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Notes on Foraging Activity of Female *Myotis leibii* in Maryland

Joshua B. Johnson
J. Edward Gates
W. Mark Ford

Abstract

Information on home range and habitat characteristics of eastern small-footed myotis (*Myotis leibii*) consist only of anecdotal accounts and unpublished research despite the need for such data for conservation of this rare species. We used radio telemetry to determine foraging site selection of four female eastern small-footed myotis in Allegany County, Maryland, in spring 2007. These bats foraged within 1.8 km of their diurnal roosts and had home ranges of <100 ha. Distance-based analysis of habitat use for one foraging bat showed that it foraged farther from the Potomac River and adjacent wetlands, and closer to hilltop forests than random, conforming to expectations based on their low wing loading and broadband, high frequency echolocation call characteristics.

Cover Photos

Small-footed myotis, by Craig Stihler, West Virginia Division of Natural Resources, used with permission.

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INTRODUCTION

The eastern small-footed myotis (*Myotis leibii*) is considered among the rarest bat species in North America. Consequently, little is known about its natural history and ecology compared to sympatric bat species (Best and Jennings 1997). Foraging areas undoubtedly are a critical component of eastern small-footed myotis habitat, as with any bat species, however, information on foraging habitat selection and home range size currently is restricted to anecdotal observations and unpublished research (Erdle and Hobson 2001).

Eco-morphology predicts that eastern small-footed myotis foraging characteristics should be similar to other bat species that have comparable wing loading and echolocation call structure (Patriquin and Barclay 2003, Ford et al. 2005). For example, bats that have low wing loading and broadband, high frequency echolocation call characteristics are capable of efficiently foraging in cluttered areas such as forest canopy (Norberg and Raynor 1987, Kalcounis and Brigham 1995). Eastern small-footed myotis are known to emit broadband, high frequency echolocation calls, which are consistent with foraging in structurally cluttered forested areas (Mukhida et al. 2004). In eastern West Virginia, recent unpublished work has shown that radio-tagged eastern small-footed myotis foraged mostly in forested areas.[1] Research on food habits of eastern small-footed myotis suggests they use a gleaning strategy, possibly conducive to foraging in forest canopies (Johnson and Gates 2007, Moosman et al. 2007). In this study, our objectives were to 1) determine foraging characteristics, i.e., home range size and foraging habitat selection, of eastern small-footed myotis; and 2) consider the conformity of their foraging characteristics to predictions based on their wing morphology, echolocation call characteristics, and food habits.

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[1]C. Stihler, West Virginia Division of Natural Resources, personal communication.

The Authors

JOSHUA B. JOHNSON is a graduate research assistant, Division of Forestry and Natural Resources, West Virginia University, Morgantown, West Virginia 26506.

J. EDWARD GATES is an associate professor, University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, Maryland 21532.

W. MARK FORD formerly was a research wildlife biologist, U.S. Forest Service, Northern Research Station, Parsons, WV 26287. He currently is a research wildlife biologist, U.S. Army Engineer Research and Development Center Environmental Lab, Vicksburg, Mississippi 39180.

SITE DESCRIPTION

We conducted our research within the Chesapeake and Ohio Canal National Historical Park (CHOH) in Allegany County, Maryland within the Ridge and Valley physiographic province. Our efforts were focused at an abandoned railroad tunnel used by this and other species of bats as a hibernaculum (Johnson and Gates 2008). The area is characterized by steep slopes, shale barrens, and rock outcrops overlooking the Potomac River. Forests on the slopes and ridges are predominately oak-hickory (*Quercus* and *Carya* spp.) with some scattered Virginia pine (*Pinus virginiana*) and red cedar (*Juniperus virginiana*). Pastures and row crops comprise a minor component of the cover types on the hilltops. Yellow poplar (*Liriodendron tulipifera*), sycamore (*Platanus occidentalis*), silver maple (*Acer saccharinum*), red maple (*A. rubrum*), and river birch (*Betula nigra*) occur along the Potomac River banks and the adjacent CHOH. Ephemeral standing water and wetlands occur along some sections of the canal. An active railroad is located on the West Virginia side of the Potomac River. Elevation in the immediate area ranges from about 130 m on the Potomac River to about 275 m on the hilltops.

METHODS

We used harp traps (1.8 m × 2.3 m; Bat Conservation and Management, Carlisle, PA) to capture bats at the tunnel as they emerged from hibernation during spring 2007. We placed two harp traps side by side in both the east and west tunnel entrances to capture bats entering or exiting the tunnel. The harp traps were surrounded with tarpaulin and/or plastic netting to prevent bats from bypassing the traps. Sampling[2] was conducted 3 nights/week following sunset for four hours for 31 nights from 12 March through 16 May 2007. Each captured bat was identified to species. We measured mass (g) and forearm length (mm), and the sex of each bat was determined before its release (Kunz 1988, Menzel et al. 2002). We traced the shape of a fully extended wing of a random sample of eastern small-footed myotis to determine wing morphology and wing loading for predictions about flight performance and habitat use (Kalcounis and Brigham 1995). Wing aspect ratio was calculated by dividing the wing length by fifth phalanx length. We used a polar planimeter (Los Angeles Scientific Instrument Co., Inc., Los Angeles, CA) to measure wing surface area of each tracing. Wing loading was calculated by dividing body mass by the combined surface area of both wings and uropatagium, following Farney and Fleharty (1969).

Radio telemetry allowed us to examine foraging activity of female eastern small-footed myotis. We used surgical cement (Torbot Group, Cranston, RI) to affix a 0.35-g radio transmitter (Model LB-2N; Holohil Systems Ltd., Carp, Ontario, Canada) between the scapulae of captured female eastern small-footed myotis. The ratio of transmitter mass to body mass (mean = 8.0 percent, std. dev. = 0.4 percent, range = 7.8-8.8 percent) was similar to ratios reported in other studies on bats, including the similarly-sized eastern pipistrelle (*Perimyotis subflavus*; Best and Jennings 1997, Carter et al. 1999, Perry and Thill 2007, Veilleux et al. 2003).

We used radio receivers and three-element Yagi antennae (Advanced Telemetry Systems, Inc., Isanti, MN) to simultaneously obtain two directional bearings from known locations (i.e., telemetry stations) at 5-minute intervals (Menzel et al. 2005). We positioned telemetry stations to minimize distances to radio-tagged bats and to reduce associated location error. Telemetry station locations and bearings were entered into Locate III (Pacer Computing, Inc., Tatamagouche, NS, Canada) to obtain Universal Transverse Mercator (UTM) coordinates of each foraging location (Nams 2006). We entered coordinates of foraging locations and diurnal roost locations for each bat into ArcView 3.2 (Environmental Systems Research Institute, Redlands, CA) and used the Animal Movement Extension to calculate a home range, regardless of minimum number of locations, for each bat using the fixed kernel method based on a 95 percent confidence interval to exclude outliers (Hooge and Eichenlaub 1997, Seaman et al. 1999, Worton 1989).

[2]Bat capture and handling protocols were approved by the Institutional Animal Care and Use Committee (ACUC) of the University of Maryland Center for Environmental Science (Protocol Number F-AL-05-06) and followed the guidelines of the American Society of Mammalogists (1998).

Table 1.—Foraging characteristics of female *Myotis leibii* in Allegany County, Maryland, March-April 2007

	Foraging					
				Distance (m) [b]		
Radio frequency	Number of nights	Number of locations	Home range size (ha) [a]	Mean	SE	Range
151.098	5	74	99.7	817.4	38.0	68.7 - 1728.0
151.379	2	5	10.2	189.5	64.0	18.4 - 314.8
151.398	3	14	62.7	355.6	98.7	16.4 - 1203.4
151.417	2	10	42.4	897.8	31.9	660.1 - 1009.8

[a] 95 percent fixed kernel.
[b] Distance from foraging location to diurnal roost.

We examined foraging habitat selection of bats for which we obtained >30 locations (Aebischer et al. 1993). A raster land use/land cover (LULC) theme from the United States Geological Survey (USGS) Gap Analysis Program was converted to a LULC vector shapefile in ArcView 3.2 (USGS 2000). From the LULC vector shapefile, we created a separate vector shapefile for each LULC type, including pasture/hayfields, wetlands, deciduous forest, coniferous forest, mixed forest, and all forests combined. Separate vector shapefiles, including the Potomac River, railways, and paved roads, were included in the analysis for nine LULC types. We used distance-based analysis to examine habitat use of radio-tagged bats because it reduces the effect of radio telemetry error and Type 1 error commonly associated with other habitat use analyses, including compositional analysis (Bingham and Brennan 2004, Conner et al. 2002). Distance-based analysis compares the distances of foraging locations to each LULC type with the distance of random locations to the same LULC type (Conner et al. 2002). For each bat, we determined the maximum distance it foraged from its diurnal roost (Johnson and Gates 2008). This distance served as a radius for a buffer from which random locations were generated; this buffer was centered on a bat's diurnal roost location. To determine if eastern small-footed myotis were foraging randomly among LULC types, we used ArcView 3.2 to pair each foraging location with a random location within the buffer. Minimum Euclidean distances from every foraging and random location to every LULC type were determined. We used a Mann-Whitney test to examine differences between foraging and random location distances to each LULC type (SAS Institute, Inc. 2004; PROC NPAR1WAY). Statistical significance was set at $P \leq 0.05$.

RESULTS

We captured 47 eastern small-footed myotis: 33 males, 13 females, and one escaped before sex could be determined. We traced the wings of seven eastern small-footed myotis. Mean single wing length (± 1 SE, range) was 86.57 mm (± 4.17, 63.0-96.0), and mean fifth phalanx length was 44.29 mm (± 0.75, 40.0-46.0). Mean wing aspect ratio was 1.95 (± 0.10, 1.40-2.18). Mean total wing surface area, not including uropatagium, was 51.75 cm^2 (± 3.42, 34.55-60.83). Mean mass of bats from which wing tracings were obtained was 4.39 g (± 0.17, 3.5-5.0). Mean wing loading was 0.065 g/cm^2 (± 0.002, 0.058-0.071).

We conducted radio telemetry on four female eastern small-footed myotis from 13 March through 4 April 2007. Radio contact was maintained with all but one bat until the transmitters died or detached from the bats (mean = 8 days, range = 7-9 days). We lost the signal of one bat (frequency 151.398) after its seventh night of activity when it crossed the Potomac River into West Virginia. Radio-tagged bats were tracked 2-5 nights and we obtained 5-74 foraging locations from each (Table 1). Bats foraged within 1.8 km of their diurnal roosts and each had minimum home range of <100 ha (Table 1).

We conducted distance-based analysis of habitat use on a single bat (frequency 151.098), located 74 times during 5 nights between 27 March and 4 April 2007 (Figure 1). Compared to random locations, this bat foraged farther from railroads, the Potomac River, and wetlands. Conversely, this bat foraged closer to paved roads, pastures, coniferous forest, and mixed forest than random

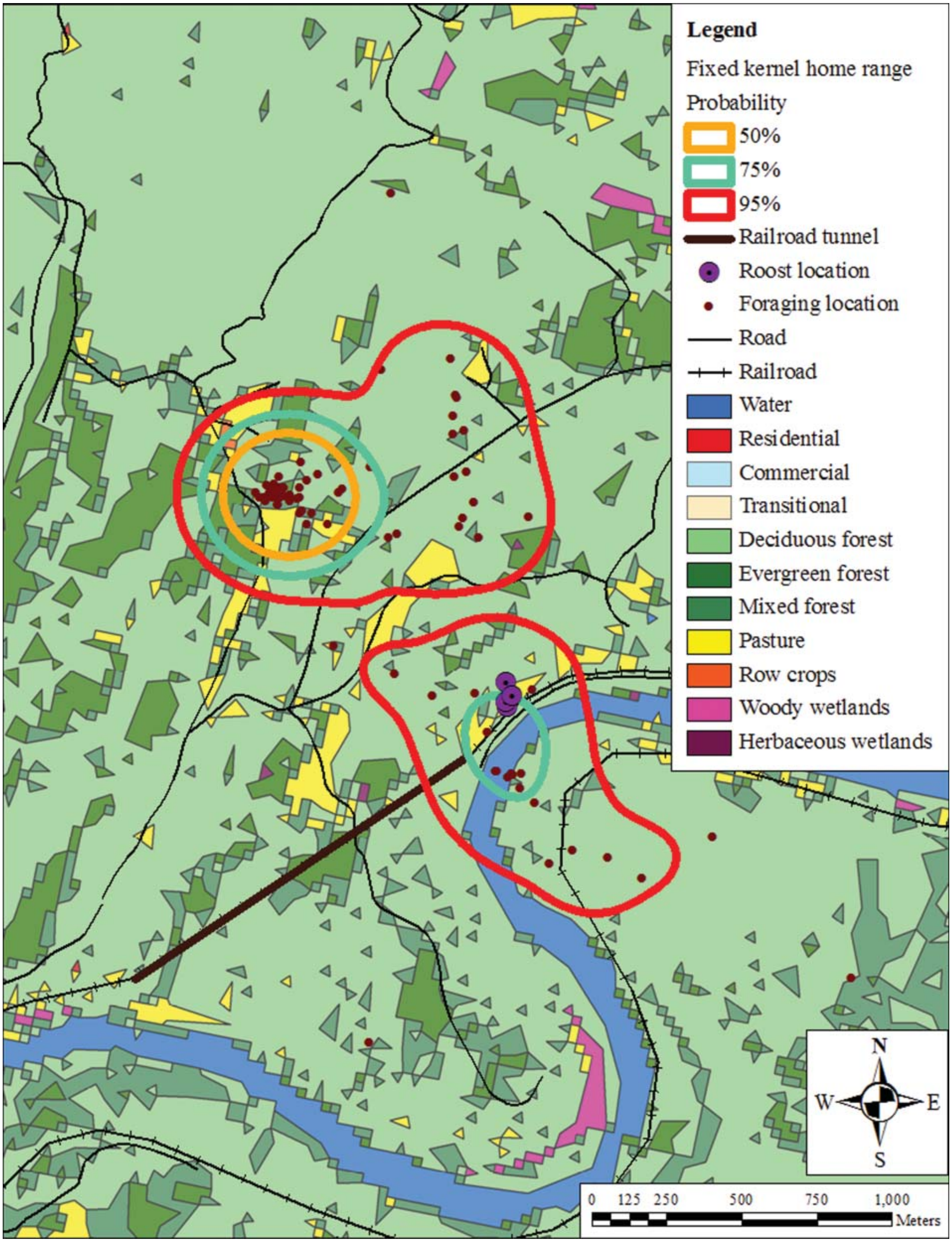

Figure 1.—Fixed kernel home range estimates for a female eastern small-footed myotis (*Myotis leibii*) in Allegany County, Maryland, spring 2007.

Table 2.—Distance-based habitat use analysis between female *Myotis leibii* (*n* = 1) foraging locations (*n* = 74) and random locations (*n* = 74) in Allegany County, Maryland, March-April 2007

	Foraging location		Random location		
Variable	Mean [a]	SE	Mean	SE	*P*
Railroad	762.4	46.4	384.3	45.4	<0.001
Potomac River	760.2	47.2	383.8	39.6	<0.001
Wetlands	585.9	24.1	365.2	22.8	<0.001
Paved roads	310.0	41.9	604.9	46.1	<0.001
Pasture	97.1	12.2	140.1	14.1	0.018
Coniferous forest	69.0	8.3	94.0	8.8	0.023
Mixed forest	39.4	5.4	54.7	5.6	0.017
Deciduous forest	6.5	1.4	6.2	1.5	0.352
All forest combined	1.0	0.4	1.4	0.6	0.958

[a] Distances (m). Tests were performed on ranked data, but actual values are shown.

locations. Distances from deciduous forest and all forest types combined did not differ ($P > 0.352$) between foraging locations and random locations (Table 2). The remaining three bats that we tracked foraged over the Potomac River, in adjacent riparian forests, and on the forested hilltops.

DISCUSSION

Our results provide insight into the home range and foraging habitat of eastern small-footed myotis, and are consistent with anecdotal observations and results of unpublished research. The foraging activity characteristics of eastern small-footed myotis may be similar to that of other myotine bats in the region, particularly that of the northern myotis. Eastern small-footed myotis have low wing loading and an echolocation call structure that is similar to that of northern myotis, which also have similar home ranges and diet preferences (Brack and Whitaker 2001, Farney and Fleharty 1969, Johnson and Gates 2007, Moosman et al. 2007, Mukhida et al. 2004, Owen et al. 2003). Bat species with low wing loading and high, frequency-modulated echolocation calls are capable of foraging efficiently in cluttered forest interiors and commonly have smaller home ranges than sympatric species in the mid-Atlantic and central Appalachian region (Kalcounis and Brigham 1995, Owen et al. 2003, Patriquin and Barclay 2003, Wund 2006). However, because we obtained >30 foraging locations for only a single eastern small-footed myotis, our results should be interpreted with caution as this individual may not be representative of the species as a whole (Girard et al. 2006). Also, we exceeded the recommended 5 percent "rule" for radio transmitter burden for the four bats that we tracked (Aldridge and Brigham 1988) and we obtained relatively few (≤14) foraging locations for three of those. Consequently, our home range calculations should be interpreted as coarse estimates for the species.

Caveats aside, our results showed that a single eastern small-footed myotis foraged more in forested areas (93.6 percent of foraging locations), particularly deciduous forests (62.8 percent), than in open areas such as pastures (2.6 percent). Also, we observed that many foraging locations were along ridge tops near day roosts, which were located in rock outcrops in shale barren slopes overlooking the Potomac River (Johnson and Gates 2008). The full extent of eastern small-footed myotis occupancy of rock outcrops in the Appalachian Mountains remains to be determined (Johnson and Gates 2008), but other known sites in Maryland have included rock outcrops such as those at High Rock, Big Savage Mountain nearby to the west.[3] Similar to other wildlife species in the region, particularly the Allegheny woodrat (*Neotoma magister*), eastern small-footed myotis are dependent on emergent rock habitats, as well as the immediately surrounding forests where they forage (Castleberry et al. 2001, Ford et al. 2006). How ongoing

[3]D. Feller, Maryland Department of Natural Resources, personal communication.

changes to ridgeline forests in the region for activities such as wind energy development (Kunz et al. 2007, Arnett et al. 2008, Baerwald et al. 2008) or recreational development (Ford et al. 2006) impacts eastern small-footed myotis foraging habitat are unknown. Accordingly a better understanding of the required spatial extent and structure of forest cover along ridgelines and rock outcrops, as well as additional foraging activity requirements, is needed to aid conservation efforts for this rare species (Johnson and Gates 2008).

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KEY WORDS: eastern small-footed myotis, habitat use, home range, Maryland, *Myotis leibii*

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