

Characteristics of bridges used for day roosting by the federally endangered gray bat (*Myotis grisescens*) in the French Broad River basin, North Carolina

Kira L. Ware

Department of Environmental Studies
University of North Carolina at Asheville
One University Heights
Asheville, North Carolina 28804 USA

Faculty Advisors: C. Reed Rossell, Jr. and Chris Nicolay

Abstract

The gray bat (*Myotis grisescens*) is a federally endangered species that uses caves almost exclusively for roosting. In 2016, gray bats were discovered using bridges for roosting in the French Broad River basin. Objectives of this study were to document characteristics of bridges used by gray bats for day roosting and compare those characteristics to randomly selected bridges not used by gray bats. During the summer of 2018, we surveyed bridges for bats over rivers and streams within the French Broad River basin. At each bridge length, width, height above water, aspect, size of gaps between joints under the bridge, and underdeck and beam material were recorded. The presence of bats based on fresh sign (e.g., presence of guano) or visual observation was also recorded. If bats were present, experts from Indiana State University determined species identification visually, and audio detectors were used to confirm identifications. Exit counts during the early evenings also were conducted to estimate the number of gray bats roosting at each site. A total of 93 bridges were surveyed. Of those, eight bridges (9%) were used by gray bats for roosting; six spanned a river and two spanned a stream. The number of gray bats roosting ranged from 1 to more than 1000 per bridge. Occupied bridges were larger and higher above the water than unoccupied bridges, and a greater proportion was constructed of concrete and steel, but never wood. These results suggest that gray bats prefer to roost under large bridges made of concrete and steel, and avoid those made out of wood. This information increases our understanding of gray bat roosting ecology and may help to facilitate conservation efforts by NCDOT when planning new bridge projects.

1. Introduction

Myotis grisescens (gray bat) is a rare insectivorous bat that typically roosts in large numbers in limestone karst caves of the southeastern United States, primarily in Missouri, Kentucky, northern Arkansas, Tennessee, and Alabama.⁷ Gray bats were listed as federally endangered in 1976 because of declining populations.¹¹ Their decline is thought to be associated with human disturbance, vandalism, pollution, and habitat destruction of their hibernaculum and summer roost sites.^{2 10} Outside of these anthropogenic factors, the most current threat to gray bats is white nose syndrome (*Pseudogymnoascus destructans*).⁸

Gray bats are typically a cave-dwelling species.⁴ They are known to roost in only a few caves in Kentucky during the winter, and then migrate to warmer roosts throughout their range for breeding and raising their young during the spring and summer.² Gray bats also occasionally have been found roosting in human-made structures including bridges and culverts.⁴ Currently, no information is available on the attributes gray bats prefer for summer roost sites, particularly for human-made structures. In general, gray bats have been found to use day roosts that are almost always near large rivers and reservoirs.¹¹ Gray bats also are known to use warmer caves or mines for maternity roosts to support the growth of their young.²

In North Carolina, gray bats are extremely rare. They were first discovered in western North Carolina in 1968, when one banded female was found in Buncombe County, which at the time was the eastern-most sighting of this species.²

¹² In 2016, researchers discovered a few large gray bat colonies roosting under bridges in the French Broad River basin.⁶ As this is a relatively new phenomenon for gray bats, little is known about the characteristics of bridges used for roosting by this species. Therefore, the objectives of this study were to describe the attributes of bridges used for day roosting by gray bats in the French Broad River basin of North Carolina, and compare those attributes to randomly available bridges not used by gray bats to better understand what attributes may be preferred for roosting. This information will help assist NCDOT and other state agencies in their conservation efforts of gray bats when planning new bridge projects.

2. Methods

From May to July 2018, researchers from Indiana State University (ISU) with the assistance of students of the University of North Carolina at Asheville surveyed randomly selected bridges within the French Broad River basin. Bridges for surveys were selected by a random integer generator from a list of bridges provided by NCDOT. This list included all bridges of various types and sizes that occur in the French Broad River basin. As gray bats are known to prefer structures for roosting near water,¹¹ only bridges that spanned water were included in the study.

For each bridge, we looked for the presence of bats based on visual observation or fresh sign (e.g., presence of guano). Researchers from ISU visually identified the species of bats if they were seen roosting. If guano and urine staining were present, but no bats observed, then researchers from ISU returned to the bridge in the evening to verify bats roosting. Exit counts also were conducted in the early evenings to estimate the number of roosting bats, and audio detection methods were used to verify species identification.

At each bridge we recorded the length and width of the top deck, and the height above water using a meter tape or rangefinder. We also recorded its aspect using a compass (0-180°) and whether the bridge spanned a stream or river. This classification was based on the given name of the spanned body of water (e.g., French Broad River vs. Ivy Creek). We categorized the underdeck and beam material as concrete, steel, wood, or a combination of materials. We also described the size of gaps present for parallel beams and perpendicular expansion joints (if present) using the categories: < 1 cm, 1-3 cm, and 4-9 cm.

We calculated summary statistics of bridge attributes for those used by gray bats (i.e., occupied bridges) and those not used by gray bats (i.e., unoccupied bridges). We calculated deck area by multiplying the length and width. We calculated degrees from facing south by subtracting the compass bearing of a bridge's aspect from 90°. Because data were not normally distributed, we used Mann-Whitney Tests to compare numerical variables (i.e., deck area, height above water, and degrees from facing south) between occupied and unoccupied bridges. We used Fisher's Exact Tests to compare categorical variables (i.e., type of water bridge spanned, underdeck and beam material, and gap size of perpendicular and parallel beams) between occupied and unoccupied bridges. We considered all statistical comparisons significant at $\alpha < 0.05$.

3. Results

Ninety-three bridges were surveyed during the study. Of those, eight bridges (9%) were occupied by gray bats; six spanned a river and two spanned a stream. Number of gray bats roosting varied by bridge and ranged from 1 to more than 1000 bats (Table 1). There was no difference between the proportions of bridges spanning a river or stream for occupied versus unoccupied bridges ($P = 0.067$). Occupied bridges had significantly larger deck areas and were significantly higher above water than unoccupied bridges ($P = 0.0008$, $P = 0.006$, respectively; Table 2). There was no difference in degrees from facing south between occupied and unoccupied bridges ($P = 0.282$; Table 2). Underdeck material and beam material of occupied bridges were both significantly different from unoccupied bridges ($P = 0.031$, $P = 0.018$, respectively; Table 3), and there were no differences in gap size between bridge types for parallel or perpendicular beams ($P = 1.0$, $P = 0.49$, respectively; Table 4).

Table 1. Estimated numbers of gray bats roosting under bridges in the French Broad River basin, North Carolina, 2018.

Bridge	Estimated Number Roosting
1	1000 +
2	1
3	361
4	75
5	25
6	30
7	1005
8	3

Table 2. Median, 95% Confidence Intervals (CI), and *P*-values for Mann-Whitney Tests comparing deck area, height above water, and degrees from facing south for bridges occupied and unoccupied by gray bats in the French Broad River basin, North Carolina, 2018.

Variable	<u>Occupied (n = 8)</u>		<u>Unoccupied (n = 85)</u>		<i>P</i> -value
	Median	95% CI	Median	95% CI	
Deck area (m ²)	1017.6	(297.3, 1379.0)	143.1	(297.3, 1379.0)	0.0008
Height above water (m)	6.3	(0.9, 4.5)	2.9	(0.9, 4.5)	0.0063
Degrees from facing south (o)	37	(10, 30)	45	(10, 30)	0.2821

Table 3. Percentage of bridges with type of underdeck and underdeck beam material used in bridges occupied and unoccupied by gray bats in the French Broad River basin, North Carolina, 2018.

Underdeck Material

Material	Occupied (n = 8)	Unoccupied (n = 85)
Concrete	50%	43%
Steel	38%	14%
Wood	0%	39%
Concrete/steel	12%	4%

Underdeck Beam Material

Material	Occupied (n = 8)	Unoccupied (n = 85)
Concrete	75%	20%
Steel	25%	55%
Wood	0%	4%
Concrete/steel	0%	2%
Wood/steel	0%	1%
No beam	0%	18%

Table 4. Gap size between beams (longitudinal gaps) and expansion joints (perpendicular gaps) for occupied and unoccupied bridges by gray bats in the French Broad River basin, North Carolina, 2018.

Longitudinal Gaps

Gap size	Occupied (n = 8)	Unoccupied (n = 85)
< 1 cm	2	26
1-3 cm	3	12
4-9 cm	0	2
No gap	5	52

Perpendicular Gaps

Gap size	Occupied (n = 8)	Unoccupied (n = 85)
< 1 cm	0	21
1-3 cm	4	15
4-9 cm	2	1
No gap	4	52

4. Discussion

This is the first study to quantify the characteristics of bridges used for roosting by gray bats. Nine percent of the 93 bridges surveyed were used by gray bats for roosting, and three bridges contained large colonies of greater than 350 individuals (Table 1). Although no studies have previously documented large gray bat colonies roosting in bridges, gray bats are known to roost in extremely large numbers within natural structures such as caves.¹¹ In our study, three times as many bridges occupied by gray bats spanned rivers compared to streams (6 vs. 2), which suggests that bridges that are over larger bodies of water may be more attractive for roosting. However, the finding of no statistical difference between whether a bridge spanned a river or stream for occupied vs. unoccupied bridges does not support this. However, because the sample size in our study was small, caution should be used when considering the statistical results in this study. Therefore, more data are needed to further explore the possibility that gray bats prefer bridges for roosting that span larger bodies of water.

The results that gray bats roosted in bridges that were larger and higher above the water than unoccupied bridges suggest that gray bats prefer larger structures for roosting. Gray bats may require more space for roosting, as they tend to roost in extremely large numbers.¹¹ In our study, two of the largest roosts (> 1000 bats) occurred in the second and third largest bridges (i.e., deck area) of all the bridges in the study (2235 and 2200 m², respectively). The median height above water for occupied bridges in our study was 6.3 m (Table 2). This result is similar with other studies that have examined bridge height for other species of roosting bats. For example, Kelley and Tuttle reported that other bat species throughout the southeastern United States roosted in bridges that were at least 3 m above the water, and Feldhammer et al. reported that bridges used for roosting in southern Illinois had a mean height of 5 m above water.⁴

There was no significant difference in degrees from facing south between occupied and unoccupied bridges. This suggests that gray bats are not selecting bridges for roosting based on their orientation towards the sun that may provide warmer roosting conditions. It may be that the climate of western North Carolina during the spring and summer is warm enough to comfortably accommodate the thermal requirements of roost sites for gray bats, and therefore, there is no selection pressure for gray bats to seek out warmer, south-facing bridges for roosting. Warm roosting conditions are known to be beneficial to bats. Keeley and Tuttle reported that roosting bats often use sun-warmed bridges that serve as heat sinks at night to conserve energy.⁴ Bats also have been reported to locate maternity

roosts in caves with higher temperatures to promote rapid growth in their young.⁴ However, because of the small sample size in our study, more data are needed to confirm our results.

The significant differences in what materials occupied and unoccupied bridges were constructed from suggest that gray bats have a preference for bridges made out of certain types of materials. The most notable finding was that gray bats never roosted in bridges constructed out of wood. This is in stark contrast to the 39% of unoccupied bridges made out of wood (Table 3). The avoidance of wooden bridges is supported by other studies.^{1 3 4 5} Occupied bridges in our study were most often made of concrete or steel (Table 3). The reasons why gray bats may prefer concrete and steel bridges and avoid timber bridges are unknown. However, it may be that concrete and steel bridges have a greater heat-retaining capacity than wood bridges. In addition, gray bats may avoid wood bridges because of creosote. Creosote is a commonly used wood preservative used in bridge construction, and fumes from this substance can be toxic.⁹ However, additional studies are needed to investigate why gray bats may prefer certain materials in bridges over others.

No significant differences were found in gap sizes of either parallel or perpendicular (i.e., expansion joints) beams for occupied vs. unoccupied bridges, suggesting that gap size of joints may not be a limiting factor to gray bats when selecting bridges for roosting. Other studies have found that bats prefer roosting in the perpendicular expansion joints of bridges, and that bats require gaps greater than one centimeter for roosting.^{1 3 4} Gray bats most commonly used expansion joints in bridges for roosting in our study. However, because of the small sample size, and the fact that the methodology for categorizing gap size in our study was very coarse, additional studies are needed to determine what gap size may be preferred for roosting gray bats.

In conclusion, gray bats in the French Broad River basin of North Carolina selected bridges for roosting that spanned rivers more so than streams. Gray bats also preferred bridges for roosting that were larger and higher above the water than randomly available bridges. In addition, gray bats used bridges for roosting that were constructed out of concrete and steel, and avoided bridges made out of wood. Based on these results, we suggest future survey efforts focus on large, concrete or steel bridges that span larger bodies of water. These results should help facilitate NCDOT's conservation efforts for gray bats when planning and carrying out new bridge projects.

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