

THE HIBERNATION OF CERTAIN BATS IN SOUTHERN MINNESOTA

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Several caves near St. Peter in Southern Minnesota were found during the winter of 1933-34 to harbor 4 species of bats, one of which, the pipistrelle (*Pipistrellus subflavus*), had not previously been recorded for the state. A second species, *Myotis keenii septentrionalis*, had previously been reported from Minnesota only on the basis of 3 specimens taken at Elk River (Bernard Bailey, 1929). A few individuals of the little brown bat, *Myotis lucifugus*, were also found; but the species occurring in the greatest numbers was the big brown bat, *Eptesicus fuscus*. This is of interest because *Eptesicus* is not ordinarily regarded as a cave bat, nor is it usually considered to occur regularly in Minnesota during the winter.

The caves were visited 3 times; on January 4, 1934, by William Wilber and Evans, on February 12 by W. J. Breckenridge, Swanson, and Evans, and on March 25 by L. Fischer and Swanson. The bats were counted on February 12, when they occurred in the following numbers: *Eptesicus fuscus*, 240; *Pipistrellus subflavus*, 15; *Myotis lucifugus*, 11; and *Myotis keenii septentrionalis*, 4. The big brown bats were found in all of the 3 caves investigated, but at the time of our visits in February and March the other 3 species were confined to one of the caves. On the January trip a few little brown bats also were present in another cave.

The 3 caves all were obviously man-made, dug in the St. Peter sandstone, which outcrops in this vicinity. They were excavated many years ago, however, and the present local residents do not seem to be acquainted with the original purpose for which they were made. The cave in which most of the big brown bats were found was described in a previous note (Evans, 1934). It was 6 to 8 feet high, about as wide, and extended approximately 150 feet into the sandstone. Originally this cave was continuous with the one in which the pipistrelles were found, but a cave-in had completely separated them. The pipistrelle cave was similar to the one described above throughout the first 50 feet of its extent, but thereafter the floor became very uneven and the passageway widened into a room with irregular walls and ceiling, the result of repeated cave-ins. The third cave had several entrances about the size of doorways. It consisted of several rooms, 12 to 14 feet high, connected by hallways. A fourth cave, near Jordan, Minnesota, was visited only on March 25, and 42 bats were found in it. This cave was used earlier by a local brewery for storing its products.

Our observations on the bats in these caves indicate that they are more or less active throughout the winter. This is in contrast to the impression created by several writers, among them Vernon Bailey (1933). His legend below a photograph of bats in Colossal Cavern reads: "(Fig. 16) These little upside down bats hang all winter by their hooked hind claws, wholly

torpid, cold, and motionless from the first of October until the warm days of April or May." Elsewhere, in speaking of the pipistrelles, he wrote: "The bats' fur was damp and beady with condensed moisture, and their bodies were as cold as the air, rigid and apparently lifeless. Here they had hung all winter by the well-curved hind claws hooked over rough places in the roof." When first seen on February 12 several of the pipistrelles in the St. Peter cave appeared just as Bailey has described, but an hour later, when we returned to photograph them, one already had flown away, and another was moving about, although we had been careful not to disturb them. The fact that several other bats were found flying about soon after we had entered the cave was an indication that their sleep was very easily disturbed.

On an earlier visit to the cave, Wilber had found no pipistrelles in the localities in which we encountered them. On January 4 no bats were seen in one of the caves which on February 12 contained over 50 big brown bats. As mentioned above, individuals of the genus *Myotis* were found on January 4 in a cave which in February had only *Eptesicus*. Obviously there had been far too much activity to be in accord with the picture of deep hibernation presented by several writers.

A note from Mr. Wilber written December 11, 1934, gives additional evidence of the movement of the bats. A small cave about one-quarter mile from the other caves mentioned is visited quite regularly, almost daily. We quote from his letter: "Have not been up to the bat caves since seeing you, but found one bat in my cave some days ago. Then a day or so later I found I had two. Then yesterday three were there so I may have a good sized family after awhile. P.S. (December 12.) Four bats today."

The degree of torpidity varied considerably in different individuals. Some, as already mentioned, flew with very little provocation, while others required 45 minutes or more in daylight to arouse them.

Observations also were made on the respiratory rate of some of the bats. One big brown bat hanging in a torpid condition was breathing irregularly, and there were long periods of complete cessation of movement. These periods of apnea lasted from 3 to 8 minutes, averaging 4.6 minutes over a period of one-half hour. Breathing periods generally lasted 3 minutes or less, during which the rate of respiration was from 23 to 48 per minute. This bat was subsequently aroused intentionally by warming and rough handling. Its respiratory rate rose to 200 per minute before it was able to fly. On March 25 we observed the respiratory rate of an undisturbed big brown bat. The bat was not breathing when found, but after two and one-half minutes it inhaled twice. It then stopped breathing for 3 minutes, after which the observation ceased. A little brown bat respired 18 times in 20 seconds; it then inhaled at a slow rate for 155 seconds, and stopped for 220 seconds. The difference in the degree of torpidity exhibited by different individuals indicates that the bats are not in a constant state of hibernation.

The insect population of the caves was adequate to provide a ready supply

of food for the bats should they desire it. Mosquitoes were especially abundant, and moths and hemipterans also were common. As an indication that the bats were utilizing this available food, two facts were significant. Bats collected on each of the 3 trips dropped large numbers of well-formed feces within a few hours of their capture, and on one occasion microscopic examination showed that chitin was present.

The activity and apparent feeding of these bats during the winter leads us to disagree with those who have assumed that so-called hibernating bats remain in constant dormancy throughout the winter. Our observations on bats tend to parallel those of Johnson (1931) on the 13-lined ground squirrel. He found that the hibernating individuals of the latter awaken between periods of torpor varying in length from 1 to 18 days. Between the periods of torpor the animals remained awake for intervals which averaged one day in length. They awakened with a full bladder and rectum, voided, and ate a small amount of food before returning to a state of torpor. Johnson's observations were the result of several experiments, each with 20 animals kept in a refrigerator.

Attempts were made to determine the body temperature of the bats in relation to that of the cave, but on the February trip only an ordinary household thermometer was available. On March 25, however, we used an accurate laboratory thermometer as well as a Leeds and Northrup potentiometer with Centigrade scale, which was loaned by the Division of Entomology through the courtesy of Dr. A. C. Hodson of that department. With the fine thermocouple junction it was possible to take the temperature of a small point quickly and with little or no disturbance of the bats. For measurements where they could be used equally conveniently the laboratory thermometer and the potentiometer checked very closely. The readings have been transposed from Centigrade to Fahrenheit.

On February 12, when the outside temperature during the period of our stay varied from 35 to 45 degrees, the temperature within the caves was quite constant. The pipistrelle cave varied from 45 degrees near the entrance to 48 degrees at the deepest part. The temperature of the cave containing the majority of the big brown bats was 42 degrees at the point where the largest mass of bats was hanging, about 100 feet from the entrance. A thermometer, thrust into the mass of bats after they had been disturbed slightly by our lights and were breathing quite regularly, registered 98 degrees. At this time, however, the bats were quite thoroughly aroused and several had flown away.

On March 25 the outside temperature was 40 degrees while that just inside the pipistrelle cave was 45 degrees and at its deepest part the temperature was again 48 degrees. The thermocouple junction was placed against the back of a big brown bat, and the potentiometer scale showed no deflection from the room temperature of 48 degrees. This bat was undisturbed, but

when it had been disturbed enough so that the junction could be placed in its mouth the oral temperature was 54.4 degrees. It is felt that this rise was actually a temperature change resulting from the disturbance of the bat, rather than a difference in the temperature of the mouth and skin of the back, because it was determined later that the thermocouple junction on the back gave a temperature which agreed closely with that measured orally. For example, a bat which had been thoroughly aroused and brought indoors into a room temperature of 69 degrees had a body temperature of 96 degrees as measured by the potentiometer both orally and on the skin of the back.

The temperature of two pipistrelles hanging together was taken by inserting the thermocouple junction between them. The cave temperature was 48 degrees, and the initial temperature of the bats was 50 degrees, but as they were gradually aroused by the slight disturbance which we caused, their temperature gradually rose to 61 degrees, soon after which one of the pipistrelles flew away.

In the second cave the room temperature near the largest group of big brown bats was 44 degrees. Special effort was made to take body temperatures both externally and by mouth before they had been disturbed or aroused appreciably, and under those conditions no change from the room temperature was measurable by either method, although the potentiometer is accurate to within one-half degree.

A few of the big brown bats were taken back alive and were divided into two groups. Some were placed in a temperature cabinet kept nearly constant at 45 degrees. With the aid of Mr. David Lindgren of the temperature rooms of the Division of Entomology, thermocouples were arranged so that the temperatures of both cabinet and bat could be read on the potentiometer scale without any disturbance to the animal, as it was not necessary even to open the cabinet door. The bats were kept in a light-proof container within the cabinet. Under these undisturbed conditions the body temperature of the bats, as measured on the skin, was almost exactly equal to that of the cabinet. Sometimes it was one-half or one degree higher than that of the cabinet.

Another group of bats was placed in a cabinet kept several degrees below freezing. In this case it was found that the temperature of the bats was always from one and one-half to 4 degrees above the cabinet temperature, which measured 27.6 degrees. According to these observations the temperature of the living bats, even in undisturbed dormancy, did not fall below 29.3 degrees. A colder temperature cabinet was not available for further tests, but it is believed that the bats would die if subjected to temperatures lower than this.

These big brown bats, taken March 25, were kept in the 27.6- and 45-degree temperature-cabinets to determine how long their hibernation could be prolonged. After 3 weeks they were still alive, but by May 1 all had died. Death may have resulted from hunger, thirst, or the enforced prolongation

of the inactivity. The humidity in the cabinets was quite high; probably about equal to that in the caves.

In this connection it may not be amiss to present some other winter records of the occurrence of bats in Minnesota, because few have appeared in print. In the winter and spring of 1932, Dr. Ralph W. Macy secured a number of bats from a large furniture store in St. Paul. These bats had been in the building all winter, and in the evenings would fly about in the store, to the annoyance of the management. All but one of the individuals captured proved to be big brown bats, of which one was taken January 31, one March 10, one March 19, three March 26, and one March 28. On April 9 a single red bat, *Nycteris borealis*, was secured. An additional big brown bat was taken March 1, 1932, at a theatre in Minneapolis, and on December 7, 1934, a student brought to one of the writers another living specimen of the same species taken inside the library building of the university. All of these bats were active.

We are grateful to Colin C. Sanborn of the Field Museum for confirming the identification of the specimens of *Myotis keenii septentrionalis*. The specimens of all species mentioned are in the collection of the University of Minnesota Museum of Natural History.

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