Timing of migration by eastern red bats (*Lasiurus borealis*) through Central Indiana

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INTRODUCTION

A lack of information about seasonal distribution and movement patterns of migratory bats is hampering efforts to manage and conserve migratory bats (Cryan, 2003). The eastern red bat (*Lasiurus borealis*) is a migratory, tree-roosting bat that occurs throughout eastern North America. Migration of this species into summer roosting areas occurs in March and April with departures believed to occur in October and November (Whitaker and Hamilton, 1998). Analysis of museum collections indicates *L. borealis* become more abundant in southern states from December through March (Cryan, 2003), although some individuals winter as far north as Kentucky, Indiana, and Illinois (Whitaker and Hamilton, 1998). Wintering areas are not well documented, but are presumed to be mostly in the southern states due to the increased number of occurrences there from December to March (Shump and Shump, 1982). Adults of several species are known to begin migration before juveniles. However, this pattern is not known for *L. borealis*. While studying the nocturnal behavior of *L. borealis* near the Indianapolis International Airport in central Indiana, we incidentally obtained information about the migratory behavior of *L. borealis*. The purpose of this paper is to report these observations which will provide information about: 1) the timing of migration of *L. borealis* through this area, 2) direction and speed of migration, and 3) if adults and juveniles leave the area at different times.

MATERIALS AND METHODS

This research was conducted on properties in Marion, Hendricks, and Morgan counties, Indiana. These properties, located 20 km southwest of Indianapolis (39°44′N, 86°17′W), are managed for conservation of the federally endangered Indiana bat (*Myotis sodalis*) (Sparks et al., 1998, 2005; Whitaker et al., 2004) by the Indianapolis Airport Authority and BAA Indianapolis (a private airport management company). The properties extend south and west along US highway 40 from the airport to Indiana state highway 267 in the west and Indiana state highway 67 in the south with Interstate highway 70 bisecting the study area. We captured bats in 50-square, 9-m mistnets that were strung near known roosting and foraging areas and across the East Fork of White Lick Creek. Once captured, each bat was identified to species, sexed, aged, weighed, reproductive condition determined, and each bat received an individually numbered lipped aluminum wing band. We radio-tagged a subset of 24♀♀ *L. borealis* weighing more than 8 g by shaving a small patch of fur in the mid-scapular area and attaching a 0.49 g radio transmitter (model LB-2 from Holohil Systems Ltd., Carp, Ontario, Canada) to the bat using a surgical adhesive (Skin-Bond, Smith and Nephew, Largo, Florida USA). We released the bats within 45 min of capture.

We located roosts each day using radio-telemetry receivers (model TRX2000S, Wildlife Materials Inc., Carbondale, Illinois, USA) and 3-element yagi antennas. At dusk, we returned to the roost and waited for the bat to emerge. Upon emergence we took a series of multi-azimuth (3–7) triangulations in order to obtain an estimated location of the bat every 2–12 min.
until the bat night roosted or left the study area. Trackers were arranged at known telemetry stations surrounding the suspected location of a bat (based on rough, in-field triangulations). We maintained communication between teams using 2-way radios and cellular telephones in order to synchronize azimuths as well as to allow trackers to reposition when needed. We tracked each bat for a minimum of three nights \((n = 12)\), until the radio was no longer functioning \((n = 2)\), or the bat disappeared from the study area \((n = 10)\). Using automobiles, we followed four bats leaving the study area until they flew out of range.

Once tracking was completed, we converted azimuths to point data using Locate II (Nams, 2000) following Duchamp et al. (2004). Estimated locations were loaded into a geographic information system (GIS, ArcView, ESRI Corporation, Redlands, California, USA, 1999) where they were overlaid on a 1998 Digital Ortho Quarter Quadrangle photographic map (United States Geological Survey, in litt.).

We examined capture data (Fig. 1) of adult \(L. \text{ borealis}\) along the East Fork of White Lick Creek from 1998–1999, 2002–2004. These data were collected using the same capture and processing methods of the current study. We split the data into three capture periods during the annual surveys from 15th May to 15th August (15th May–14th June, 15th June–14th July, and 14th July–15th August). We used a \(\chi^2\) goodness of fit test to test the null hypothesis that there was no difference in the capture rates of adult \(L. \text{ borealis}\) between the three monthly netting cycles.

**RESULTS**

We captured and radiotagged 24 ♀♀ \(L. \text{ borealis}\) (15 adult, 9 juvenile) between 15 May and 15 August 2003 and 2004. We radiotracked 13 of these bats to small, relatively stable home ranges (minimum convex polygon technique, \(\bar{x} = 68 \pm 38 \text{ SD ha}\)) over a period of 3–7 days \((\bar{x} = 4)\) until the radio ceased to function. The average maximum commuting distance for the resident bats was 960 m (range = 415–1,755 m). Eight of the 11 radiotagged bats that did not occupy stable home ranges disappeared from the study area in late summer (15 July–15 August) within two days of capture. We radio-tracked four individual \(L. \text{ borealis}\) (2 adult, 2 juvenile — Fig. 2) leaving the study area, and all were flying in a linear, westerly direction (2 SW, 2 NW) when we lost contact with them (distance from roost: \(\bar{x} = 9,453 \text{ m}, \text{ range} = 6,615–15,672 \text{ m}\). We tracked juveniles leaving the study area (12 and 13th August) approximately 1–2 weeks after adults left (29th July and 6th August). We attempted to locate these bats on subsequent days, but were unsuccessful, suggesting migration had begun.

Long-term monitoring data also support the hypothesis that \(L. \text{ borealis}\) is moving through the Indianapolis area in late July and early August. We captured adult \(L. \text{ borealis}\) at twice the frequency during the third netting period (15th July–14th August) as compared to earlier netting periods (15th May–14th June and 15th June–14th July),
and this difference was almost significant ($\chi^2 = 5.29$, d.f. = 2, $P < 0.10$; see Fig. 1).

DISCUSSION

The following observations support the hypothesis that *L. borealis* begins migrating through central Indiana in late July: 1) we radio-tracked four bats leaving the study area and these bats flew 10 times as far as bats using stable home ranges at this site, 2) these long-distance movements occurred after young in the area were weaned, 3) these movements occurred in a linear direction, 4) a sudden increase in loss of radio tags occurred in late summer, and 5) the number of *L. borealis* significantly increased during late summer netting.

Most data pertaining to migration of *L. borealis* is based on range-wide analysis of museum specimens. Cryan (2003) suggested that *L. borealis* winters in southeastern areas of the United States and expands to more northern regions in summer, but some individuals hibernate in leaf litter as far north as Missouri (Boyles et al., 2003). Cryan (2003) also suggested that autumn migration of *L. borealis* is oriented toward the east and south. The bats we tracked near Indianapolis, conversely, were moving in a westerly direction in late summer. This difference in direction could indicate small-scale movements of the animals exiting the local area that were not apparent in the larger-scale data analyzed by Cryan (2003). Further, the westerly direction of *L. borealis* tracked on the southwest side of Indianapolis lead the bats through small cities (Plainfield and Mooresville, Indiana). Our observation combined with collision records from the Chicago Convention Center at a similar time of year (Timm, 1989) suggest that these bats do not avoid urban areas during migration, but may be attracted to developed areas.

**FIG. 2.** Four *L. borealis* leaving the local area compared to the maximum home range — black polygon (95% MCP), 143 ha — for this species at this location. Arrows indicate direction of flight. Times indicate from when the bat left the roost until the last triangulation was taken. Date, age, and distance flown by each bat are noted.
Hutchinson and Lacki (1999) noted female *L. borealis* making occasional forays out of the range of the receivers located at stationary tracking sites, but all returned within 45 min. However, we tracked these bats in automobiles and followed them until we lost radio contact and they were not located in or around the study area on subsequent days. Therefore, we suggest that they were migrating instead of just increasing their foraging range.

Adult female *L. borealis* started disappearing from the area near Indianapolis Airport sooner than juveniles. By the beginning of August, juveniles were the only bats that we tracked to stable home ranges. Every adult female (*n* = 4) that was captured and radiotagged at this time disappeared within a day from the study area. This pattern of adults migrating prior to juveniles is known for several other bats including *Myotis griseescens* (Tuttle, 1976) and *Tadarida brasiliensis* (Davis et al., 1962).

Several hypotheses have been advanced to explain this behavior. First, by migrating adults could reduce competition with juveniles. Second, juveniles may need more time to obtain sufficient fat reserves before migrating, therefore requiring them to migrate later. Third, because the sexes are somewhat segregated, it is possible that leaving sooner ensures the chances of obtaining a high quality mate. Those juveniles that do not breed during their first year would not need to migrate until later. If so, this hypothesis would suggest that most *L. borealis* hibernating near the northern periphery of the hibernating range are juveniles.

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LITERATURE CITED


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