

Notes on Occurrence and Reproduction of Bats In Indiana

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Abstract

A total of 1,907 bats from Indiana was examined, of which over half were big brown bats, *Eptesicus fuscus*, a species which was found to be somewhat active all winter. Most other species were found primarily during April through October. Some *Lasiurus cinereus* appear to hibernate in Indiana. Reproductive information for *Pipistrellus subflavus* and *Eptesicus fuscus* is presented. Most *Eptesicus* had two embryos. Parturition in this species occurs around June 1 in Indiana. Testis size in *Eptesicus* was greatest in August, but at least some individuals appear capable of breeding much of the year. *Lasiurus borealis* produced young about mid-June; juvenile red bats tend to leave their mothers when about 80 millimeters total length and they weigh about 4 to 6 grams. A number of new county distribution records are included in this paper.

Introduction

This paper presents information on seasonal occurrence, reproduction and growth, and distribution for 10 of the 12 species of bats recorded from Indiana (Table 1). These data were collected mostly from 1963 to 1971 during our investigations of Indiana mammals (11, 12, 14, 15, 21). The bats examined were obtained from several sources. Some were shot about wooded or water areas or collected from buildings and caves. Many were collected by citizens of various areas and submitted

TABLE 1. Bats taken, by month, in Indiana during present study.

Species	Month												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
<i>Eptesicus fuscus</i>	34	32	47	73	98	99	265	271	78	44	48	37	1,126
<i>Lasionycteris noctivagans</i>	0	0	0	0	2	2	0	0	3	5	0	0	12
<i>Lasiurus borealis</i>	0	0	0	8	20	98	154	130	35	11	1	0	457
<i>Lasiurus cinereus</i>	1	0	0	1	12	8	18	3	1	2	0	1	47
<i>Myotis austroriparius</i>	0	0	0	0	0	0	0	4	1	0	0	1	6
<i>Myotis keenii</i>	0	0	0	1	1	3	1	5	4	0	2	0	17
<i>Myotis lucifugus</i>	0	0	1	3	8	5	13	51	24	3	3	4	115
<i>Myotis sodalis</i>	0	1	0	4	4	2	4	7	9	4	3	0	38
<i>Nycticeius humeralis</i>	0	0	0	0	3	4	1	3	1	2	1	0	19
<i>Pipistrellus subflavus</i>	0	1	0	2	9	12	8	21	11	1	5	0	70
Total													1,907

to the Indiana Department of Health for rabies examination. We thank Jerry D. Brown for some of the *Eptesicus fuscus* testis measurements.

Results

A total of 1,907 bats from Indiana was examined during the present study (Table 1). More than half (1,126) were big brown bats, *Eptesicus fuscus*, which might indicate this as the most common bat in the state. However, since *Eptesicus* is active during the winter, while *Lasiurus borealis* is not, the months May to September were used for comparison. During those months 811 big brown bats and 437 red bats were taken. Since *Eptesicus* is the common bat in buildings, perhaps citizens are more apt to encounter it than other species. Also, the total for *Eptesicus* is inflated by a few collections of numbers of bats from buildings, 133 from Madison during rabies studies (22) and several other smaller collections. Red bats are solitary and cannot be collected by such methods. We can conclude that these are the two most common bats in Indiana.

Next in abundance would appear to be *Myotis lucifugus* and *Pipistrellus subflavus*. It was surprising to take 47 of the relatively uncommon hoary bats, *Lasiurus cinereus*, most from April to October, but one each in December and January. Perhaps these latter individuals were hibernating in Indiana (20), although this species presumably migrates south for the winter. There are also isolated reports from Indiana and other states that suggest that red bats also may hibernate at this latitude (5).

Except for *Eptesicus* and the two *Lasiurus cinereus*, most bats were taken during the months April through October, except for a few *Myotis* and *Pipistrellus* found in hibernation in caves. It is evident (Table 1) that there is much winter activity in *Eptesicus*, a hibernating species. Many of those taken were active at the time of capture, or were obviously recently active (found in a place where they would have been noticed). It is not known where the majority of the big brown bats spend the winter. Certainly, the large summer population in Indiana cannot be accounted for by the relatively small numbers that hibernate in Indiana caves, and banding records do not yet indicate long-range fall migrations. A group of 17 big brown bats found March 26, 1969, in a barn in Vigo County, was thought to have still been in winter quarters since the bats were torpid, there was no food in their stomachs or intestines, and they were wedged so tightly into tiny crevices that their skins were torn and myobiid mites on their abdomens were crushed when the bats were removed. Seven of the bats were found singly, but groups of 2, 3, and 5 were present. Six of the singles were female; the group of two consisted of two males, and the other groups each contained one male. Examination of the crevices on January 21, 1972, turned up no bats, hence the bats found earlier likely entered the barn after leaving their winter quarters.

The records of *Lasionycteris* are of interest. The previous late spring record for this migrant was May 28 (14), but we have two individuals taken June 1 and June 10 from Lake County.

Reproduction

There is but a single breeding record of *Myotis sodalis* for Indiana (13), but our additional June and July records further substantiate the conclusion that the species breeds there. There is little information on *Pipistrellus* breeding in Indiana. Eight gravid females were shot over a pond in Vigo County and appear to have been the small colony of bats using a nearby barn. The colony disappeared at the time these were shot. Embryos ranged from 11 to 21 mm crown-rump length (avg. 14.3 mm). Six females contained two embryos each; two had one. An additional female, shot in Vigo County on June 30, had recently given birth, as had a female taken July 10 in Jefferson County.

Ovulation in *Eptesicus* occurs about the first week in April in Maryland, and sperms are present in the female genital tract at this time (1); birth occurs about June 1, giving a gestation of about 2 months. Eastern United States populations have two young per litter and western populations one (4, 6, 7). In 1971, three collections of big brown bats were made from a breeding colony in Putnamville, Putnam County, Indiana. On April 14, 7 of 14 females contained no visible embryos; one female appeared to have one tiny embryo; 6 females appeared to have two tiny embryos each (counts based on uterine swellings). Each of 30 females taken May 14 was pregnant. Three each had one embryo; 27 each had two embryos. Embryos averaged 10.7 mm crown-rump length and varied from 4 to 16 mm. Each of 15 females taken May 24 was gravid; two had one embryo each and 13 had two. The average crown-rump length of embryos was 17.3, with a range of 13 to 21 mm. In addition, two females from a Vigo County barn taken April 3, 1963, contained two tiny embryos. Our latest records of embryos in this species are June 1 and 2 (Vigo County) and June 4 (Allen County). The first young of the year appeared in our sample in June. The smallest one, taken June 11, weighed 7.8 g, measured 60 mm in total length, and had a forearm length of 20 mm.

Copulation in *Eptesicus fuscus* occurs primarily in autumn, but may occur also during the winter (7, 16). Copulation of big brown bats has been reported in Indiana caves on November 23, January 8, February 7, and March 12 (10). Phillips (16) found sperm in the reproductive tracts of four of five females taken October 18, in each of four females taken October 29, and in four of five females taken in February and March, in northeastern Kansas. We examined five big brown bats (2 males; 3 females) taken March 26 in Vigo County. The males had living sperm in the epididymus; two of the females had living sperm in their uteri.

Testis size has been found to be greatest in August, but regression occurred by the time of autumn copulation (4, 16). Testes size was tabulated, by month, for Indiana *Eptesicus* (Table 2). In August and September the highest percentage of males in the sample had testes more than 5 mm long and testes size averaged greatest in those months. This indicates that the largest amount of breeding activity takes place in August and September, but judging from testis size males may be capable of breeding much of the year.

TABLE 2. *Testes measurements in mm, by month, of male Eptesicus fuscus and Lasiurus borealis, Indiana.*

	Number	No. with Testis ≥ 5	% with Testis ≥ 5	Avg. Testis Length	Avg. Testis Width
<i>Eptesicus fuscus</i>					
Jan.	13	7	53.8	4.42	2.19
Feb.	14	8	50.0	4.81	2.56
Mar.	15	9	60.0	5.37	2.40
Apr.	22	12	54.5	4.76	2.11
May	29	12	41.4	4.77	2.41
June	24	17	70.8	5.37	2.55
July	54	41	75.9	5.87	3.04
Aug.	117	98	83.8	6.88	3.72
Sept.	32	31	96.9	7.06	3.75
Oct.	14	7	50.0	4.43	2.68
Nov.	18	11	61.1	5.48	2.53
Dec.	14	8	57.1	5.04	2.39
<i>Lasiurus borealis</i>					
Apr.	2			3.50	2.50
May	3			3.30	1.50
June	4			4.13	2.25
July	22			4.43	2.55
Aug.	13			4.99	3.15
Sept.	9			5.06	2.89
Oct.	2			3.00	2.00
Nov.	1			4.00	2.00

Few red bats were taken that could be classed as adult males. From April through June, before young males entered the population, only 11 of 56 (19.6%) adult red bats were males. A similar sex distribution has been found in Kansas (3, 8).

Of 13 gravid female red bats examined, 2 each had 2 embryos, 7 had 3, 2 had 4, 1 had 5, and 1 had embryos destroyed by shot. An average of 3.2 embryos among 44 pregnant females has been reported (1). The earliest embryos found by us were in a female collected April 30; she contained 4 measuring 1.8 mm in diameter. The latest date was June 19 (3 embryos 10 mm crown-rump length). Crown-rump measurements were made on other embryos as follows: May 9 (10 mm); May 17 (10 mm); May 21 (9 mm); May 26 (6 mm); May 26 (12 mm); May 26 (10 mm); May 31 (12 mm); June 5 (15 mm); June 14 (22 mm). The three embryos found June 14 were probably near term; the eyes were visible as dark spots and the milk teeth had erupted. Standard measurements of these young were total length 44, 44, 41 mm; tail length 15, 12, 12 mm; hind foot length 6, 6, 6 mm. The one male had testes 1 by 1.5 mm. Young taken with adult females on June 6, 14 and 17 were of

similar size and were possibly newborn. Hamilton (6) stated that young were born about mid-June, while in Kansas and southern Illinois (8, 9) parturition occurs in late May and early June. A female taken April 19 appeared to have given birth, judging from the expanded and flaccid condition of the uterus. This would seem to be an unusually early date. Another female taken May 3 had four placental scars. Twenty females that had given birth were collected between June 20 and July 20. It appears that most females give birth about mid-June in Indiana.

The largest young taken with a female (3 young, July 14) measured 79, 79, and 81 mm in total length and weighed 6.4, 7.4 and 7.6 g. Young only slightly smaller were taken with four other females on June 20, June 23 and two on July 1. One young, taken with a female on June 15, weighed 4.4 g. and was 64 mm total length (Table 3). The stomach of this young contained 60 chironomid and 40% Coleoptera remains. Two other large young taken with females had traces of vegetation and milk in their stomachs.

TABLE 3. *Size variation in young red bats taken with females in Indiana.*

Date Found	No. Juv.	No. Females	Total Length (mm)	Tail Length (mm)	Hind Foot (mm)	Weight (g)	Forearm (mm)
June 15	4	1	63-65	20-21	6-6.5	4.2-4.4	
June 20-23	16	5	50-77	14-29	6-8	2.2-7.5	24-36 ¹
June 30-July	12	3	44-77	13-29	5-8	3.6-5.0 ²	17-34
July 14	3	1	79-81	29.32	6-7	6.4-7.6	31-36

¹Forearm data not available on smallest two litters.

²Smallest not weighed.

The 29 juvenile red bats less than 80 mm in total length and taken without accompanying females are of interest. We do not know whether some of this sample had been weaned, but suspect that most (or all) had merely become separated from their mothers. All of the above young were collected in late June and July (July 31 the latest) and all that had any food in their stomachs contained milk; two of them (with forearms of 31 and 27 mm) contained parts of ants and other insects in their intestines. Three large young found on June 30 had milk in their stomachs and intestines; the largest of this trio measured 91 mm in total length, had a forearm of 38 mm, and weighed 7.5 g. Judging from the growth rate of other young examined, this litter must have been born in early May. Two lone immatures taken July 28 and August 11 contained only insect remains, thus were evidently independent of their mothers. These bats had total lengths of 85 and 86 and forearms of 36 and 39 mm, respectively. It would appear that juvenile red bats tend to become independent of their mothers when about 80 mm in total length and weighing from 4 to 6 gm.

None of 25 adult female red bats shot in June and July during our study were carrying young. Despite various records (6, 7) of females

carrying their young on foraging flights, we do not feel that this occurs regularly. Females with attached young may be frightened from their roosts, thus fly off carrying the young (if the young are not too large) or be forced to the ground by the weight of large, attached young. More data are required on this.

Hamilton (6) collected female red bats with quantities of sperm in their uteri the first week in August and stated that the species mates in August, while other authors (1, 7) thought mating probably takes place in August and September. Males taken in Indiana have the largest testes in August and September (Table 2) and although testes size alone is not necessarily proof of reproductive ability, it does suggest that this is the season of mating.

Female hoary bats with two young each were taken May 23 (Johnson County) and June 19 (Vigo County). The May young had total lengths of 79 and 80, forearm lengths of 36 and 37, and one weighed 7.1 g. Comparable data for the young taken June 19 were total lengths 100, 102; forearm lengths 42, 44; and weights 13.2 and 13.1 g. A lactating female captured May 28 gave birth to two young that day. Whether this was normal parturition is unknown, but there are numerous instances in the literature of births shortly after capture, some of which may be cases of induced abortion brought on by conditions of captivity. Caution should be used in considering such cases as parturition dates. Young are probably born in Indiana in late May or early June. Two small adult females (total length 105, 107, forearm 51, 52) taken in late May, but showing no evidence of reproductive activity, suggest, on very limited data, that females might not breed their first year.

Three evening bats each with two embryos were examined, one taken May 20 in Monroe County, one May 26 from Tippecanoe County, and one June 27 from Marshall County.

Distribution records

New county distribution records for bats in Indiana follow:

Myotis lucifugus: Clinton, Gibson, Hancock, Howard, Madison, Tipton, Union and Vanderburgh.

M. keenii: Johnson, Vanderburgh.

M. sodalis: Dubois, Hancock, Hendricks, Jefferson, Johnson, Marion, Morgan, Vanderburgh.

Lasionycteris noctivagans: Hendricks, Howard, Lake, Vanderburgh

Pipistrellus subflavus: Gibson, Johnson, Morgan, Spencer, Vanderburgh, and Wells. (The latter represents the most northern locality in Indiana where the pipistrelle has been recorded and is some 80 miles north of Wayne County, the closest previously known station. This was the only individual taken north of Marion County.)

Eptesicus fuscus: Bartholomew, Clark, Floyd, Hancock, Hendricks, Howard, Jasper, Knox, Lake, Martin, Miami, Morgan, Newton, Starke, and Sullivan.

Lasiurus borealis: Adams, Bartholomew, Brown, Gibson, Greene, Hancock, Hendricks, Jasper, Johnson, Madison, Noble, Rush, Shelby, Sullivan, Vanderburgh, and White.

L. cinereus: Clay, Elkhart, Johnson, Morgan.

Nycticeius humeralis: Carroll, Clinton, Gibson, Jefferson, Johnson, Marshall, Monroe, and Vanderburgh.

Discussion

It is apparent that winter bat activity occurs in Indiana during the period when we generally assume that bats (especially *Eptesicus fuscus*, various species of *Myotis*, and *Pipistrellus subflavus*) are hibernating. Whether such activity is usual requires more investigation; it would seem that much of it, in the case of *Eptesicus* particularly, is normal. Urine in the bladder may cause bats to wake periodically (19). While the need for water may be responsible for winter movements (16), Rysgaard (17) felt that some food was necessary in winter, for he found chitin in the mouths of some bats; he also found that *Eptesicus fuscus* drank water in winter. Other authors also feel that winter activity is for feeding (1, 18). In Indiana, winter movement appears not to be related to feeding, based on stomach analyses of winter-taken specimens (Whitaker, unpublished data). Big brown bats have been kept for six months at 4.5°C without food with no ill effects (2).

Delayed fertilization is presumably advantageous to bats, allowing them to mate in the fall when they are in good condition with plenty of food, thus avoiding an excess use of energy during early spring when energy may be at a premium. This advantage would seem to be negated, at least in part, if bats mate in winter, as appears to be the case in *Eptesicus fuscus* (10) and in *Myotis lucifugus* (23). Additional winter activity would further drain this energy and would seem to be strongly selected against, if energy is at a premium. It may well be that bats are physiologically adapted so that they can easily survive the winter on stored fat with energy to spare. Possibly, winter activity facilitates mating, ensuring that a high percentage of females become pregnant. This would be an advantage since the reproductive potential of bats is low (one litter per year and one to two young per litter in most species). Delayed fertilization may have evolved along with winter mating, allowing young to be born at the optimum time. Delayed fertilization might also be a mechanism by which bats take advantage of chance matings over extended periods of time.

It also appears that *Lasiurus cinereus* and *Lasiurus borealis*, both considered migrant species that leave the latitude of Indiana in winter, may actually remain in winter. Possibly the portion of the total population that behave in this fashion is small, but we need further data. The fact that *Lasiurus borealis* will appear and fly about during periodic warm periods in mid-winter in Indiana indicates that these animals probably were nearby.

Literature Cited

1. BARBOUR, R. W., and W. B. DAVIS. 1969. Bats of America. Univ. Ky. Press, Lexington. 286 p.
2. BEER, J. R., and A. G. RICHARDS. 1956. Hibernation of the big brown bat. J. Mammal. 37:31-41.
3. BIRNEY, E. C., and J. D. RISING. 1967. Notes on distribution and reproduction of some bats in Kansas, with remarks on incidence of rabies. Trans. Kans. Acad. Sci. 70:519-524.
4. CHRISTIAN, J. J. 1956. The natural history of a summer aggregation of the big brown bat, *Eptesicus fuscus fuscus*. Amer. Midland Natur. 55:66-95.
5. DAVIS, W. H., and W. Z. LIDICKER. 1956. Winter range of the red bat, *Lasiurus borealis*. J. Mammal. 37:280-281.
6. HAMILTON, W. J., JR. 1943. The mammals of eastern United States. Comstock Publ. Co., Ithaca, N.Y. 432 p.
7. JACKSON, H. H. T. 1961. Mammals of Wisconsin. Univ. Wisc. Press., Madison. 504 p.
8. JONES, J. K., JR., E. D. FLEHARTY, and P. B. DUNNIGAN. 1967. The distributional status of bats in Kansas. Misc. Publ. Mus. Natur. Hist. Univ. Kans. 46:1-33.
9. LAYNE, J. N. 1958. Notes on mammals of Southern Illinois. Amer. Midland Natur. 60:219-254.
10. MUMFORD, R. E. 1958. Population turnover in wintering bats in Indiana. J. Mammal. 39:253-261.
11. ————. 1967. The hoary bat in Indiana. Proc. Indiana Acad. Sci. 78:497-501.
12. ————. 1969. Distribution of the mammals of Indiana. Indiana Acad. Sci. Monogr. 1. 114 p.
13. ————, and L. L. CALVERT. 1960 *Myotis sodalis* evidently breeding in Indiana. J. Mammal 39:586-587.
14. ————, and J. B. COPE. 1958 Summer records of *Myotis sodalis* in Indiana. J. Mammal 39:586-587.
15. ————. 1964. Distribution and status of the Chiroptera of Indiana. Amer. Midland Natur. 72:473-489.
16. PHILLIPS, G. L. 1966. Ecology of the big brown bat (Chiroptera: Vespertilionidae) in northeastern Kansas. Amer. Midland Natur. 75:168-198.
17. RYSGAARD, G. N. 1942. A study of the cave bats of Minnesota with special reference to the large brown bat, *Eptesicus fuscus fuscus* (Beauvois). Amer. Midland Natur. 28:245-267.
18. SWANSON, G., and C. EVANS. 1936. The hibernation of certain bats in southern Minnesota. J. Mammal. 17:39-43.
19. TWENTE, J. W., JR. 1955. Some aspects of habitat selection and other behavior of cavern dwelling bats. Ecology 36:706-732.
20. WHITAKER, J. O., JR. 1967. Hoary bat apparently hibernating in Indiana. J. Mammal. 48:663.
21. ————. 1967. Habitat and reproduction of some of the small mammals of Vigo County, Indiana, with a list of mammals known to occur there. Occas. Papers Adams Ctr. Ecol. Stud. 16:1-24.
22. WHITAKER, J. O., JR., W. A. MILLER, and W. L. BOYKO. 1969. Rabies in Indiana bats. Proc. Indiana Acad. Sci. 78:447-456.
23. WIMSATT, W. A. 1945. Notes on breeding behavior, pregnancy and parturition in some vespertilionid bats of the eastern United States. J. Mammal. 26:23-33.