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Distribution and Overwintering of *Myotis leibii* and *Eptesicus fuscus* (Chiroptera : Vespertilionidae) in Ontario

by M. Brock Fenton¹

In eastern North America, *Myotis leibii* (Audubon and Bachman) (= *M. subulatus*, Glass and Baker, 1968), the small-footed myotis, and *Eptesicus fuscus* (Palisot de Beauvois), the big brown bat, reach their northern limits of distribution in Ontario and Quebec. Both hibernate in caves and abandoned mines but are not common in these hibernacula. Data accumulated between December 1965 and April 1971 on distribution, sex ratios, selection of hibernation sites, and variation in weight during hibernation are presented and compared with similar data for other species, including *Myotis lucifugus*, *M. sodalis*, *M. keenii*, and *Lasiurus borealis*.

The locations of the following abandoned mines visited during the study are shown in Fig. 1: Alona Bay (5), Gowganda (6), Jackfish (3), Schreiber (2), Wawa (4) and Webbwood (7). Also in Fig. 1 is the location of the Cavern Lake Cave and the sites from which specimens of *M. leibii* (Δ) and *E. fuscus* ($\blacktriangle$) were reported by Peterson (1966). The Renfrew mine is located in Ontario at 45°22'N, 77°08'W, and the Bryson mine in Quebec at 45°45'N, 76°45'W.

Materials and Methods—In winter bats were obtained by hand from hibernation sites, while in summer they were caught in hand nets and mist nets as they flew through

hibernacula. Upon capture, bats were identified with respect to sex, species and, where possible, age, and banded using Number 2 Bat Bands supplied by the U.S. Fish and Wildlife Service. Bats were weighed alive to the nearest 0.1 g using an Ohaus triple beam balance with an attached cage (Ohaus Scale Corp., Florham Park, N.J.). Temperatures were obtained with Taylor (Taylor Instruments of Canada, Toronto, Ontario) and Sci-Bor (Science Borealis Ltd., Mississauga, Ontario) maximum-minimum thermometers, Bacharach Tempscribe thermographs (Bacharach Industrial Instrument Co., Pittsburgh, Pa.), and a Y.S.I. telethermometer (Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio). Student-Fisher *t*-tests least squares regression analyses and *F* tests for linearity were applied to the weight data using an Olivetti Programma 101 (Olivetti-Underwood Corp., New York, N.Y.).

Distribution—Peterson (1966) reported a specimen of *M. leibii* taken in Lake Superior Provincial Park on the east shore of Lake Superior on 21 September 1964 (Fig. 1) and noted that the locality was some 325 miles northwest of the previous known limit of the range. The following data were obtained during investigations of summer "swarming" activity of bats at hibernacula (Fenton, 1969).

At an abandoned mine near Webbwood, five male and four female *M. leibii* were caught on the nights of 3-4 and 4-5 August 1968 (Fig. 1), and at a similar site near

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Figure 1
Distribution of the known occurrences of *Myotis leibii* and *Eptesicus fuscus* in northern Ontario relative to the -18°C mean minimum January isotherm (from Chapman and Thomas, 1968). Collecting localities for specimens of *E. fuscus* from Peterson (1966) are indicated by ▲, that of *M. leibii* (Lake Superior Provincial Park) by △. Hibernacula known for northern Ontario are indicated by □ and numbered according to the following code: 1, Cavern Lake cave; 2, Schreiber mine; 3, Jackfish mine; 4, Wawa mine; 5, Alona Bay mine; 6, Gowganda mine; and 7, Webbwood mine. The distribution of the -18°C mean minimum January isotherm is shown only for Ontario.

Alona Bay, two adult males of this species were caught on the night of 5-6 August 1968. Between 6 and 12 August, this species was not encountered at abandoned mines near Wawa, Jackfish, Schreiber, or Gowganda (Fig. 1). One torpid *M. leibii* was observed at the mine near Alona Bay on 22 November 1968, but in January 1967 none was found at the mines near Webbwood, Alona Bay, Wawa, Jackfish, Schreiber, or Gowganda. (Minimum outside temperatures at the last five localities ranged from -26° to -40°C ; Mr. B. Yorke, personal communication.) Environmental conditions in these mines were suitable for hibernation, as witnessed by the presence of torpid *M. lucifugus* and *M. keenii* throughout the winter. As two of the nine *M. leibii* taken at Webbwood in August 1968 were young of the year, the species must breed in that area.

Eptesicus fuscus was reported by Allin (1942) from Cavern Lake Cave (Fig. 1) on 22 November 1941, but I did not find bats of this species hibernating in any of the northern Ontario hibernacula. At Webbwood, two male *E. fuscus* were caught on

the night of 4-5 August 1968, while one male and one female young of the year were taken at Alona Bay mine on the night of 5-6 August 1968. Skeletal remains (ROM 43625), including the skull, of one *E. fuscus* were found on the floor of the Jackfish mine on 2 October 1967. The presence of young of the year of *E. fuscus* at the Alona Bay site suggests that the species breeds in that area.

On 23 February 1972, B. Trevor-Deutsch and G. Muller found three torpid *E. fuscus* at the Cavern Lake Cave, and a day later, one torpid *E. fuscus* at the Schreiber mine. These represent the first *E. fuscus* observed from the north shore of Lake Superior in mid-winter.

Myotis leibii and *E. fuscus* were found in hibernacula near Alona Bay and Webbwood during August, but the former species has not been taken in other hibernacula in northern Ontario in January, suggesting that *M. leibii* may migrate south to overwinter. Since *E. fuscus* has not been consistently recorded from northern hibernacula in mid-winter, some individuals of this species might also migrate south for the winter. Such an ex-

planation would account for the absence of females and young of *M. leibii* at Alona Bay, as pregnant females might be able to fly only limited distances from hibernacula to summer roosts that are suitable for parturition and rearing of young. *Eptesicus fuscus*, however, has a greater flight speed than some *Myotis* sp. (Patterson and Hardin, 1969) and may have greater powers of dispersal enabling pregnant females to fly farther north in time to give birth and to rear their young.

Myotis leibii is not known to occur north of the -18°C mean minimum January isotherm (Fig. 1) as drawn by Chapman and Thomas (1968). Peterson (1966) reported several specimens of *E. fuscus* from localities north of this January isotherm; his records are consistent with the suggested powers of dispersal of this species and may also reflect a greater flexibility of roosting habits relative to *M. leibii*. The presence of *M. leibii* and *E. fuscus* adjacent to Lake Superior could be attributed to the warming effect of the lake (Chapman and Thomas, 1968).

Sex Ratios—Percentages of males in wintering populations of *M. leibii* and *E. fuscus* are compared with data from other studies (Table 1). Results obtained here agree with those published elsewhere (Mohr, 1936; Rysgaard, 1942; Hitchcock, 1965; and Phillips, 1966). Male and female *M. leibii* were

encountered in almost equal numbers, but male *E. fuscus* were more numerous than females (Table 1). The incidence of male *E. fuscus* in clusters (87%) was greater than that for isolated individuals (53%) as reported by Phillips (1966) for this species and also for *M. lucifugus* (Fenton, 1970).

Hibernation Sites—Martin *et al.* (1966) reported the occurrence of torpid *M. leibii* and *E. fuscus* under rocks on the floor of mine passages in Clinton County, New York, and reviewed the few, similar reports for North America. Although large numbers of *M. daubentonii* hibernate under rocks in hibernacula in Europe (Roer and Egsbaek, 1966), reports of bats hibernating under rocks in North America have involved only small numbers.

Thirty torpid *E. fuscus*, representing part of a group of undetermined size, were found in a pile of loose rock at the bottom of a stope in the mine near Bryson, Quebec, on 22 March 1968. In an area where the ambient temperature was 3°C , bats were distributed throughout the loose rock and aggregated in small groups of two or three. These bats were still hibernating in the loose rock on 23 April 1968 when the temperature had risen to 4°C .

Allen (1962, p. 268), when referring to the habit of *M. leibii* of hibernating in crevices, suggested that "Perhaps their very

TABLE 1. Percentages of male *Myotis leibii* and *Eptesicus fuscus* at eight hibernacula (sample size in parentheses)

	November	December	January	February	March	April	$\bar{X}$
<i>Myotis leibii</i>							
Renfrew mine, Ontario							
1966-1967	—	45 (9)	42 (12)	80 (10)	60 (10)	—	57 (41)
1967-1968	47 (17)	—	83 (23)	45 (13)	45 (22)	—	50 (75)
Bonnechere cave, Ontario*							53 (728)
Eldorado mine, Ontario*							37 (51)
<i>Eptesicus fuscus</i>							
Renfrew mine, Ontario							
1966-1967	50 (6)	43 (14)	60 (20)	60 (20)	67 (21)	20 (5)	56 (86)
Bryson mine, Quebec	70 (62)	—	—	—	65 (269)	92 (79)	72 (410)
Wakefield cave, Quebec*							75 (94)
Bonnechere cave, Ontario*							74 (491)
Leavenworth mine, Kansas†							64 (475)

*Hitchcock, 1965.

†Phillips, 1966.

Figure 2
Temperatures at which *Eptesicus fuscus* (A), *Myotis leibii* (B), and *Myotis lucifugus* (C) were found in torpor. N = number of occurrences, with the number of bats shown in parentheses.

much smaller and more delicate feet may be correlated with this habit." Martin *et al.* (1966), however, disagreed with Allen and suggested that the floor of a cave or mine might be a cooler, more stable thermal zone for hibernation than walls or ceilings. Their suggestion is substantiated by my findings at Bryson, for during the time that the temperature changed from 3° to 4°C in the area occupied by the *E. fuscus*, temperatures rose from 6° to 8°C in an adjacent area harbouring torpid *M. lucifugus*.

Both these bats select cool sites for hibernation (Mohr, 1936; Rysgaard, 1942; Hitchcock, 1949; and Hall, 1962). The temperature ranges over which torpid *M. leibii*, *E. fuscus*, and *M. lucifugus* were found are shown in Fig. 2. *Myotis leibii* and *E. fuscus*

tolerate colder temperatures (−9°C) than do *M. lucifugus* (−4°C) without arousing from torpor. My observations in the hibernacula indicated that temperatures below these levels stimulated arousal from torpor.

Data given here for arousal of bats from torpor at subfreezing temperatures (*viz.* at −9°C for *M. leibii* and *E. fuscus* and −4°C for *M. lucifugus*) are similar to those obtained by Davis and Reite (1967) for *M. lucifugus*. Metabolic compensation by torpid *M. lucifugus* exposed to subfreezing temperatures may be energetically less expensive than arousal (Davis, 1970), but only to a certain temperature (−4°C). The ability to remain torpid at subfreezing temperatures (not a uniform trait in the sample studied by Davis and Reite, 1967) might be more com-

mon in those *M. lucifugus* that hibernate in colder parts of the range of this species.

Data given here for *E. fuscus* (Fig. 2) differ from published information indicating that bats of this species arouse from torpor at subfreezing temperatures and remain active until the ambient temperature increases (Davis and Reite, 1967). Davis (1970) discussed the adaptive value of arousal under these conditions. He also noted that data conflict with results of Swanson and Evans (1936) indicating (as do those of Goehring, 1971) that *E. fuscus* remain torpid at subfreezing temperatures. Seasonal variation in the ability to arouse from torpor at lower temperatures (Menaker, 1962; Smalley and Dryer, 1963) could account for these discrepancies (Davis, 1970).

At subfreezing temperatures *M. leibii* and *E. fuscus* may become supercooled (see Davis and Reite, 1967; Davis, 1970), a physiological state that may be energetically less costly than metabolic compensation, *sensu* Davis (1970). Davis and Reite (1967) suggested that supercooling was a transient condition. Lyman (1970), however, interpreted their data to indicate that supercooled bats only arouse when exposed to an abrupt or gradual increase in temperature; a decrease in temperature would not effect arousal according to Lyman (1970). As *M. lucifugus*, *M. leibii*, and *E. fuscus* in Ontario aroused when ambient temperatures dropped below their respective thresholds of tolerance, either these bats were not in a supercooled condition or previous suggestions concerning supercooling need verification.

Myotis leibii and *E. fuscus* enter hibernacula late in autumn and are always the first to depart in spring (late November to early April at the Renfrew mine). During warm periods in winter, when temperatures at their hibernation sites rise above 4°C, bats of these two species may arouse and depart from caves and mines to occupy other hibernation sites as yet unknown. This suggestion is supported by the presence of torpid *E. fuscus* at the mine near Bryson in May when surface temperatures were above freezing. Here bats hibernated deep in the mine (500 to 600 feet below ground level) in passages containing considerable ice and with ambient temperatures below 4°C and were not

exposed to warmer temperatures and thus did not arouse from torpor. These data for *M. leibii* and *E. fuscus* support the hypothesis of Martin *et al.* (1966) concerning the selection of cool, thermally stable areas for hibernation.

The number of species composing clusters of torpid bats provides a further indication of species-specific tolerances to temperatures suitable for hibernation. I commonly observed *M. leibii* hibernating in physical contact with *E. fuscus*, usually in small clusters (less than five bats). I also found that *E. fuscus* hibernated in physical contact with *M. lucifugus*, and once I found one *E. fuscus* in the centre of a cluster of torpid *M. sodalis* (Fenton, 1966). Torpid *M. leibii* were never seen close to or in physical contact with *M. lucifugus* or *M. sodalis*. These observations indicate that *E. fuscus* may tolerate a broader range of temperatures during hibernation than do *M. lucifugus* or *M. leibii*.

The absence of *M. leibii* and *E. fuscus*, the species most tolerant of low temperatures, from northern hibernacula is noteworthy. Several bats known to hibernate in exposed situations may withstand subfreezing temperatures (e.g., *Lasiurus borealis* to -26°C; Davis, 1970) and yet apparently do not hibernate in regions of their ranges with the coldest winter temperatures.

Changes in Weight during Hibernation—Changes in body weight of *M. leibii* during the winters of 1966–1967 and 1967–1968 at the Renfrew mine are shown in Fig. 3. Weights of male and female *M. leibii* taken from hibernation in December 1966 averaged 5.6 g, but by April 1967 the mean weight had decreased to 4.7 g, representing a weight loss of 0.9 g (16%). Body weights of males were not significantly different from those of females. An *F* test for linearity indicated that a least squares regression analysis between time and change in weight was not significant.

Weights of male and female *E. fuscus* that were torpid in November 1966 at the Renfrew mine averaged 21.6 g, but 157 days later in April 1967, the mean weight was 16.4 g. During the winter 5.2 g (24%) of the November weight were lost. Weights of females were significantly greater than those

Figure 3

Changes in weight of *Myotis leibii* hibernating in the Renfrew mine during the winters of 1966-1967 and 1967-1968 as shown by Dice-Leraas diagrams. Males and females are combined in each sample. Sample size is given below or above the diagrams.

of males ($p = 0.05$); moreover, females lost weight at a slower rate. The relationship between time and change in weight was linear ($p = 0.05$). These data are similar to those of Beer and Richards (1956) for *E. fuscus*, as shown by a comparison of the regression lines from the two studies:

Beer and Richards (1956)

Males $y = 20.59 - 0.0385x$

Females $y = 21.49 - 0.0300x$

This Study

Males $y = 20.46 - 0.04x$

Females $y = 22.07 - 0.03x$

The amount of weight lost during hibernation relative to the initial weight before hibernation was similar in *E. fuscus* (24%) and *M. lucifugus* (25%; Fenton, 1970), but the rate of weight loss was slower and the duration of hibernation longer in the latter. Loss of weight in *M. leibii* was proportionally less than in *M. lucifugus* and *E. fuscus*.

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Summary—*Myotis leibii* (= *M. subulatus*) and *Eptesicus fuscus* occur along the north shore of Lake Huron and the east shore of Lake Superior in summer but are absent from these areas in winter. In hibernating populations of *M. leibii*, males and females are almost equally numerous, whereas males predominate in hibernating populations of *E. fuscus*. Within hibernacula, both bats were found torpid between -9° and 4°C . Large numbers of *E. fuscus* hibernated in loose rock on the floor of a mine passage in Quebec. Both species lost weight continuously during the winter. *E. fuscus* males weighed significantly less than females throughout the hibernation period and lost weight at a faster rate.

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