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SEASONAL ACTIVITY OF BATS AT COPPERHEAD CAVE

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Abstract: Copperhead Cave is an abandoned mine in Vermillion County, Indiana, serving as both a hibernaculum and a swarming area for northern bats (*Myotis septentrionalis*), little brown bats (*M. lucifugus*), and eastern pipistrelles (*Pipistrellus subflavus*). A double-frame harp trap was used to document bat activity at the mouth of the mine on a weekly basis from the fall of 1989 to the spring of 1991. Most of the trapped bats were banded and released. Little brown bats of both sexes emerged gradually from hibernation between 14 March and 19 May 1990 and between 15 March and 1 May 1991. In contrast, northern bats emerged in much larger numbers between 9 March and 27 April 1990 and between 21 February and 22 April 1991. The mine served as a swarming area from the end of July to the end of October for both species of *Myotis* and through the first week of October for the pipistrelles. The pipistrelles exhibited almost no winter activity (flight). However, the little brown bats and the northern bats were active at the mine entrance throughout the winter. Turnover in the bat populations of this mine is quite high, as indicated by the low number of banded bats recovered: 336 of 1733 (19.4%) individuals of *Myotis lucifugus*; 174 of 2090 (8.3%) individuals of *M. septentrionalis*; and 100 of 546 (18.3%) individuals of *Pipistrellus subflavus*.

INTRODUCTION

Copperhead Cave is an abandoned clay mine in a bluff 1 km west of the Wabash River and 1.5 km west of Montezuma in Vermillion County, Indiana. The mine is about 120 km northwest of the edge of the unglaciated cave country of southern Indiana, and it represents an artificial cave in an area where no natural caves exist. We were informed that the mine served as a hibernaculum for bats, and initial monitoring indicated that the mine was used in other seasons as well.

Regular monitoring of the mine entrance was initiated to determine:

1. The species, number, and sex of the bats using the mine;
2. The seasonal use of the mine;
3. The uses to which the mine was put;
4. The dates of entrance into and exit from hibernation;
5. The size of the bat population; and
6. Whether or not a stable bat population used the mine for extended periods of time, or if significant population turnover occurred.

MATERIALS AND METHODS

A double frame harp trap was used to sample bats flying at the entrance to the mine. Monitoring started in September 1989 and was to be terminated for the season on 30 October, because we assumed that bat activity would essentially cease by that time. However, to verify that little or no winter activity occurred, the trap was placed at the mine

Table 1. Summary of information on the bats taken in a trap at the entrance to Copperhead Cave.

Date	*M. lucifugus*		*M. septentrionalis*		*Pipistrellus*	
	male	female	male	female	male	female
1989						
Sept 19	110	14	41	27	4	3
22	100	10	3	10	6	0
26	62	19	7	10	3	4
30	67	7	10	18	2	5
Oct 3	40	11	1	1	7	0
10	24	11	16	21	23	15
13	21	5	64	38	3	2
17	31	5	7	1	1	0
20	9	2	4	2	1	0
24	7	2	41	12	1	0
28	8	3	28	8	0	2
30	7	4	15	6	0	0
1990						
Jan 16	9	3	1	2	0	0
23	3	4	1	2	0	0
27	2	0	2	2	0	0
Feb 3	0	0	0	1	1	0
8	7	3	6	5	1	1
17	0	0	1	0	0	0
23	0	0	0	0	0	0
Mar 3	1	5	2	1	0	0
9	3	1	12	4	0	1
14	3	3	61	6	0	0
17	3	0	15	1	0	0
24	0	1	21	3	1	0
31	0	5	70	44	0	0
Apr 4	0	0	32	32	0	0
7	1	4	37	62	0	1
11	4	5	10	10	0	0
17	3	7	9	19	0	0
27	7	7	9	0	12	8
May 6	2	0	1	0	0	3
9	4	0	1	0	2	4
12	2	2	0	0	1	1
19	2	4	0	0	4	0
26	0	0	1	3	3	0

Date	*M. lucifugus*		*M. septentrionalis*		*Pipistrellus*	
	male	female	male	female	male	female
June 2	0	0	3	0	3	0
15	2	0	78	2	1	0
23	1	0	75	0	1	0
29	2	0	35	0	2	0
30	3	0	57	0	1	0
July 1	2	0	32	0	1	0
2	3	0	21	0	2	0
3	6	1	19	0	3	0
4	3	0	20	0	10	0
5	7	0	17	0	6	0
6	6	0	7	0	1	0
10	1	1	0	0	7	0
17	2	0	1	0	9	0
25	8	1	5	0	8	1
31	8	3	31	11	5	2
Aug 7	9	7	3	1	0	0
15	22	23	66	56	6	3
20	42	37	35	52	2	2
25	47	46	82	89	33	15
Sept 2	44	25	48	55	4	5
9	47	12	12	34	8	4
13	40	9	18	17	2	6
21	53	17	15	28	1	0
26	36	9	33	49	4	9
Oct 5	12	6	25	37	1	3
12	10	1	12	8	1	0
19	11	1	10	1	0	0
29	2	1	13	6	0	0
Nov 8	4	1	2	1	0	0
15	1	2	4	2	0	0
20	1	3	4	8	0	0
30	1	4	0	2	0	0
Dec 8	1	0	1	2	0	0
16	1	0	2	3	0	0
21	1	0	1	4	0	0
1991						
Jan 2	1	0	1	2	0	0
10	3	0	3	2	0	0
18	0	2	0	0	0	0
25	0	2	1	0	0	0

Date	*M. lucifugus*		*M. septentrionalis*		*Pipistrellus*	
	male	female	male	female	male	female
Feb 2	3	1	0	2	0	0
8	1	0	0	0	0	0
17	3	1	2	0	0	0
21	1	3	0	10	0	0
28	3	4	7	13	0	0
Mar 3	165	149	7	6	84	86
7	1	1	2	2	0	0
15	4	10	7	13	0	0
22	0	2	12	5	0	0
29	15	5	6	3	0	2
Apr 5	1	1	30	10	0	0
22	4	4	11	8	1	1
May 1	2	2	0	0	8	8
9	0	1	0	0	4	5

entrance on 21 November 1989, left in place, and checked daily through early December. After early December, the trap was checked sporadically. Through 9 January 1990, a total of 63 bats was taken in this untended trap: 22 in November, 22 in December, and 19 in January. Included were 32 little brown bats, 29 northern bats, and 2 pipistrelles. Much more winter activity occurred than had been anticipated. Therefore, starting on 16 January 1990, the trap was tended approximately one night per week until 9 May 1991 (Table 1). In addition, an assessment of the bats hibernating in the mine was made on 23 February 1988, and similar assessments were made on 14 January 1989, 27/29 December 1989, and 3 March 1991 (Table 2). Nearly all the bats taken in the trap and nearly all of those found in hibernation during the later two assessments were banded (plastic numbered bands from National Band and Tag Co, Newport, Kentucky). The bands remained on the bats quite well, but the numbers often become difficult to read within a year or two. Four thousand, three hundred sixty-nine bats were banded, and 610 were recaptured at Copperhead Cave.

RESULTS

Bats use this mine year round (Table 1), although the amount of use varies seasonally. Decreased activity was encountered at the mine entrance from November through February and from early in May through the first week in June. The majority of bats encountered belonged to three species: the little brown bat, *Myotis lucifugus,* the northern bat, *Myotis septentrionalis,* and the pipistrelle, *Pipistrellus subflavus.* All three species swarm there in the fall, presumably for mating purposes, and all three also hibernate in the mine. A few bats of two other species were also taken: seven Indiana bats (*Myotis sodalis*) and five big brown bats (*Eptesicus fuscus*). These bats will not be discussed further.

Of particular interest was the fact that northern and little brown bats were active all winter at this mine. Increased activity occurred on warmer nights (Whitaker and Rissler, 1992). There was little winter activity by pipistrelles. The bats entering and leaving the

Table 2. Bats in hibernation in Copperhead Cave.

Date	*M. lucifugus*		*M. septentrionalis*		*Pipistrellus*	
	male	female	male	female	male	female
Feb. 23, 1988	111*				201*	
Jan. 14, 1989	106*				113*	
Dec. 27/29, 1989	85	48	0	0	47	45
March 3, 1991	165	149	7	6	84	86

* Bats were counted without removing them from the wall; thus, information on sex is not available.

mine in midwinter do not feed even on warm nights, when insects are flying (Whitaker and Rissler, 1992). Some of the winter flights may reflect movements between hibernacula. However, some of the flying may occur because the bats are simply flying outside rather than inside during normal winter awakenings from hibernation (Cockrum, 1956; Menaker, 1964; Mumford, 1958). The total number of bats taken in 1990 and 1991 during the winter trapping sessions included: 27 northern bats and 10 little brown bats in December; 15 northern bats and 20 little brown bats in January; and 47 northern bats and 30 little brown bats in February. Only three pipistrelles were taken during the winter trapping sessions.

Myotis lucifugus. *Myotis lucifugus* usually hibernates in caves, but this mine provides a cave-like environment in an area with no caves. The mine served as a hibernaculum for the following minimum number of little brown bats on the following dates: 111 on 23 February 1988; 72 on 14 January 1989; 133 on 27/29 December 1989; and 314 on 3 March 1991.

No major peak of spring emergence activity by little brown bats was observed in either 1990 or 1991. The relatively small number of bats present probably emerged rather gradually from March through May. These data correlate fairly well with data on the buildup in a maternity colony of this species at Brazil, Clay County, Indiana. At Brazil, emergence started gradually in late March and was largely complete by late April (Ronald Davis, unpublished data).

Copperhead Cave did not serve as a major bachelor quarters for this species in the summer, as there was relatively little activity during June and July 1990. Between two to eight bats, including only three females, were taken each night from 1 June to 25 July. On 31 July, eight males and three females were taken, followed by seven females and nine males on 7 August 1990. Thus, the end of July and early August appear to mark the beginning of swarming for this species. These dates correlate quite well with a decrease in the summer population in the colony at Brazil in Clay County, where the number of bats present dropped off drastically beginning in early August. Swarming tapered off in October, with swarming by females decreasing sooner than that by males (10 October versus 17 October in 1990; 5 October versus 19 October in 1991). Apparently, the bats move gradually to their swarming areas and then gradually into hibernation. Some of the bats hibernate at Copperhead Cave, but most move elsewhere, as indicated by the low number of banded bats found in hibernation. Prior to 3 March 1991, a total of 1470 little brown bats had been banded in or at the entrance to Copperhead Cave, whereas on 3 March, only 72 banded little brown bats were found hibernating there. This number represents only 4.9% of the total number of bats banded. Several of the bats banded at Copperhead Cave were found hibernating during the winter of 1990-91 about 100 km to the southwest in

Table 3. The total number of bats banded at Copperhead Cave.

Species	Male	Female	Unknown
M. lucifugus	1234	491	8
M. septentrionalis	1431	652	7
Pipistrellus	325	219	2
Eptesicus	4	1	
M. sodalis	4	3	

Ray's and Clyfty Caves in the Lawrence County area.

Myotis septentrionalis. Copperhead Cave apparently serves as a hibernaculum for northern bats, although not many individuals were found in hibernation. Three lines of evidence indicate that the mine is a hibernaculum: the (1) number of northern bats that entered the cave in fall; the (2) number that emerged in winter and spring; and the (3) bats found hibernating in tiny cracks in winter. The numerous cracks in this mine must serve as winter quarters for hundreds of northern bats, but finding them was very difficult in these cracks. On relatively warm spring nights, when northern bats were emerging from the mine, numerous individuals were found exiting from the cracks (e.g., twelve were observed on 15 March 1991).

Northern bats emerge from hibernation early in the season. Large numbers exited from the mine on nights when the temperature approached 10° C from the second week of March through April each year (Table 1). The modal exodus time for males was approximately one week ahead of that for females.

An attempt was made to estimate the number of northern bats using Copperhead Cave in spring. Sampling times averaged 7.5 hours or 0.625 of the dark period at that time of year. To determine if banded bats might be reentering the mine or if bat activity might taper off after our normal sampling period ended, bats were trapped throughout the night on two separate occasions. The results indicated that bat activity continued all night and that individuals seen earlier did not generally return to the mine after our normal sampling period ended. The emergence of northern bats in 1990 started about 9 March and lasted through 17 April, a total of 40 nights. Samples were collected on ten of these nights. The average number of northern bats taken per night was 22.7 (4.2 bats/0.625 = 22.7 bats; SD = 15.9, SE = 5.3). Based on this number, an estimated 908 northern bats exited the mine in spring (22.7 bats/night x 40 nights = 908 bats). This figure is a tentative, minimal estimate of the hibernating population.

During May and into early June 1990, few northern bats were active at Copperhead Cave. Six were taken in May, and three were taken on 2 June. However, from 15 June to 5 July, large numbers of males but only two females were taken (a total of 354 bats was taken in nine sessions). Our first interpretation was that the mine was serving as a bachelor colony. This would have been our final interpretation, if we had sampled only once. However, if the males were quartering there, we should have had many recaptures. Only 10.7% of the captures were of banded bats (38 recaptures out of 354 total captures). Of the recaptured bats, only 2.3% (eight) were originally banded during the first sampling pe-

riod. The data suggest that these northern bats were summer migrants, although we do not know where they would be going or why. The large number of northern bats that were present in this three week period precludes their being simply summer wanderers. We are unaware of other data which include extended observations on concentrations of males in summer.

Fall swarming began at about the same time as it did for the little brown bat. However, the onset was more abrupt. Thirty-one males and 11 females were captured on 31 July, after only five had been captured six days previously. Major swarming activity lasted through the first week in October. After that, the number of northern bats taken per sample remained low through December. It was not possible to tell when fall swarming stopped, because northern bats were taken throughout the winter.

Pipistrellus subflavus. The numbers of pipistrelles counted while hibernating in the mine were: 201 on 23 February 1988; 113 on 14 January 1989; 99 on 27/29 December 1989; and 176 on 3 March 1991. Pipistrelles apparently move about very little in their hibernaculum during winter. The water droplets that accumulate on them at that time indicate long-term hibernation in contrast to the frequent awakenings characteristic of *Myotis.* Most pipistrelles had left hibernation by the end of April in 1990: none were taken on 17 April; 20 were taken on 27 April; and only 3 were taken on 6 May. However, a few pipistrelle females were still leaving the mine through the first two weeks in May. In 1991, they left later: 16 were taken on 1 May, and 9 were taken on 9 May. This agrees with our unpublished data indicating the formation of pipistrelle maternity colonies beginning in late April and extending through much of May.

Small numbers of male pipistrelles were taken from 4 July through 31 July. The mine may have served as a migratory stopover for these bats. Alternatively, these males may have represented early swarming individuals, although females were not included in swarming until the end of July. The largest number of swarming individuals was encountered on 25 August (33 males and 15 females). Swarming activity occurred throughout all of August and September and into the first week of October. At that time, the bats either moved elsewhere or entered the cave to hibernate. After 12 October 1990, no pipistrelles entered the trap until 29 March 1991. In 1989-90, however, five pipistrelles were taken on 13 October, five more were taken later in October, and 13 were taken between November and April.

CONCLUSION

Copperhead Cave serves as a swarming area and hibernaculum for little brown bats, northern bats, and pipistrelles. In addition, the mine may serve as a midsummer stopover for migrating northern bats and pipistrelles.

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