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# SEASONAL POPULATION VARIATION AND EMERGENCE PATTERNS IN THE EVENING BAT, *NYCTICEIUS HUMERALIS,* AT A WEST-CENTRAL INDIANA COLONY

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ABSTRACT: Information on seasonal population levels and emergence patterns of the evening bat, *Nycticeius humeralis,* was collected at a maternity colony in the belfry attic of Briley Chapel Church in Clay County, Indiana. Female evening bats were present from early May through the end of October, with peak population numbers occurring after parturition in mid-June. A population decline occurred in 1990, possibly due to disturbance of the colony by banding operations. Emergence for foraging became progressively later each month relative to sunset and was significantly later on days of heavy overcast than on clear days. Attic temperatures below 13.0° C significantly decreased the foraging activity of evening bats.

## INTRODUCTION

The evening bat, *Nycticeius humeralis,* is listed as endangered in Indiana and has never been abundant in the State. The only known active maternity colony of evening bats in Indiana is located in a tiny (1 m sq) attic, directly above the belfry of Briley Chapel Church in Clay County, Indiana (Figure 1). Briley Chapel is surrounded by large agricultural fields punctuated by small (0.5 ha to 2.5 ha) woodlots. The principle crop is corn, but other fields are in soybeans and pasture. Numerous small water impoundments are found in the area. The Eel River flows generally north to south about 1.5 km east of the church, flanked by a rich bottomland. Numerous buildings, such as houses, churches, and barns, are found within the observed foraging areas of *Nycticeius* and provide seemingly suitable locations for other colonies. The nearest known bat colony (*Myotis lucifugus*) is approximately 4 km east of Briley Chapel Church in a barn.

The colony was first located in July 1987 by J.O. Whitaker, Jr. (Whitaker and Gammon, 1988). The attic is a small pyramidal structure, containing a colony of 200 to 450 adult female and young bats during the summer. Bats gain access to the roost through 3 small (ca. 3 x 8 cm) openings on the north, east, and south sides at the peak of the roof directly under the weathervane. Other than 1 flight count taken on 27 July 1987 by Whitaker (Whitaker and Gammon, 1988), no studies of this colony were started until 28 July 1988, at which time regular evening flight counts commenced. The purpose of this study was to gather information on the yearly population cycle of a maternity colony and to note seasonal changes in the emergence patterns of the bats in relation to sunset and temperature.

## MATERIALS AND METHODS

Data on seasonal variation in colony size and emergence time were gathered by direct observation of the bats as they emerged for nightly foraging. Visual observations were

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Figure 1. Location of the maternity colony and temporary roost in Briley Chapel Church, Clay County, Indiana.

made from the northeast corner of the church, where an unobstructed view of the exits was available (Figure 1). Flight counts for 1989 and 1990 began prior to arrival of the bats in spring and continued until examination of the attic confirmed that bats were no longer present in the autumn. Exit counts were considered complete enumerations, because the limited space through which the bats were forced to leave and the proximity of the openings to each other made it highly unlikely that any would be missed.

Nightly flight counts began upon emergence of the first bat and continued for 30 minutes or until all bats had exited from the colony, whichever came first. Flight counts were conducted at least one night per week but usually 2 to 3 nights per week beginning on 28 July 1988 and continuing until mid-November, after which time, no bats were noted. (Collecting dates reportedly range from 8 April to 15 November (Mumford and Cope, 1964).)

During the 1988 season, access to the inside of the attic was limited to the 3 exit holes used by the bats at the base of the weather vane, and a small (10 x 10 cm) hole in the floor of the attic. On 18 February 1989, an opening of approximately 0.5 m sq was made in the floor of the attic. This opening was covered with a sheet of plywood and held in place by metal clips attached at the corners, which allowed the attic to be sealed, when observations were not being taken. This opening made it possible to count bats from inside, to determine if all bats had left the colony on evening foraging flights, to confirm both arrival and departure of the bats in the spring and fall, and to place a 7-day recording hygrothermograph (Friez Instrument Division, Bendix Corporation) within the attic to gather temperature and humidity data.

The hygrothermograph was placed on the floor of the attic and was in operation throughout the 1989 and 1990 seasons from early April until mid-November. It was assumed that temperature and humidity would fluctuate relatively little from the floor to the

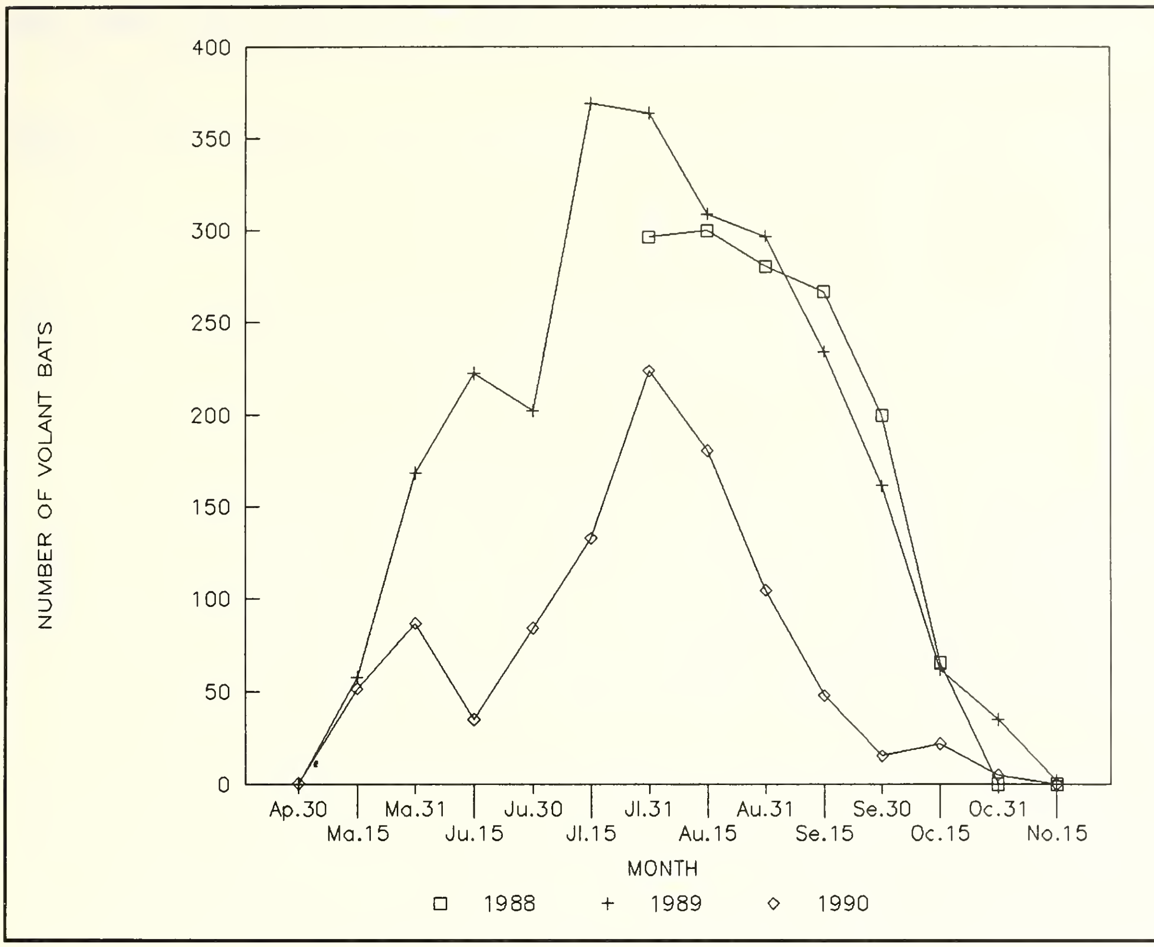


Figure 2. Mean number of bats (adults and juveniles) per 2-week period at Briley Chapel Church for 1988, 1989, and 1990.

attic peak, because of the small size of the structure.

## RESULTS AND DISCUSSION

**Population.** Adult evening bats were found at the Briley Chapel Colony from the first of May through October (Figure 2). The bats were first noted in 1989 on 1 May (n = 12) and in 1990 on 27 April (n = 2). The last date bats were observed at the colony was 15 October (n = 31), 3 November (n = 2), and 18 October (n = 4) for 1988, 1989, and 1990, respectively. Peak pre-parturition numbers were reached during the last week of May: 225 in 1989 and 145 in 1990.

The population declined 8.4% in 1989 and 48.3% in 1990 from the end of May until parturition occurred in mid-June. This decrease prior to parturition may indicate that females disperse to alternate colonies or temporary roosting sites, although none of the former were found in the area.

Peak flight counts were reached in mid-July as the young bats became volant. The peak for 1989 (n = 491) occurred on 20 July and for 1990 (n = 244) on 23 July. Counts taken in 1987 and 1988 indicate a peak of 358 and 314, respectively, but these counts were taken later in the month and may have been made past the actual peak time. Data from both 1989 and 1990, when observations were being made 2 to 3 times per week, indicate a fairly rapid drop-off in the number of volant bats by the end of July. Following the mid-July peak, the colony experienced a gradual decline in the number of both adults and young

Table 1. Number of bats (adults and juveniles) at Briley Chapel Church during 1988, 1989, and 1990 based on flight and belfry counts.

| MONTH | 1988 | 1989 | 1990 |
|---|---|---|---|
| APRIL | | | |
| Mean | | 0.0 | 0.4 |
| Std. Dev. | | 0.0 | 0.89 |
| Range | | 0.0 | 0.0 |
| n | | 4 | 5 |
| MAY | | | |
| Mean | | 109.4 | 61.7 |
| Std. Dev. | | 66.99 | 42.08 |
| Range | | 12-224 | 30-145 |
| n | | 15 | 9 |
| JUNE* | | | |
| Mean | | 211.0 | 53.8 |
| Std. Dev. | | 13.77 | 36.81 |
| Range | | 187-225 | 14-112 |
| n | | 7 | 13 |
| JULY | | | |
| Mean | 296.5 | 365.4 | 178.4 |
| Std. Dev. | 24.75 | 69.58 | 53.43 |
| Range | 279-314 | 251-491 | 72-244 |
| n | 2 | 8 | 12 |
| AUGUST | | | |
| Mean | 284.4 | 302.8 | 142.7 |
| Std. Dev. | 26.86 | 27.33 | 45.39 |
| Range | 242-313 | 261-335 | 68-200 |
| n | 5 | 6 | 10 |
| SEPTEMBER | | | |
| Mean | 245.9 | 221.4 | 36.5 |
| Std. Dev. | 49.12 | 16.59 | 24.96 |
| Range | 130-306 | 200-235 | 5-75 |
| n | 16 | 5 | 12 |
| OCTOBER | | | |
| Mean | 43.6 | 48.9 | 13.1 |
| Std. Dev. | 88.63 | 28.96 | 12.16 |
| Range | 0-223 | 8-85 | 0-29 |
| n | 6 | 8 | 7 |

| MONTH | 1988 | 1989 | 1990 |
|---|---|---|---|
| NOVEMBER | | | |
| Mean | | 0.5 | 0.0 |
| Std. Dev. | | 1.00 | 0.0 |
| Range | | 0-2 | 0.0 |
| n | | 4 | 1 |

* Parturition occurred around 12 June in 1989 and 19 June in 1990. Young become volant in 18-21 days.

throughout August and September (Table 1) and a more rapid decline in October.

The colony apparently experienced a decline in 1990 in both returning adults and young produced as compared to previous years. Based on peak flight counts, the 1990 colony was only 49% the size of the 1989 colony. The 1990 figures also represent a decline of 32% from the 1987 figures and 23% from the 1988 figures, although these are minimal estimates, since the data from those years were probably collected after the peak had occurred. The estimated number of young produced at the colony was 200 to 250 in 1989 and 100 to 125 in 1990.

No obvious reason for the decline is apparent. Bain (1981) suggested that excessive disturbance of a nursery colony of evening bats in Florida was a major cause of abandonment. Watkins (1969) noted that the abandonment of 6 of 28 evening bat nursery colonies in Missouri and Iowa was evidently due to human disturbance. Because the decline in this colony was not evident until 1990, the disturbances from banding and radiotelemetry studies in 1989 may have caused the population decline.

During 1990, the colony was completely vacated from 7 June through 15 June, after 105 individuals were banded. During this same time period, bats began appearing at dusk from beneath the soffits on either side of the chimney at the opposite end of the church (Figure 1). The number of adults in the belfry did not reach pre-disturbance levels until 7 July, and they continued to use this alternate site on a limited basis throughout the summer.

**Emergence.** Data on mean emergence time in relation to sunset for *Nycticeius humeralis* are shown in Figure 3. Bats emerged prior to sunset on only 4 of 134 nights during the study (once each in May, June, July, and August). On 3 of these occasions, rain was falling as the bats emerged, and on the 4th, the sky was heavily overcast.

The mean emergence time of evening bats over the entire 3-year period on days of heavy overcast or cloud cover was significantly earlier than on clear days ($t = 11.12$, $df = 132$, $P < 0.0005$; Figure 4). The mean emergence time of bats on cloudy days was 10.1 minutes after sunset ($n = 40$, $SD = 6.4$) and on clear days 18.6 minutes after sunset ($n = 94$, $SD = 5.9$). This observation agrees with those of Gould (1961), who found a closer correlation between emergence and ambient light than between emergence and sunset time.

Of the 130 observations during which flights occurred after sunset, 16 (12.3%) occurred from 0 to 9 min, 85 (65.4%) from 10 to 20 min, and 29 (22.3%) from 20 to 39 min after sunset. Because it is still quite light at sunset, bats were often foraging well before darkness.

Evening bats emerged earlier with respect to sunset in the spring and later during the autumn. Emergence time became later each night relative to sunset time as the season progressed (Figure 5). In 1989, mean emergence time after sunset ranged from 11.9 min

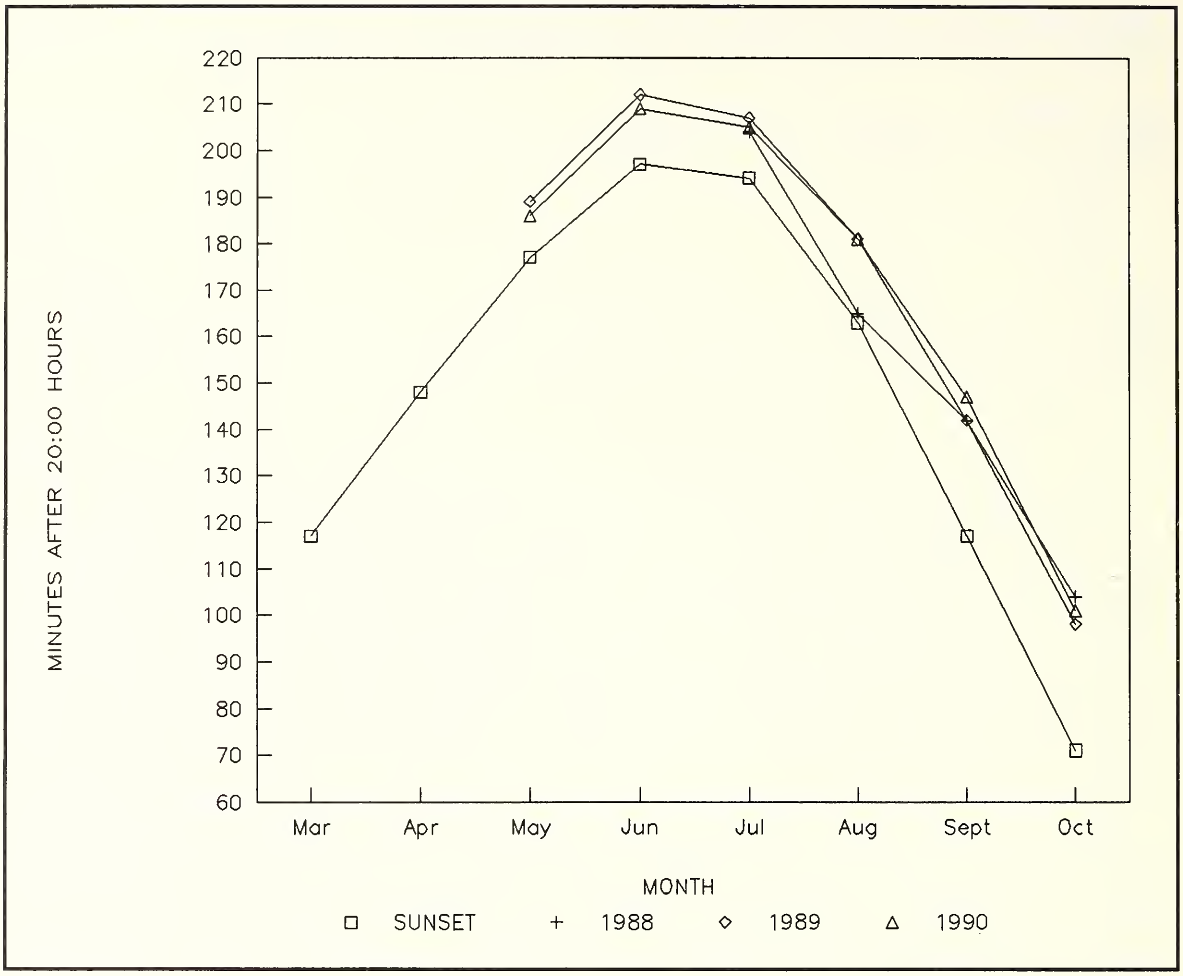


Figure 3. Mean monthly emergence time of evening bats from Briley Chapel Church, relative to sunset, for 1988, 1989, and 1990. The times of sunset were obtained from the Department of Geography, Indiana State University, Terre Haute, Indiana.

in May (n = 13) to 26.8 min in October (n = 5). In 1990, it ranged from 8.0 min after sunset in May (n = 8) to 21.5 min in October (n = 4). During 1988, data were collected starting in July and with the exception of the first month, in which the sample size was small (n = 2), the same trend was followed each year with emergence in October averaging 23.3 min (n = 4) after sunset.

Many authors (Church, 1957; DeCoursey and DeCoursey, 1964; Swift, 1980; Twente, 1955; and Venables, 1943) have noted emergence times for various species of vespertilionid bats to be earlier in both spring and fall relative to sunset. Herreid and Davis (1966) note 3 typical emergence patterns in bats in relation to sunset: 1) species without seasonal differences in emergence time in relation to sunset; 2) species which leave relatively later in the spring and fall; and 3) species which leave relatively earlier in the spring and fall. The evening bats from the Briley Chapel colony would seem to provide evidence for another pattern: i.e, a progressively later emergence in relation to sunset from spring through fall.

Herreid and Davis (1966) suggest that some bat species have, in effect, shortened the length of spring and fall nights by emerging later, because the nights during these seasons are longer than required for feeding. They further suggest that other species in northern latitudes must feed when insects are available, thus forcing earlier emergence in the fall and spring. Because individuals of *Nycticeius* emerged later each month, they may require progressively less time to feed from May through October. However, even though the bats emerged later in the autumn than in the spring, they foraged later into the autumn night.

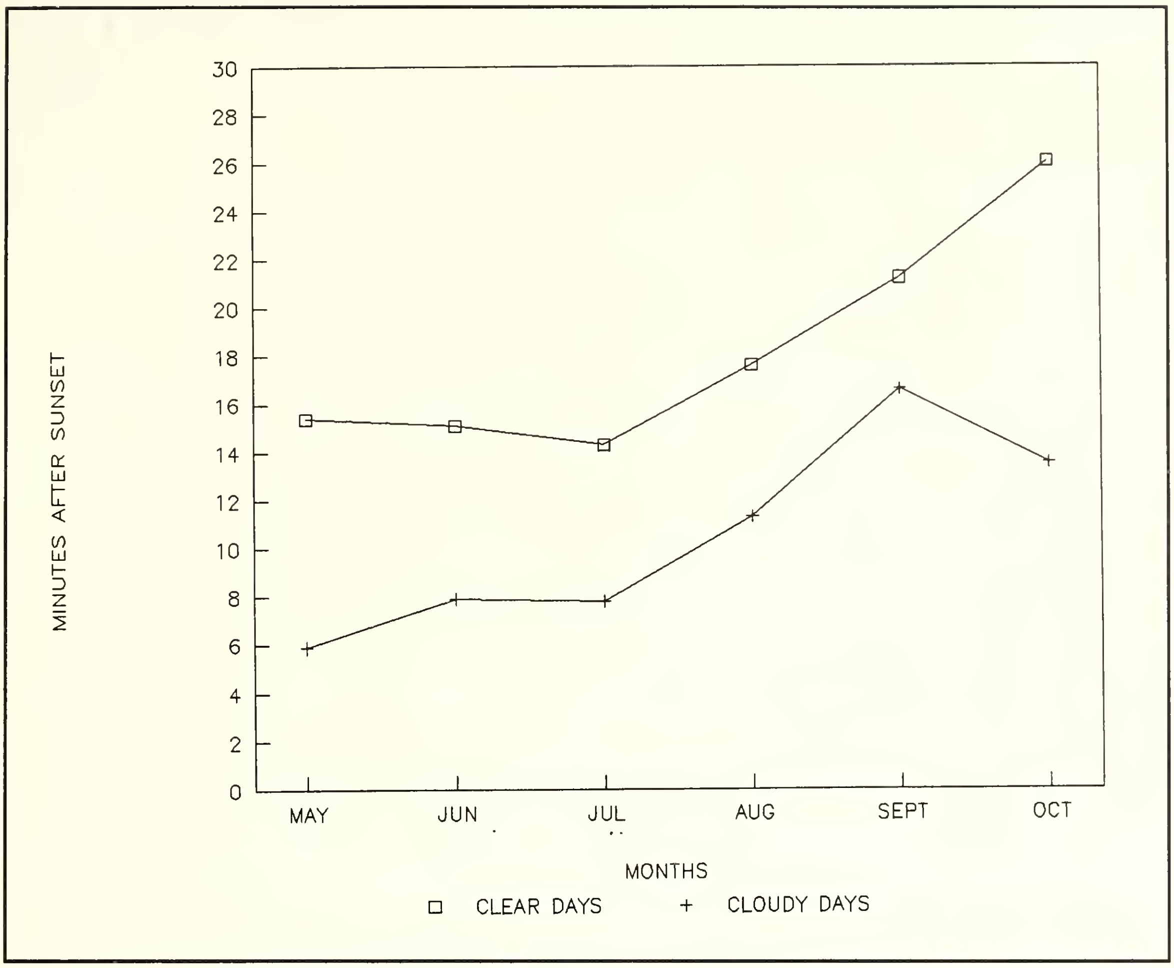


Figure 4. Mean monthly emergence time of evening bats from Briley Chapel Church, relative to sunset, on clear and cloudy evenings.

Thus, the total foraging time was greater in the fall (Clem, 1991). This difference could indicate that the bats are taking advantage of increased insect activity during the autumn in preparation for migration.

During 1989 and 1990, the attic was entered 46 times to determine if all bats had exited on the evening foraging flight. Flights occurred 42 times. These checks were made immediately following the foraging flight or on the 4 nights when no flight occurred, 30 minutes past the time, when the foraging flight should have occurred. On the 4 nights when no flights occurred, all the bats were present in the attic as expected. Some bats remained in the attic on 5 other nights as well.

Temperatures in the roost and in the outside air are listed for nights when bats were counted exiting from the attic as well as for nights when no flight occurred (Table 2). Attic temperatures on evenings when no flight occurred were 12.8°, 12.2°, 10.6°, and 2.8° C (mean = 9.6° C). Air temperatures on the same evenings were 1.7°, 7.8°, 11.1°, and 10.0° C (mean = 7.7° C). Attic temperatures on evenings when a portion of the bats remained in the attic were 13.3°, 15.6°, 20.0°, 20.6°, and 23.9° C (mean = 18.7° C). Air temperatures on the same evenings were 12.8°, 7.8°, 18.3°, 17.2°, and 21.7° C (mean = 15.6° C). At 13.3° C, 91% of the bats remained in the attic, and at 15.6° C, 10% remained there. The last 3 attic temperatures (20.0°, 20.6°, and 23.9° C) found from 8% to 0.3% in the attic, after the evening flight. Mean colony temperature on evenings, when all bats exited the colony, was 26.0° C, and mean air temperature was 22.6° C.

O'Farrell and Bradley (1970) noted increased capture rates for both *Pipistrellus*

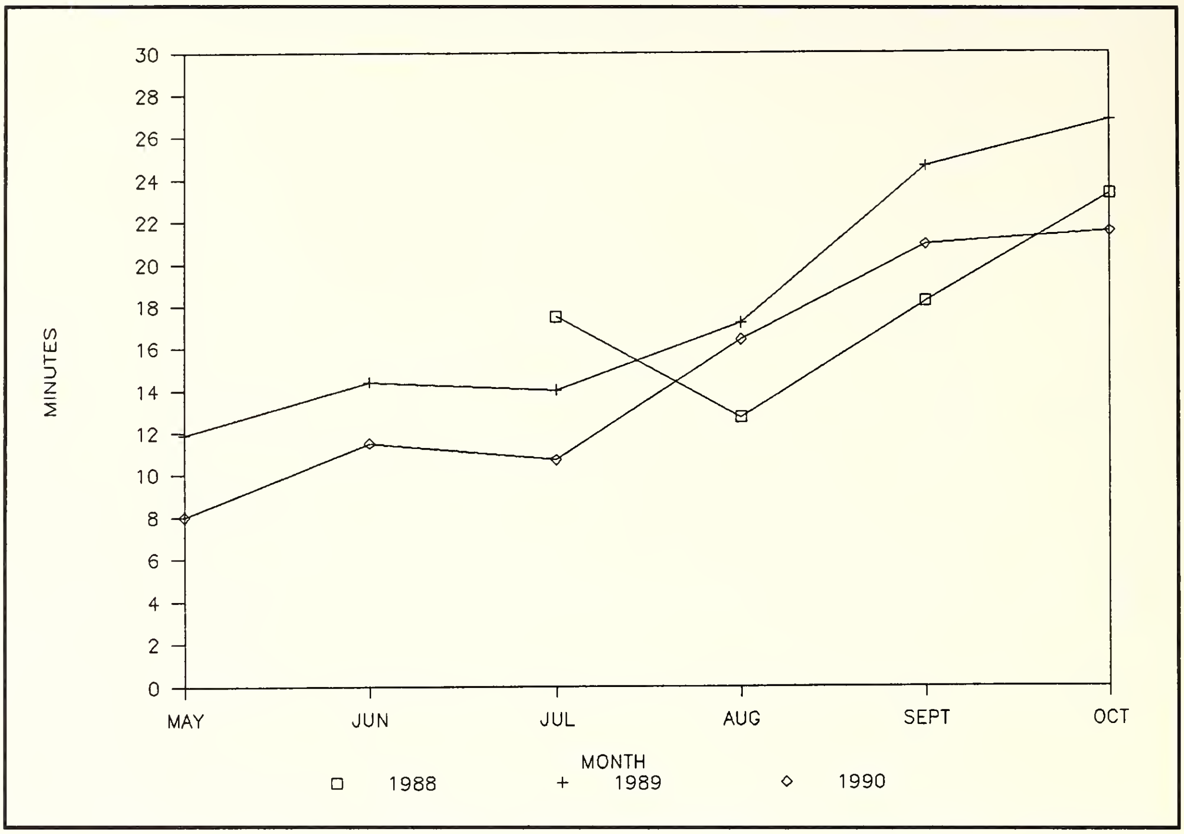


Figure 5. Mean monthly emergence time of evening bats from Briley Chapel Church, relative to sunset, showing progressively later emergence through the seasons.

*hesperus* and *Myotis californicus* at higher temperatures, indicating peaks of seasonal activity during warmer months. O'Shea and Vaughn (1977) noted slower and later emergence and briefer foraging periods for the pallid bat, *Antrozous pallidus,* during periods of cooler temperatures. The only published data dealing with *Nycticeius humeralis* indicated curtailed activity as an ambient temperature of 10° C was approached (Watkins, 1971).

The number of evening bats remaining in the Briley Chapel colony on evenings in May and October, when internal colony temperature was below 13.0° C, was significantly greater than on evenings, when the temperature was above 13.0° C ($\chi^2 = 330.2$, df = 1, $P < 0.005$). Bats remaining in the attic after the evening emergence were in varying degrees of torpor. On the 4 occasions when no evening flight occurred, the bats were clustered at the peak of the attic in torpor. There was no movement or vocalization. In contrast, bats were active when the roost was entered prior to evening emergence, when temperatures were higher.

Attic temperature is influenced by air temperature at the Briley Chapel colony, since no heat is provided to the belfry from the church. Temperatures were taken from 30 to 60 minutes past sunset, and generally, air temperatures were lower at this time than attic temperatures. Of the 46 checks made, 38 indicated air temperatures 0.5° to 12.2° C lower than attic temperatures. Of the 8 times attic temperature was lower, it ranged from 0.5° to 6.1° C. These results are probably due to more rapid cooling of the air than the attic after sunset on relatively clear, warm days. On 2 of the days when flights occurred (11 and 15 October 1990), the attic was 7.8° and 12.2° C warmer than the air temperature at the time the evening flight occurred.

Observable behavioral differences were noted for bats exiting the colony on these 2 nights, when outside temperature was 7.8° C. Flight appeared slower and more deliberate.

Table 2. Effect of temperature (in degrees Celsius) on flight and activity of *Nycticeius humeralis* at Briley Chapel Church, Clay County, Indiana. The data are arranged based on increasing colony temperature.

| COLONY TEMP | AIR TEMP | COLONY COUNT | FLIGHT COUNT | DATE IN | % REMAINING ATTIC |
|---|---|---|---|---|---|
| 2.8 | 1.7 | 40 | 0 | 20 Oct/89 | 100.0 |
| 10.6 | 7.8 | 5 | 0 | 18 Oct/90 | 100.0 |
| 12.2 | 11.1 | 60 | 0 | 06 Oct/89 | 100.0 |
| 12.8 | 10.0 | 12 | 0 | 04 May/89 | 100.0 |
| 13.3 | 12.8 | 60 | 6 | 03 Oct/89 | 90.9 |
| 14.4 | 19.4 | 0 | 24 | 04 Oct/90 | 0.0 |
| 15.6 | 7.8 | 2 | 20 | 11 Oct/90 | 9.1 |
| 16.7 | 21.7 | 0 | 29 | 08 Oct/90 | 0.0 |
| 17.8 | 13.9 | 0 | 32 | 05 May/90 | 0.0 |
| 18.9 | 18.3 | 0 | 5 | 24 Sep/90 | 0.0 |
| 20.0 | 26.1 | 0 | 147 | 07 Jul/90 | 0.0 |
| 20.0 | 18.3 | 1 | 12 | 17 Sep/90 | 7.7 |
| 20.0 | 7.8 | 0 | 11 | 15 Oct/90 | 0.0 |
| 20.0 | 19.4 | 0 | 170 | 14 Jul/90 | 0.0 |
| 20.6 | 17.2 | 4 | 196 | 01 Sep/90 | 1.0 |
| 21.1 | 20.6 | 0 | 147 | 12 Jul/90 | 0.0 |
| 21.1 | 25.0 | 0 | 145 | 29 May/90 | 0.0 |
| 21.7 | 23.9 | 0 | 8 | 24 Oct/89 | 0.0 |
| 21.7 | 19.4 | 0 | 207 | 29 Sep/89 | 0.0 |
| 21.7 | 20.0 | 0 | 14 | 06 Jun/90 | 0.0 |
| 22.2 | 26.1 | 0 | 109 | 30 Aug/90 | 0.0 |
| 22.8 | 22.2 | 0 | 335 | 18 Aug/89 | 0.0 |
| 23.3 | 21.1 | 0 | 67 | 08 May/90 | 0.0 |
| 23.3 | 22.2 | 0 | 90 | 25 May/90 | 0.0 |
| 23.9 | 21.1 | 0 | 75 | 23 Jun/90 | 0.0 |

| COLONY TEMP | AIR TEMP | COLONY COUNT | FLIGHT COUNT | DATE IN | % REMAINING ATTIC |
|---|---|---|---|---|---|
| 23.9 | 21.7 | 1 | 302 | 15 Aug/89 | 0.3 |
| 23.9 | 18.9 | 0 | 38 | 18 May/90 | 0.0 |
| 25.5 | 17.8 | 0 | 24 | 20 Sep/90 | 0.0 |
| 25.5 | 21.1 | 0 | 166 | 13 Aug/90 | 0.0 |
| 26.7 | 18.9 | 0 | 181 | 07 Aug/90 | 0.0 |
| 26.7 | 27.8 | 0 | 95 | 21 Aug/90 | 0.0 |
| 26.7 | 24.4 | 0 | 80 | 13 Oct/89 | 0.0 |
| 26.7 | 27.2 | 0 | 214 | 19 Jul/90 | 0.0 |
| 26.7 | 23.9 | 0 | 11 | 27 Oct/89 | 0.0 |
| 27.8 | 23.9 | 0 | 104 | 23 Aug/90 | 0.0 |
| 27.8 | 26.1 | 0 | 294 | 29 Aug/89 | 0.0 |
| 28.3 | 26.7 | 0 | 261 | 22 Aug/89 | 0.0 |
| 28.3 | 23.9 | 0 | 67 | 19 Jun/90 | 0.0 |
| 28.9 | 22.2 | 0 | 244 | 23 Jul/90 | 0.0 |
| 30.0 | 24.4 | 0 | 24 | 11 Jun/90 | 0.0 |
| 30.6 | 22.2 | 0 | 210 | 30 Jul/90 | 0.0 |
| 30.6 | 28.3 | 0 | 120 | 03 Jul/90 | 0.0 |
| 31.1 | 24.4 | 0 | 17 | 07 Sep/90 | 0.0 |
| 31.1 | 25.6 | 0 | 232 | 17 Jul/90 | 0.0 |
| 31.7 | 28.3 | 0 | 72 | 05 Jul/90 | 0.0 |
| 35.6 | 33.3 | 0 | 68 | 27 Aug/90 | 0.0 |

Bats returned to the roost in less than 1 minute and experienced some difficulty re-entering the attic. Several were noted flying onto the sloped roof of the belfry, releasing immediately, and after a brief flight around the church, attempting to re-enter the attic. On each of the 2 nights when air temperature was 7.8° C, the day had been sunny, and colony temperature was 15.6° and 20.0° C at the time of emergence. These data, coupled with the temperature data on evenings when no flight took place, would seem to indicate a critical colony temperature of 12° to 13° C, below which normal flight activity is curtailed.

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