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Acoustic evidence of bats using rock crevices in winter: A call for more research on winter roosts in North America

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Abstract

The Northern Long-eared Myotis (*Myotis septentrionalis)* is known to hibernate in mines and caves, often using cracks within these hibernacula as roost sites. We hypothesized that *M. septentrionalis* might use deep cracks in rock outcrops for hibernation as well. To test this hypothesis, we placed acoustical bat detectors near rock outcrops away from any known mines or caves during winter in Nebraska. We documented calls of *M. septentrionalis* as well as *Perimyotis subflavus* and *Eptesicus fuscus* in December near rock outcrops, which suggests that individuals of all three species were hibernating in rock crevices in winter. Of the 34 sites we monitored, we identified the calls of *M. septentrionalis* at two sites (about 250 km apart). The dominant rocks at both sites were limestone and shale with large, deep cracks. Given the recent listing of this species as threatened by the US Fish and Wildlife Service, it is important to understand the possible role of cracks in rock outcrops as alternative hibernacula.

Keywords: acoustics, bats, bat detector, hibernation, *Myotis septentrionalis*, Nebraska, Northern Long-eared Myotis, rock crevices, winter

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Many hibernating bats in temperate North America spend winter below ground in caves or mines (Barbour and Davis 1969). Exceptions include the Big Brown Bat (*Eptesicus fuscus*), which also commonly uses buildings in winter (Perkins et al. 1990, Whitaker and Gummer 1992, Nagorsen et al. 1993), and occasional observations of hibernating bats found in storm sewers (e.g., Goering 1954), dams (e.g., Kurta and Teramino 1994), abandoned railroad tunnels (e.g., Johnson and Gates 2008) and wells (e.g., Griffin 1945). In areas without caves or mines, Griffin (1945) speculated that temperate bats use deep crevices in rocks for hibernation. However, in the 70 years since this paper, few studies have explored this possibility. Bogan et al. (2003) speculated on the likely use of cracks for hibernation by crevice-roosting bats, but noted the difficulty in finding these hibernacula. Recently, researchers documented Big Brown Bats using rock crevices during winter in Canada (Lausen and Barclay 2006) and during autumn in the United States (Neubaum et al. 2006). Also, Moosman et al. (2015) recently found Eastern Small-footed Myotis (*Myotis leibii*) using crevices in talus slopes from early March to late October and speculated that those bats hibernate in crevices during winter. These new findings raise the question, are we looking in all the right places for hibernating bats?

Current thinking holds that the Northern Long-eared Myotis (*Myotis septentrionalis*) uses caves and mines for hibernation and migrates short distances to reach these hibernacula. There is good evidence that some *M. septentrionalis* use caves and mines for hibernation (Caceres and Barclay 2000), but reports of distance of movements from summer to wintering grounds for this species are few (Caire et al. 1979, White et al. in review). However, if we accept that *M. septentrionalis* is both an obligate cave or mine hibernator and a short-distance migrator, then there is a problem in Nebraska. Mines are rare and localized (White et al. 2016), and the distribution of *M. septentrionalis* extends far beyond known mining sites. Therefore, it seems that in some areas of the state either *M. septentrionalis* is willing to migrate 100's of kilometers to reach a suitable mine, or it uses other types of hibernacula.

We hypothesize that *M. septentrionalis* hibernates in deep crevices in rock faces in addition to caves and mines. This species is known to use cracks within caves and mines (Caire et al. 1979, Whitaker and Rissler 1992) therefore perhaps they use cracks in rock outcrops that are sufficiently deep to have a microclimate that allows survival through the winter. Rocky outcrops are far more widely distributed in the state than mines and caves. Indeed the distribution of *M. septentrionalis* in Nebraska has a rough correlation with rock outcrops (Figure 1). Along the Republican, Little Blue, Big Blue, Missouri, and Niobrara Rivers, rock outcrops are present and *M. septentrionalis* is found along these rivers. The absence of this species on most of the Platte, Loup, and Elkhorn Rivers is consistent with the lack of rock outcrops in these areas (Figure 1).

To test this hypothesis we needed evidence that cracks were being used by *M. septentrionalis* in winter. In eastern Nebraska, *M. septentrionalis* is known to move from summering grounds to sites of hibernation (mines in southeastern Nebraska) by early November (White et al. in review), and some individuals return to summer sites in March (Geluso et al. 2004, Whitaker and Rissler 1992, our own observations in Nebraska). Therefore, the presence of *M. septentrionalis* at a site in December, January, or February can be taken as evidence the site is used for hibernation. Also, Lemen et al. (2016) documented (through use of acoustical detectors) that *M. septentrionalis* emerged from a mine on mild nights throughout the winter in Nebraska. Therefore, we set up acoustic detectors at rocky sites away from any known mines or caves in winter (December-March) to test for the presence of *M. septentrionalis*.

In the winter of 2015-16 we deployed acoustic detectors (SM2Bat+ with SMX-U1 microphones and SM4BAT FS with SMM-U1 microphones, Wildlife Acoustics) at 34 sites in 9 different localities with exposed rock in Nebraska (Fig. 2). Microphones were placed within 10 m of rocky outcrops. Microphones were affixed to poles and were about 2-3 m above the surface of the ground with the microphone pointed towards the rocky outcrop. Bat call sequences were recorded as full-spectrum in WAC0 (lossless compression) format and later converted to wav format using Kaleidoscope Pro software (Wildlife Acoustics). Bat passes (i.e., a sequence of bat calls) were separated into files with a maximum duration of 7 seconds. Recordings were only made on nights with temperatures at sunset above freezing (Lemen et al. 2016) and detectors

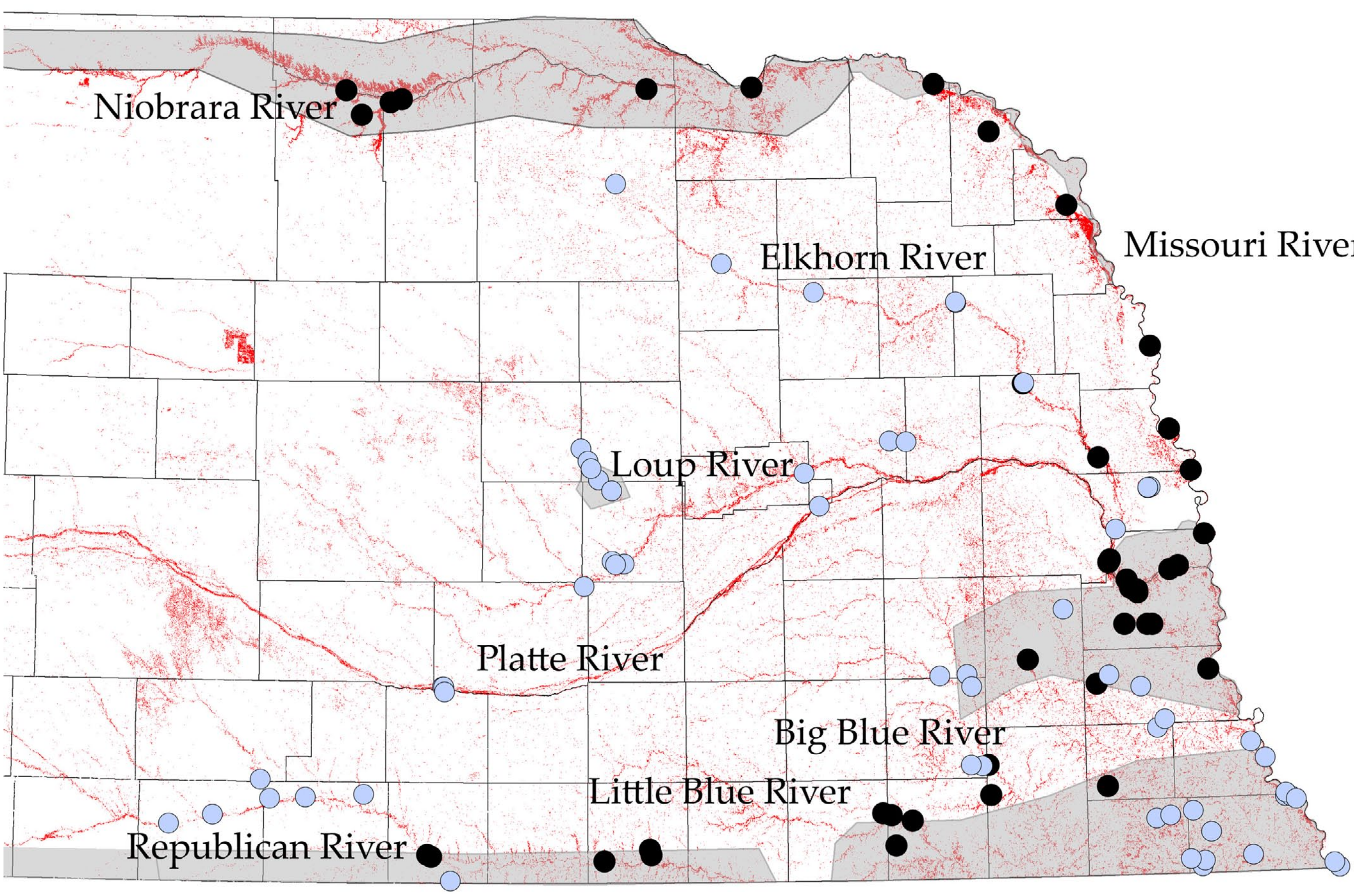

Figure 1. Presence (black circles) or absence (blue circles) of the Northern Long-eared Myotis (*Myotis septentrionalis*) based on an acoustical survey (White et al. 2016). Areas where bedrock reaches the surface are shaded in gray and based on the following maps (Burchett et al. 1972, 1975, and 1988, Dreeszen et al. 1973, Eversoll et al. 1988, Souders 2000). Forests (based on **2005 Nebraska land use** map; CALMIT, University of Nebraska Lincoln) are shown in red. Some of the major river drainages are labeled.

were only left out one or two nights at each site. We used a two-step process to identify call sequences. First, Kaleidoscope Pro (Bats of North America 3.0.0) was used to automatically identify call sequences (using the intermediate setting for accuracy/sensitivity). Second, all identifications of *M. septentrionalis, Eptesicus fuscus* and *Perimyotis subflavus* were verified by visual inspection based on methods described in White et al. (2016).

We identified the calls of *M. septentrionalis* at two of our sites (Fig. 2). Rock faces at both sites are dominated by Greenhorn limestone and Graneros shale of the late Cretaceous and are deeply cracked. At Ponca State Park there is a vertical rock face about 10 m in height. At Little Blue River the rock face is about 2.5 m high. Both of these recordings were made in December (7 December at Ponca and 21 December at Little Blue River), which suggests *M. septentrionalis* was hibernating in the rock faces (on the basis of timing of fall migration from summering grounds in eastern Nebraska; White et al. in review). In addition to *M. septentrionalis*, we recorded *P. subflavus* at the same two sites, plus an adjacent site at Ponca State Park. We identified the calls of *E. fuscus* at 22 of 34 sites. The acoustical recordings indicated all activity of *M. septentrionalis* was within 2.5 hours of darkness (sunset + 30 minutes). This same activity pattern held true for both *E. fuscus* and *P. subflavus* as well.

Eptesicus fuscus is known to use rock crevices as hibernacula (Lausen and Barclay 2006), so detection of this species flying around rocky outcrops in Nebraska in winter was not surprising. However, this is the first evidence that *P. subflavus* and *M. septentrionalis* might use rock crevices in winter. While we consider the use of rock crevices as the most likely explanation for our data, there are other possible explanations. First it is possible that the bats were using human structures in the area and not rock crevices. If *M. septentrionalis* in Nebraska is routinely using human structures for hibernation it would obviously greatly expand the number of available hibernacula. At one site where we detected *M. septentrionalis* there was a house only 200 m away. However, at the other site the nearest

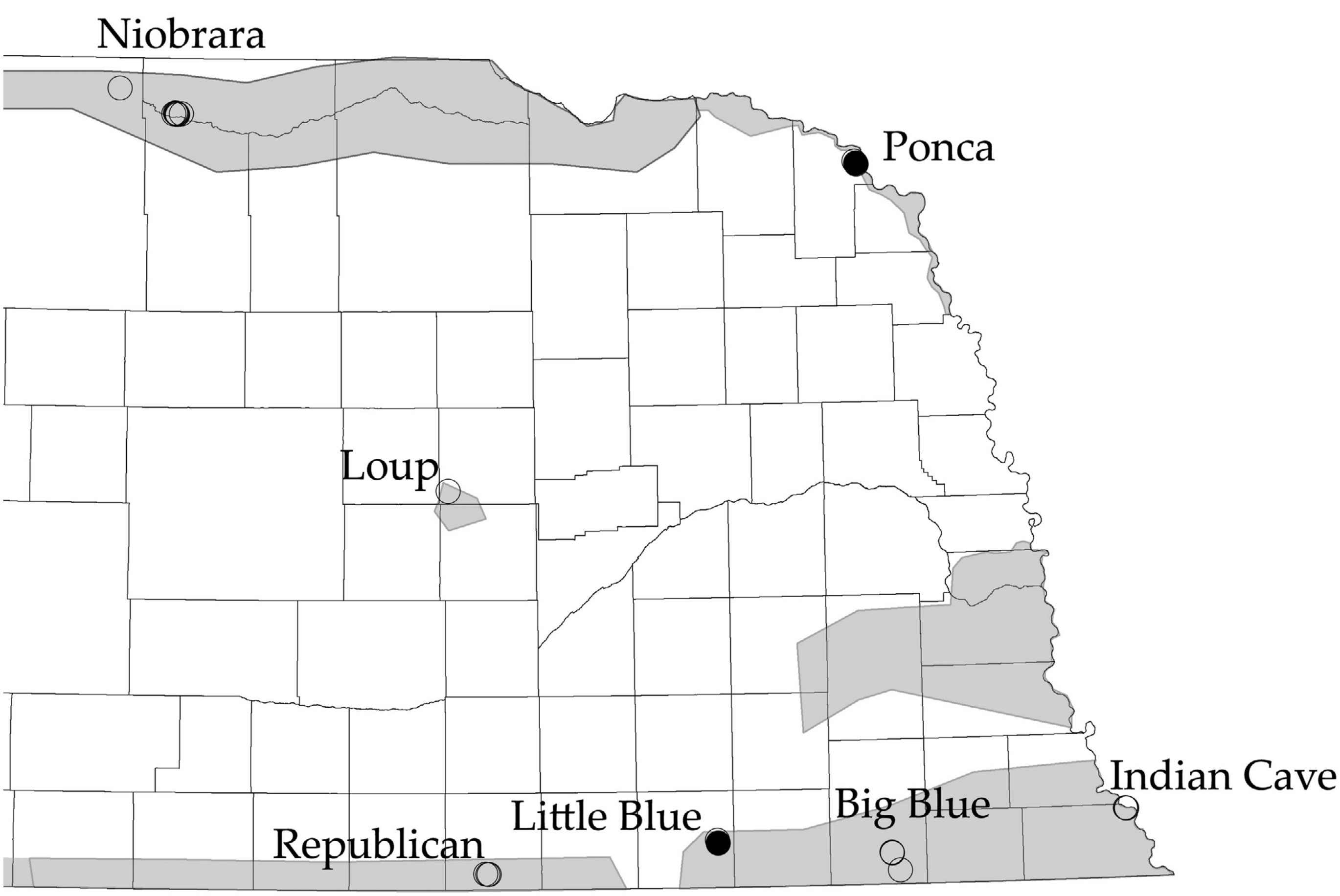

Figure 2. Presence (solid circles) or absence (open circles) of the Northern Long-eared Myotis (*Myotis septentrionalis*) from an acoustical survey of rock outcrops from December 2015 to March 2016. Areas where bedrock reaches the surface are shaded in grey and based on sources listed in Fig 1.

building was 1800 m away. The greater distance of the second site suggests to us that it is unlikely that the bats were coming from that house. A second possibility is that the bats are using sites in the surrounding forest for hibernacula. Higgens et al. (2000) noted that "some (*M. septentrionalis)* spend the winter under loose tree bark" in South Dakota. However it is not clear what evidence this statement is based on or how bats could survive the temperatures of a South Dakota winter in tree roosts.

At this point we have no idea of the ratio of bats in Nebraska that overwinter in rock faces versus those that move to mines, so it is premature to assume that rock faces play a key role in the survival of these species in this area. But, at least some individuals of these three species appear to use rock crevices as sites of hibernation, and we advocate for more research on this important topic.

Bedrock is not omnipresent in Nebraska (Figs. 1 and 2). And even in places where bedrock is found at the surface, the rocks vary considerably in their nature. In some areas there are tall cliffs that are formed naturally, for example along the Missouri River in northeastern Nebraska. In other areas quarrying has exposed large rock faces and sheer cliffs can be found. Much of the rock found along the Niobrara River, locally known as cap rock, is a soft, relatively unconsolidated rock that seems to produce fewer cracks. That said, there are many miles of these rock faces and there may be the occasional deep crack that offers a hibernaculum. In other areas with highly erodible rocks, the outcrops typically assume the same gentle slope as the hillside. The suitability of such sites as hibernacula is not known but looks doubtful to our eyes. Often the larger rock faces in such areas are found along road cuts where erosion has not had time to modify the newly exposed rock face. A general problem with finding rocky outcrops that harbor bats is that these rock faces are so widespread, even in Nebraska, that there is little to concentrate the bats in one area and make them easier to find.

We see no reason why the use of rock crevices by *M. septentrionalis* in winter would be limited to eastern Nebraska. Thus, we suggest bat biologists search for hibernacula of *M. septentrionalis*, as well as other species of bats, in rock outcrops throughout their ranges. As mentioned above, rocky areas might be so common that finding specific crevices bats use in winter could be challenging. However, as many species of bats emerge from hibernacula on winter nights with mild temperatures (e.g., Whitaker and Rissler 1992, Lausen and Barclay 2006, Lemen et al. 2016), a first step would be to place bat detectors near rock outcrops on mild winter nights. After bat calls are detected, other techniques, such as radiotelemetry (Lausen and Barclay 2006) or a thermal imaging camera, could be used to identify cracks that bats are using as hibernacula. Such research on rock faces could produce new insights into the use of cracks as hibernacula, but we would also encourage researchers to investigate other sites such as human structures, storm sewers, culverts, etc. as potential hibernacula for *M. septentrionalis.*

The use of rock faces as hibernacula by *M. septentrionalis* raises several interesting issues for the conservation of this bat. It could mean that intermediate to long distance migration is not typical in this species, which is consistent with short migratory distances reported in the literature (Caire et al. 1979, White et al. in review). If *M. septentrionalis* does not routinely travel 100's of kilometers during migration, then this could help explain why this species is one that is rarely killed at wind turbine facilities (Johnson 2005). The role of mines and caves as the obligate sites for hibernation of *M. septentrionalis* would also be challenged. Finally, the microclimate in these rock crevices might be different from that in caves and mines and could have consequences for the spread and impact of WNS on this species and others (Langwig et al. 2012). Also, if the use of rock crevices in winter is widespread in *M. septentrionalis*, and individuals are more dispersed among a larger number of hibernacula than previously thought, this species might fare better against WNS than predicted (Langwig et al. 2012, Frick et al. 2015). Moreover, with the spread of white-nose syndrome to Washington (white-nosesyndrome.org 2016), there is an immediate need to understand where western species of hibernating bats roost in winter. Few caves and mines are known to have large numbers of hibernating bats in western North America (e.g., Perkins et al. 1990, Nagorsen et al. 1993, Hendricks 2012). It is possible that some western species utilize rock crevices instead of caves and mines in winter, but currently this is unknown (Bogan et al. 2003). We agree with Weller et al. (2009) that bat research in the 21st century needs to be broadened and we hope this manuscript will spark an effort to address this gap in our understanding of the natural history hibernating bats.

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