Short Note

David O. Ribble* and Galen B. Rathbun

Preliminary observations on home ranges and natural history of *Scotinomys teguina* in Costa Rica

Abstract: We conducted a brief radiotelemetry study of *Scotinomys teguina* (Alston's singing mice) in Costa Rica to better understand their natural history and spatial ecology. We radio-collared five mice, one of which was quickly eaten by a pitviper. The home ranges of the remaining mice were in moist habitats and ranged from 255 to 1620 m², with extensive overlap between adjacent individuals. Singing mice, being small, diurnal, uniformly dark-colored insectivores foraging in dense forest floor habitats, have an adaptive syndrome similar to soricids, which may be due to the low diversity of shrews through Central America.

Keywords: adaptive syndrome; Costa Rica; habitat use; home range; singing mice.

The genus *Scotinomys* Thomas, 1913 includes two small (~15 g) rodents endemic to montane cloud-forests of Central America (Buchanan and Howell 1967). *Scotinomys xerampelinus* Bangs 1902 (long-tailed brown or singing mouse) and *Scotinomys teguina* Alston 1877 (Alston's brown or singing mouse) are largely allopatric, with the former occurring only in Costa Rica and Panama and the latter from southern Mexico to Panama (Hooper 1972, Hooper and Carleton 1976). Localized sympatry occurs in Costa Rica and Panama with *S. xerampelinus* occurring at 2200–2900 m and the other at 1000–2900 m (Pasch et al. 2013). Although the behavior of both species has been studied in captivity (Hooper and Carleton 1976), less research has been done on their ecology, but it is known that they nest, and forage for small invertebrate prey, in

the dense leaf and log litter of forests and forest edges (Hooper 1972). The life history of *Scotinomys* compared to most small rodents is of particular interest because they are diurnal and they vocalize or sing (Miller and Engstrom 2007, Pasch et al. 2013). Their social structure has not been studied extensively (but see Blondel et al. 2009), thus how the vocalizations function socially is unknown, despite considerable speculation (Campbell et al. 2014). Our objective in this study was to gather information on the spatial and behavioral ecology of *S. teguina* (Figure 1) that would build on the insights gained from studies of captives (Hooper and Carleton 1976).

We studied *Scotinomys teguina* at the Monteverde Biological Station (MBS) located on the Pacific slope of the Tilaran Mountain Range of Costa Rica. The MBS property ranges in elevation from 1400 to 1800 m and is dominated by tropical cloud forest habitat with trees 25–40 m in height forming a closed canopy with a relatively open understory (Haber 2000). The area is characterized by a dry season from late December to mid-May that is followed by a wet season. We started our 2-week radiotelemetry study on 27 April 2016, and the wet season began the following week with nearly daily thunder and rain storms.

We used PicoPip radio transmitters (Biotrack, UK) that weighed 0.29 g and had a predicted battery life of ~23 days with a pulse length of 12 ms and pulse rate of 30 per min. We attached the 151 MHz radio transmitters to small nylon cable-ties that we preformed to the size and shape of *Scotinomys teguina* neck by heating the collar in hot cooking oil and molding it in a ~6 mm diameter circle near the locking-tab of the cable-tie. The transmitter was secured to the cable-tie with stainless fishing leader wire (Surflon 1×7 5 kg test with black nylon coating) with an aluminum jewelry crimp (Beadon #0, 0.8 mm) and then glued with super glue. The 4-cm-long antenna was threaded around the cable-tie collar. The complete radio-collars weighed on average 0.49 g (0.46 – 0.51 g) which was ~4% of the mean body mass of *S. teguina*. To avoid anesthetizing the mice, one of us hand-held a mouse by the tail and hips in a thin cotton cloth bag, leaving the head exposed, while the other slipped the radio collar over the head while the mouse aggressively savaged a

*Corresponding author: David O. Ribble, Department of Biology, Trinity University, One Trinity Place, San Antonio, TX 78212, USA; and Monteverde Institute, APDO 69-5655, Monteverde, Puntarenas, Costa Rica, e-mail: dribble@trinity.edu
Galen B. Rathbun: Department of Birds and Mammals, California Academy of Sciences (San Francisco), P.O. Box 202, Cambria, CA 93428, USA

Figure 1: Radio-collared *Scotinomys teguina* (28 April 2016, #22 in Table 1) at creek-side study site (Figure 2) in cloud forest habitat, Monteverde Biological Station, Costa Rica (84.847 W, 10.3197 N). Image GBR © California Academy of Sciences.
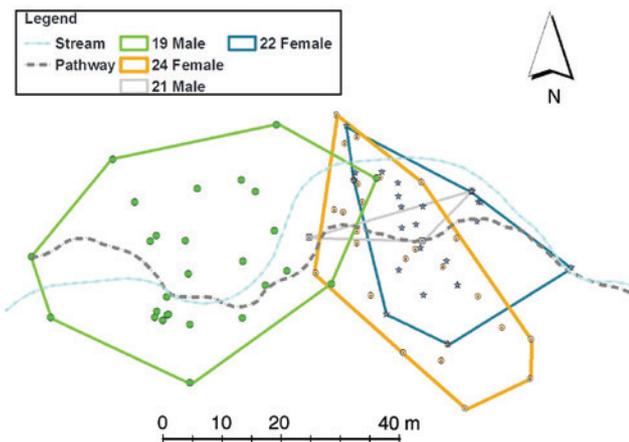

Figure 2: Minimum convex polygons (MCP) of *Scotinomys teguina* radio telemetry locations recorded 27 April–11 May 2016 at the Monteverde Biological Station, Costa Rica.
The colors of the locations match the outline color of the MCP. Male 21 was located for only 3 days before being eaten by a snake (see text). Home range of female #20 located near the Biological Station is not shown.

pencil eraser. We then tightened the cable-tie appropriately, cut off the excess cable-tie, and released the mouse at the capture site (Figure 2). At the end of our study we attempted to live-trap every radio collared *S. teguina* to remove the transmitters (Table 1).

We began collecting radio locations on individuals at least 1-h after release. *Scotinomys teguina* are reportedly largely diurnal (Hooper and Carleton 1976), so we collected data during daylight between 0600 and 1800 h every day, and during one night. We separated locations by at least 1 h to avoid spatial auto-correlation. We systematically walked along the stream-side trail that bisected our study area (Figure 2) and scanned for the transmitter frequencies with a hand-held Telonics TR-4 receiver and a two-element antenna (Telonics, Inc., Mesa, AZ, USA) and then homed in on each location. We recorded if a mouse was active or not based on radio signal traits. Due to the dense tree canopy cover and surrounding high slopes, it was impossible to use a GPS receiver to record locations reliably, but a few trap locations were recorded with a Trimble XT receiver and differentially corrected to ±1 m. The locations of the remaining trapping stations and all the mice (transmitters) were determined based on the distance (tape-measure) and bearing (hand-held magnetic compass) from the GPS-determined trap locations. All locations were mapped using ArcMap 10.4.1 (ESRI, Redlands, CA, USA) and the home-range size was calculated from the minimum convex polygon that encompassed all locations.

We radio-collared four *Scotinomys teguina* (two males and two females) along the intermittent creek (Figure 2) and one female behind the MBS field station (#20; Table 1). None of the females had any obvious indication of being in reproductive condition (none pregnant, lactating, or in estrus), but both males had descended testes. The home range of #20 is not plotted because it was 400 m from the stream site. Male #21, 3 days after he was radio-collared, was recorded between 0800 and 1720 h at the same four locations on the ground under a mound of dense forest debris. The next morning at approximately 0600 h we

Table 1: Home range statistics and demographics of radio-collared *Scotinomys teguina*.

Demographics				Radiotelemetry data					
ID	Sex	Breeding condition	Wt (g)	Total (n)	Unique (n)	Days monitored	Home-range size (m²)	% Active[a]	Fate of transmitter
19	M	Scrotal	12.0	31	26	7	1620	90	Remained
20	F	Not	15.5	9	5	6	255	56	Remained
21	M	Scrotal	13.5	6	3	2	84	–	Predation
22	F	Not	11.5	29	20	12	697	72	Removed
24	F	Not	14.0	35	27	13	913	83	Remained

[a]% Active is the percentage of all locations in which the mouse was determined to be active.

discovered the signal in a tree about 2 m above the mound coming from a Side-striped Palm Pitviper (*Bothriechis lateralis*, Peters 1862) snake with an obvious mid-body bulge.

All four *Scotinomys teguina* overlapped with each other (Figure 2), and females #22 and #24 overlapped extensively (e.g. 68% of the home range of #22 was overlapped by #24; and 52% of #24 was overlapped by #22). Furthermore, on five occasions #24 was radio located within a few meters of #22. We rarely saw the radio-tagged mice, despite being within a few meters of them. The ground-level microhabitat, especially where they tended to shelter or be inactive, was very complex and dense, suggesting that these animals were following trails to escape detection. In addition, their dark uniform coloration made them very difficult to spot, even when they were at eye-level high on stream banks or singing. We heard singing coming from the direction of male #19 on three occasions, all before 0800 h, and singing from female #24 once at 0700 h.

Female #20 was radio-collared behind the primary MBS field station building (Table 1). She was captured in a 3-m diameter pile of discarded construction wood along the forest edge, and spent her time either along the edge of the forest (67% of locations) or 20-m from the edge across a lawn in an irrigated flower garden (33%). We never radio tracked this mouse in the dry interior forest beyond the edge. When located in the groomed garden bed that lacked much surface litter, this mouse was located below the surface in open-mouthed vertical burrows at the lawn and flower bed interface.

The close association of *Scotinomys teguina* with the moist habitats, including the stream bed (Figure 2) and irrigated garden during the dry season was corroborated when one of us (DOR) returned to our study site in December 2016 at the end of the rainy season and in 80 trap-days failed to capture any *S. teguina* along the creek. The association with moist habitats, including moist meadows (Hooper 1972, Hooper and Carleton 1976) is important in determining the distribution of *S. teguina*, which may include seasonal shifts associated with seasonal rains and prey availability (Hooper and Carleton 1976).

Blondel et al. (2009) studied the home ranges of *Scotinomys xerampelinus* using radiotelemetry and live-trapping, but because they only had on average ~8 locations/individual it is difficult to compare their results with ours. They did observe that males and females overlapped with multiple individuals of both sexes, similar to what we observed with *S. teguina*. Unfortunately, the number of individuals we radio-tracked is too low to conclude much about the social structure of *S. teguina*, other than they do not have a highly structured social structure (e.g. monogamy or polygyny).

Much of the natural history of *Scotinomys* is more similar to that of soricid shrews than most new world rodents (e.g. *Peromyscus*). For example, many shrews forage along trails through and under the dense forest floor litter (Churchfield 1990), similar to what we and Hooper and Carleton (1976) found in *S. teguina*. Likely related to this crypsis, many shrews lack counter-shading in their pelage, as does *Scotinomys* (Reid 1997, figure 1). Many shrews, especially the smaller species, are insectivores associated with wet and damp habitats, which is probably partially related to their very small body size, sometimes high metabolism, and need for abundant prey – likely related to several life history traits, but especially the need to reduce high respiratory water loss (McNab 2002). The similar association of *S. teguina* to moist habitats may also be related to their small size and insectivorous diet. In soricids, social organization and intraspecific behavior is mediated through strong odors and vocalizations for intraspecific communication (Churchfield 1990), traits we observed in *S. teguina* and documented by Hooper and Carleton (1976). As noted by many authors, the insectivorous shrews are remarkably aggressive (see review in Churchfield 1990), which we and Hooper and Carleton (1976) have noted for *S. teguina*.

Shrew diversity and abundance decreases remarkably from north to south in the Americas (Churchfield 1990). There are only about 19 species of shrews that occur in southern Mexico and Central America north of Colombia, and few appear to be very abundant (Reid 1997, Timm and LaVal 2000). We speculate that *Scotinomys* may have evolved this adaptive syndrome (Brooks and McLennan 1991) that is similar to soricid shrews in part due to the decline in shrew diversity through Central America into South America.

Much of the natural history and social behavior of singing mice remains unknown in natural populations. We believe this is fertile ground to explore in natural populations to better understand the context of their singing behavior as well as to understand their unique adaptive syndrome compared to other new world rodents.

by the animal use committee at Trinity University (no. 050615 DR1). Finally, we thank the Costa Rican National Conservation System for sanctioning this research (SINAC Research Permit no.: 014-2016-INV-ACAT).

References

Blondel, D.V., J. Pino and S.M. Phelps. 2009. Space use and social structure of long-tailed singing mice (*Scotinomys xerampelinus*). J. Mamm. 90: 715–723.

Brooks, D.R. and D.A. McLennan. 1991. Phylogeny, ecology, and behavior – a research program in comparative biology. The University of Chicago Press, Chicago.

Buchanan, O.M. and T.R. Howell. 1967. Zoogeography of *Scotinomys* in middle America, with the description of a new subspecies from Nicaragua. J. Mamm. 48: 414–419.

Campbell, P., B. Pasch, A.L. Warren and S.M. Phelps. 2014. Vocal ontogeny in neotropical singing mice (*Scotinomys*). PLoS One 9: e113628.

Churchfield, S. 1990. The natural history of shrews. Cornell University Press, Ithaca.

Haber, W.A. 2000. Plants and vegetation. In: (N.M. Nadkarni and N.T. Wheelwright, eds.) Monteverde – ecology and conservation of a tropical cloud forest. Oxford University Press, New York. pp. 39–94.

Hooper, E.T. 1972. A synopsis of the rodent genus *Scotinomys*. Occas. Pap. Mus. Zool. Univ. Mich. (Ann Arbor) 665: 1–32.

Hooper, E.T. and M.D. Carleton. 1976. Reproduction, growth and development in two contiguously allopatric rodent species, genus *Scotinomys*. Misc. Publ. Mus. Zool. Univ. Michigan 151: 1–52.

McNab, B.N. 2002. The physiological ecology of vertebrates – a view from energetics. Comstock Publishing Associates, Cornell University Press, Ithaca, NY.

Miller, J.R. and M.D. Engstrom. 2007. Vocal stereotypy and singing behavior in Baiomyine mice. J. Mamm. 88: 1447–1465.

Pasch, B., B.M. Bolker and S.M. Phelps. 2013. Interspecific dominance via vocal interactions mediates altitudinal zonation in neotropical singing mice. Am. Nat. 182: E161–E173.

Reid, F.A. 1997. A field guide to the mammals of Central America and Southeastern Mexico. Oxford University Press, NY.

Timm, R.M. and R.K. LaVal. 2000. Mammals. In: (N.M. Nadkarni and N.T. Wheelwright, eds.) Monteverde – ecology and conservation of a tropical cloud forest. Oxford University Press, New York. pp. 223–244.