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Jeremy A. White

University of Nebraska at Omaha, jeremywhite@unomaha.edu

Brett R. Andersen

University of Nebraska at Omaha, brandersen@unomaha.edu

Hans W. Otto

University of Nebraska at Omaha, hotto@unomaha.edu

Cliff A. Lemen

University of Nebraska-Lincoln, clemen2@unl.edu

Patricia W. Freeman

University of Nebraska-Lincoln, pfreeman1@unl.edu

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Winter Activity of Bats in Southeastern Nebraska: An Acoustic Study

Jeremy A. White,^{1*} Brett R. Andersen,¹ Hans W. Otto,¹ Cliff A. Lemen,² and Patricia W. Freeman²

¹ Department of Biology, University of Nebraska at Omaha, Omaha, NE 68182, USA

² School of Natural Resources and University of Nebraska State Museum, University of Nebraska-Lincoln, 428 Hardin Hall, Lincoln, NE 68583-0974, USA

*Corresponding author: Jeremy A. White, jeremywhite@unomaha.edu

Abstract

Many North American bats are active outside hibernacula in winter, but no information on winter activity has been reported for Nebraska. We recorded activity of bats during two winters (December-February 2012-2013 and 2013-2014) at one location in southeastern Nebraska with an acoustic detector. Bats were active throughout both winters and temperature at sunset was a good predictor of bat activity. Red bats (*Lasiurus borealis*) were active at our site in early December but were not recorded later in winter. We suspect these individuals were late migrants to more southern wintering sites. Big brown bats (*Eptesicus fuscus*) were recorded in each month during both winters, but reasons for winter activity at this site were not clear. This study provides baseline data for winter activity of bats in southeastern Nebraska; however, more research is encouraged to gain a better understanding of winter bat activity in Nebraska and other regions of the Great Plains.

Keywords: acoustics, bats, bat detector, echolocation, Nebraska, winter

Introduction

Bats in temperate regions generally migrate to warmer climes or hibernate before onset of winter. Hibernating bats arouse periodically (Speakman and Thomas 2003) and many species are active outside of hibernacula in winter (review by Boyles et al. 2006). Although winter bat activity is known in the northern United States and Canada, most records of winter activity are from the southern United States (Boyles et al. 2006 and citations therein, Geluso 2007, 2008, but see Lausen and Barclay 2006, Schwab and Mabee 2014). In Nebraska, just north of 40° N latitude, bats have been captured from March to November outside of roosts (Benedict 2004, Geluso et al. 2004b), but no activity has been reported from December to February. The objective of our study was to determine, by use of an acoustic detector, whether bats were active outside of hibernacula in winter at a site in southeastern Nebraska. Recording bat echolocation calls with acoustic detectors is an efficient technique to document activity in winter, a season when bats are expected to leave hibernacula infrequently at such northern latitudes.

Materials and Methods

We conducted our study at Camp Catron and Retreat Center north of Nebraska City, Otoe County, Nebraska (40.70694°N, 95.89716°W). Camp Catron is located in a small tract of upland deciduous forest about 1.6 km from the Missouri River. The forested site is mainly surrounded by agricultural fields (corn and soybean) and orchards/vineyards (apple and grape as well as other fruits) but is connected to riparian forests along the Missouri River by a strip of forest along Walnut Creek, a small tributary of the Missouri River. Major trees at the site included oak

(*Quercus* sp.), hickory (*Carya* sp.), elm (*Ulmus* sp.), black walnut (*Juglans nigra*), and hackberry (*Celtis occidentalis*). Several heated buildings are on the property and on property immediately adjacent to Camp Catron (e.g., Kimmel Orchard & Vineyard) that might serve as hibernacula for big brown bats (*Eptesicus fuscus*).

We recorded bat activity in a clearing along Walnut Creek. Bat echolocation calls were recorded with a SM2Bat+ detector and SMX-US microphone (Wildlife Acoustics, Inc., Maynard, MA, USA). The microphone was on a pole 4 m above the ground and pointed over Walnut Creek. The creek was 1.5-3 m wide and the clearing about 40 m wide at our recording point. Bat echolocation calls were recorded as full-spectrum calls in WAC format and later converted to WAV format using Kaleidoscope software (version 2.0.7, Wildlife Acoustics, Inc., Maynard, MA, USA). Bat passes (i.e., a sequence of ≥ 2 bat calls) were separated into files with a maximum duration of five seconds. We transformed bat passes into spectrograms using SonoBat software (version 3.2.0, SonoBat, Arcata, CA, USA) and visually identified calls to species by comparing them to known calls from a reference library provided by SonoBat.

We recorded bats from sunset to sunrise during winter (we defined winter as December-February following Boyles et al. 2006) for two consecutive years, 2012-2013 and 2013-2014. We recorded for a total of 92 nights in winter, including nine nights in 2012-2013 (1-6 December, 18-19 January, and 17 February) and 83 nights in 2013-2014 (1-2 and 10-31 December, 1-31 January, and 1-28 February). We acquired weather data, including maximum daily temperatures, from the weather station at the Nebraska City Municipal Airport located 11 km from Camp Catron (The

Weather Underground, Inc. 2014). In 2012-2013 we only deployed the detector on relatively warm nights. But in 2013-2014, we recorded during all weather conditions and this more complete record of warm and cold nights permitted an analysis of winter activity that year.

To test for the role of temperature on winter activity of bats in 2013-2014, we used a binary logistic model. Nights with no bat recordings were scored as zero and nights with any recordings were scored as one. This procedure avoids the problem of independence of recordings produced by one bat making repeated passes by the microphone. We tested for the significance of two promising temperature variables, maximum daytime temperature and temperature at sunset. Using hourly temperature readings the temperature at sunset was calculated through linear extrapolation. The logistic regression was run using the glm function (family = binomial) in R (R Core Team 2013). The regressions for maximum and sunset temperatures were run separately and together in a multiple regression. We also determined time of night bats were active in 2013-2014.

Results

Bats were volant outside winter roosts in each month (December, January, and February) in southeastern Nebraska. We recorded a total of 208 bat passes during winter 2012-2013 and 2013-2014 from two species of bats at the study site. Eastern red bats (*Lasiurus borealis*) were recorded in early December during both winters (1, 3, and 5 December 2012 and 2 December 2013), but were not recorded in later months, accounting for only 7.2% of bat passes (15 out of 208). All other bat passes were identified as sequences from big brown bats (*Eptesicus fuscus*; 90.4%, 188 out of 208 passes) or were unidentifiable sequences (2.4%; 5 out of 208 passes). Our experiences with acoustics demonstrate some calls of big brown bats and silver-haired bats (*Lasionycteris noctivigans*) are difficult to distinguish. We did not observe diagnostic calls of silver-haired bats in our winter survey, thus we assume that all low frequency bat passes were from big brown bats.

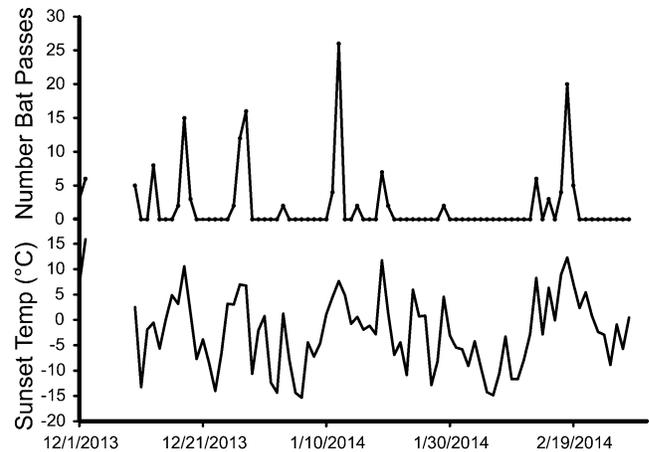


Figure 1. Number of bat passes recorded by an acoustic detector and temperature at sunset during December 2013-February 2014 in southeastern Nebraska.

In 2012-2013, bats were detected on 67% (6 of 9) of nights. Temperature at sunset varied from 8 to 14°C on those nine days. During winter 2013-2014, bats were detected on 27% (22 of 83) of nights; sunset temperatures ranged from -15 to 16°C (Figure 1). In winter 2013-2014, bat activity occurred on only one night when the sunset temperature was below 0 °C (13 December, Figure 1). In our multiple regression, sunset temperature had a highly significant z value, but once that variable is entered into the analysis, the z value for maximum temperature is not significant. Running the logistic regression for just sunset temperature also found a highly significant z (Table 1). Further, the residual deviance indicates a good fit of the logistic model to our data (Table 1). For example, probability of detecting a bat was nearly 0 when the temperature at sunset was -5°C, whereas the probability of detection increased to 0.8 at 5°C (Figure 2). In winter 2013-2014, bats were active at different times of the night, but the peak in activity was about 90 min after sunset (Figure 3).

Table 1. Results of a binary logistic regression testing the influence of sunset temperature on bat activity in December 2013-February 2014 in southeastern Nebraska.¹

Regression: Bat Activity ~ Sunset Temperature (°C)				
	Estimate	Std. Error	z value	Pr(> z)
Intercept	-1.5501	0.4746	-3.266	0.00109*
SunsetTempC	0.5073	0.1236	4.103	4.08e-05*
		df		
Null deviance:	95.995	82		
Residual deviance:	42.191	81		

¹ For the binary logistic regression, bat activity was coded as active (1) or not active (0) where nights with ≥1 bat pass recorded by an acoustic detector = active and zero recordings = not active.

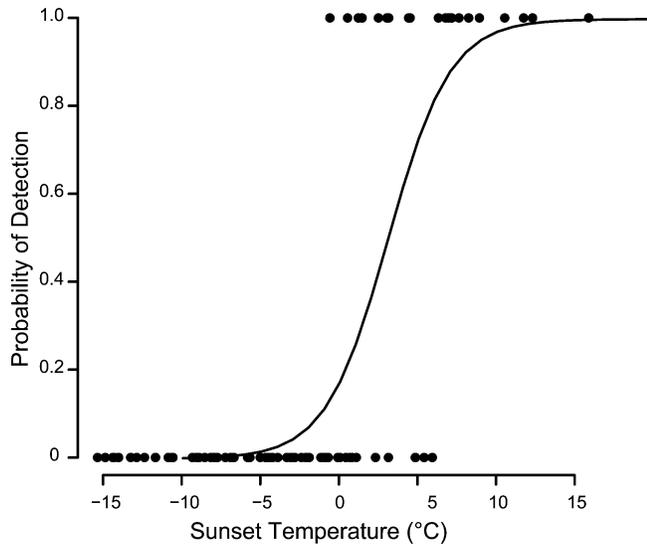


Figure 2. Temperature at sunset and probability of detection of bats by an acoustic detector during December 2013–February 2014 in southeastern Nebraska. Black circles represent nights of recording; 1 indicates that one or more bat passes were recorded and 0 indicates no bat passes were recorded.

Discussion

Bats were active throughout winter (December–February) at our study site in southeastern Nebraska, and a majority of winter bat passes were from big brown bats. However, silver-haired bats have similar echolocation calls to big brown bats, occur in Nebraska in November, and might hibernate in the region (Benedict 2004, Geluso et al. 2004a). Thus, we cannot exclude the possibility that ambiguous low frequency calls in winter were made by silver-haired bats, although these were relatively few. Besides passes by big brown bats and a few unidentifiable sequences, the only other species recorded during winter was the eastern red bat.

Red bats were only recorded in early December during both years. Red bats are active during winter in Missouri (e.g., Dunbar et al. 2007) as well as other states southeast of Nebraska (Boyles et al. 2006), but the species previously has not been reported from Nebraska this late in the year. The latest seasonal capture of a red bat from the state is 1 November (Geluso et al. 2004b) whereas the earliest is 26 April (Jones 1964). Given that red bats are active in southeastern Nebraska until early December, the possibility exists that some individuals hibernate in the region but went undetected in winter or did not arouse during warmer periods at our study site. However, with our nearly continuous surveys in winter 2013–2014, and equal to higher temperatures than nights with red bat activity in Missouri (Dunbar et al. 2007), the most parsimonious conclusion is that eastern red bats did not overwinter at our study site

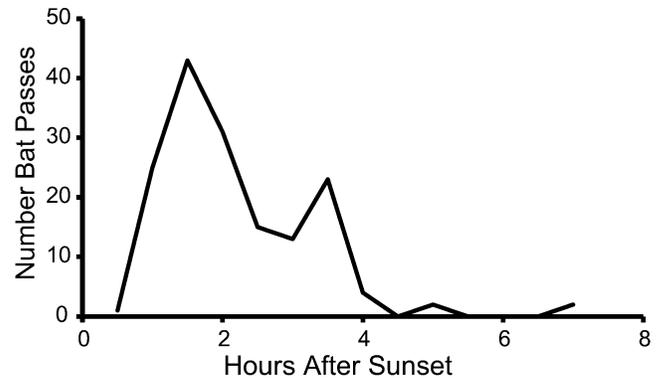


Figure 3. Time after sunset that bat passes were recorded by an acoustic detector on 22 nights, December 2013–February 2014, in southeastern Nebraska.

in southeastern Nebraska. Individuals recorded in early December in southeastern Nebraska likely represent late migrants on southward movements. Boyles et al. (2006) suggested that the winter range of red bats is restricted to regions with adequate food availability as red bats actively feed in winter in Missouri. The lack of detection of red bats in January and February at our site is unclear, but likely reflects low abundance of insects, temperatures too cold to sustain overwintering behaviors, a lack of adequate winter roost sites, or some combination of such factors.

Bats were recorded on some winter nights with cold temperatures (e.g., $<0^{\circ}\text{C}$ at sunset), but bats were frequently active on nights with sunset temperatures $\geq 5.0^{\circ}\text{C}$. Temperature at sunset was a better predictor of winter activity than maximum daytime temperature. Our study agrees with a recent acoustical winter study in Montana that demonstrated a positive correlation between bat activity and temperature at sunset (Schwab and Mabee 2014). Interestingly, a peak in bat activity did not occur immediately following sunset when temperatures were likely warmest during the night, but occurred about 90 min after sunset. From our data, we could not determine reasons for winter flights, but evidence from other studies suggests that some bats leave hibernacula in winter to feed (Avery 1985) or drink (Lausen and Barclay 2006).

Arousal from hibernation and winter activity is energetically expensive, even when bats take advantage of partial passive rewarming (Halsall et al. 2012). Some species of bats, including big brown bats, feed during winter, but foraging might depend on latitude and availability of insects (Boyles et al. 2006, Dunbar et al. 2007). For example, big brown bats did not feed during flights outside of winter hibernacula in Alberta (Lausen and Barclay 2006), whereas those in Missouri fed in December and January (Dunbar et al. 2007). Insects were observed at our study site on warm winter days (R. Anderson, Camp Director, personal communication), so it is possible that bats were

pursuing insects on some winter nights. Additionally, bats might have been drinking at our study site, as Walnut Creek did not freeze and provided a source of open water during winter. More targeted studies are needed to determine why bats leave hibernacula in winter in Nebraska.

It is worth noting that we did not record any calls of *Myotis* bats at our study site during winter. Many species of *Myotis* are known to leave hibernacula in winter (Boyles et al. 2006 and citations therein, Schwab and Mabee 2014) including *Myotis septentrionalis* and *Myotis lucifugus* (Whitaker and Rissler 1992). These species occur in eastern Nebraska but the nearest known hibernacula to our study site are mines that are >25 km away (Benedict 2004). The lack of detection of these two species in winter and the distance from known winter roosts suggests that *Myotis* do not occur at our study site in winter. However, a lack of detection of *Myotis* in the region represents important baseline data, especially in light of the continued westward advance of White-nose syndrome, a fungal disease that has caused devastating population declines of certain species of cave bats (e.g., Frick et al. 2010). Further winter research on bat activity in Nebraska and other areas of the Great Plains is encouraged to determine 1) baseline winter activity patterns of cave bats before the arrival of White-nose syndrome, 2) reasons bats leave hibernacula in winter, and 3) whether eastern red bats, or other migratory species, overwinter in the region.

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