers.

Inactive (hibernating) bats were sampled at an abandoned mine in Renfrew County, Ontario (Fenton 1970) on 12 December 1984, 20 February and 20 March 1985, and 4 January, 2 February, and 9 March 1986. Each individual was weighed, measured, and banded in the same manner as the active bats except forearm measurements were not recorded on 20 March 1985. Once the measurements were taken, the bats were replaced in the mine. I avoided using data for the same individuals on successive sampling periods since the arousals induced by their capture could cause increased weight loss relative to undisturbed individuals.

I sacrificed and froze 18 inactive and 6 active bats to determine the fat content and lean dry weight of each animal (Millar 1981). The bats were thawed, weighed, and then dried at 70°C for 5 days and weighed again. The dry carcasses were ground in a Moulinex coffee grinder and the tissue extracted for 20 h in a Soxhlet extractor.

Results

I sampled 43 active E. fuscus (19 males and 24 females) between 8 November 1984 and 23 April 1985 (17) and between 23 October 1985 and 31 March 1986 (26). Seventeen of the 43 active bats came from the Loeb Building on the campus of Carleton University, Ottawa, Ontario. The other 26 individuals...
Fig. 1. Body mass versus date for E. fuscus. Triangles represent the mass of active bats caught in buildings in Ottawa. Circles represent the mass of inactive bats sampled at the Renfrew mine. The line represents the significant regression of mass versus sample date for inactive bats (see text).

were captured in various other buildings around Ottawa. A total of 116 inactive bats was sampled at the mine (75 males and 41 females).

Body mass did not differ significantly between 1984–1985 and 1985–1986 for active (ANOVA $F = 1.2$, $p > 0.05$) or inactive bats (ANOVA $F = 0.35$, $p > 0.05$). I therefore pooled the data for the two years. The mass of inactive E. fuscus sampled at the mine decreased over the winter ($Y = -0.034x + 22.2$, $r = 0.35$, $p < 0.01$; Fig. 1), but there was no significant correlation between the mass of active E. fuscus and the date of capture ($r = 0.03$, $p > 0.05$).

There was a limited overlap in the masses of active and inactive bats. Only six inactive individuals weighed less than 14.5 g, and of these only two were less than 14.0 g. In contrast, only 10 active bats weighed more than 14.0 g, and of these, only 5 had body masses greater than 14.5 g.

The masses of inactive bats sampled in the mine ($\bar{x} = 17.4 \pm (SE) 0.2$ g, $n = 116$) were significantly greater than the masses of active bats taken from buildings ($\bar{x} = 12.7 \pm 0.3$ g, $n = 43$; ANOVA $F = 159$, $p < 0.05$). The masses of inactive bats from the two March samples, when bats approached the end of the hibernation period ($\bar{x} = 16.3 \pm 0.2$ g, $n = 63$), were also significantly greater than those of active bats captured at any time throughout the winter (ANOVA $F = 97.8$, $p < 0.05$).

The fat content of inactive bats from the mine ($\bar{x} = 2.46 \pm 0.15$ g, $n = 18$) was significantly greater than the fat content of active bats ($\bar{x} = 0.63 \pm 0.20$ g, $n = 6$; $t = 6.27$, df = 22, $p < 0.05$). The fat-free dry weight of inactive bats ($4.45 \pm 0.07$ g) was also significantly greater than that of active individuals ($3.72 \pm 0.24$; $t = 3.97$, $p < 0.01$).

Fifteen of the 36 active bats brought into captivity subsequently died despite attempts to feed them. Ten of these individuals, weighed within 6 h of death, had a mean mass of $9.6 \pm 0.3$ g. This mass does not account for the water lost between death and weighing.

The forearm length of active E. fuscus was significantly shorter than that of inactive individuals ($\bar{x} = 45.6 \pm 0.2$ mm, $n = 43$ vs. $\bar{x} = 46.3 \pm 0.2$ mm, $n = 73$; ANOVA $F = 4.73$, $p = 0.03$).

The mass of active bats was scaled significantly with forearm length ($Y = 0.154x + 5.82$, $r = 0.30$, $p < 0.05$).

**Discussion**

I have shown that the mass of active bats is not related to the time of capture, the mass of active bats is significantly lower than inactive (hibernating) individuals, and the mass of inactive bats sampled in March, when their reserves should approach their lowest levels, is still significantly greater than that of active bats. These results are consistent with the predictions of the hypothesis that E. fuscus become active when they reach a critically low energy reserve. Figure 2 shows a regression of mass versus date for inactive bats from two of the most common classes of forearm length (45.6–46.5 mm and 46.6–47.5 mm).

From the regressions, I predict the mass of bats leaving hibernation during the month of April should be 16.3 g for the larger forearm class and 15.7 g for the smaller. Sixteen of the 18 active individuals of the same two forearm classes, some caught as early as November 20, weighed less than the mass predicted for bats leaving hibernation. This suggests that these bats selected hibernation sites in which they expended energy at a faster rate and that they reached critically low energy reserve levels prior to the “appropriate” time to terminate hibernation.

Fenton (1972) found that the average mass of E. fuscus entering hibernation in November was 21.6 g, similar to the mass I predict bats of average forearm classes should have (Fig. 2). Fenton found that the average mass of bats leaving hibernation in April was 16.4 g, which is also in the range predicted by the regressions.

My data suggest that the critical mass at which E. fuscus leave hibernation scales to forearm length. The regression predicts that the mass of active bats with a forearm of 42 mm should be
12.3 g and for individuals with a forearm of 48 mm should be 13.2 g. That the mass of active bats is lower than the predicted mass of bats arousing from hibernation may result from the energy expended (mass lost) during the time spent active, and (or) from bats prolonging arousal until energy reserves are considerably lower than those predicted for bats departing from hibernation sites in April.

Since I could not consistently determine whether bats were adults or juveniles, by using the degree of ossification or the shape of the epiphyseal joints (Racey 1974), I do not know if the proportion of juveniles in the active and inactive samples was the same. Ewing et al. (1970) showed that juveniles of three Myotis species had less fat when entering hibernation than adults, suggesting that juveniles would be more likely to reach a critically low energy reserve than adults. My finding that active individuals had significantly shorter forearms supports the hypothesis that the proportion of juveniles in the active sample was greater than in the inactive sample. I predict that for known age bats, inactive juveniles (1) should have lower energy reserves on average than adults, (2) should reach a critically low energy reserve before adults, but that the energy reserve levels of active bats should be in the same range as I found, regardless of age. The fact that I found almost equal numbers of active males and females suggests that winter activity and low energy reserves are not sex related.

My results could also be interpreted as support for the hypothesis that some buildings are not suitable as hibernation sites for E. fuscus. If this was the case, bats hibernating in buildings should suffer a high degree of mortality and quickly abandon these sites. However, the Loeb Building has been used as a hibernaculum for at least the past 10 years (M. B. Fenton, personal communication), which suggests some degree of suitability. Since the exact location of the hibernaculum in the building is unknown, I could not sample individuals who remained hibernating. If some building sites are suitable as hibernation sites for E. fuscus, I predict that inactive individuals found in buildings should not weigh significantly less than inactive bats in the mine at the same time, and that bats captured leaving the mine during the winter should be lighter than individuals remaining in hibernation.

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