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Roosts Used by *Sturnira lilium* (Chiroptera: Phyllostomidae) in Belize[1]

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ABSTRACT

Between 9 and 22 January 1999, radio-tracking revealed that nine *Sturnira lilium* (seven females, one lactating, and two males) used hollow trees ($N = 5$), vine tangles ($N = 2$), or the bases of palm fronds ($N = 1$) as day roosts near Lamanai in Belize over 43 roost days. The bats roosted in hollows of four tree species, and the roost entrances ranged from 2.0 to 7.9 m above the ground. Radio-tagged individuals returned to the same roosts day after day, with the exception of a subadult female that used at least three day roosts over the course of the study. In their day roosts, *S. lilium* were inconspicuous, difficult to flush, and easily overlooked. Radio-tagged bats usually roosted alone and emerged significantly later than bats without radio tags.

Key words: *day roosts; hollow trees; Lamanai; palms; roost fidelity; vine tangles.*

Day roosts are crucial resources for bats because they provide protection from the weather and predators; some also offer conditions favorable for raising young (Kunz 1982). In spite of this, for many species of bats we have little or no knowledge regarding day roosts. Even when researchers have worked systematically to locate roosts, lack of information is the rule rather than the exception. For example, Simmons and Voss (1998) searched intensively for roosts and reported data on roosts for 30 of 78 species from their study area in French Guiana. Many bats are secretive and inconspicuous when roosting, but radio-tracking can be an effective way to locate them in their roosts (*e.g.*, Morrison 1979, 1980).

Lack of information about day roosts prevails even for some commonly captured bats. For example, although bats of the genus *Sturnira* (in many cases, *S. lilium*) are among the most often captured in mist nets at many Neotropical sites, they rarely have been found in roosts. *Sturnira lilium* are believed to roost in caves, culverts, buildings, and hollow trees (Goodwin & Greenhall 1961, Villa-R. 1966, Gannon *et al.* 1989). Captures in mist nets indicate that *S. lilium* use caves as night roosts (M. D. Engstrom, pers. comm.), but there are few records of caves being used as day roosts (Villa-R. 1966). As caves are checked routinely during the day by those studying bats, the relative absence of *S. lilium* suggests that this species uses other day roosts. Furthermore, it is not clear whether individuals of *S. lilium* typically roost in groups, solitarily, or some mixture of the two. Wohlgenant (1994) found that individuals he caught together roosted together in a captive situation.

The discrepancy between the frequency of *S. lilium* being captured in mist nets as opposed to being found in roosts raises questions about patterns of habitat use. *Sturnira* species often are caught in greater numbers in habitats that represent mosaics of vegetation, such as disturbed sites (*e.g.*, Fenton *et al.* 1992, Brossett *et al.* 1996), compared to intact rain forest (*e.g.*, Brosset *et al.* 1996, Simmons & Voss 1998). This may reflect a dichotomy of needs between foraging and roosting *S. lilium*.

Body size (12–18 g), a generalist diet, and activity in a variety of habitats (Gannon *et al.* 1989)

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TABLE 1. Sturnira lilium *radio-tagged during this study, showing the sizes of the bats (0.47-g transmitters = 2.8–3.9% of the body masses of the bats) and the numbers of the roosts they used (Table 2). Also shown are the dates the bats were tagged, the dates we lost contact with them, and the number of roost days we followed each individual. Flact = lactating female; Fsa = subadult female. Bat with tag no. 824 was killed by a predator; bat with tag no. 865 changed roosts.*

Tag no.	Sex	Forearm (mm)	Mass (g)	Date tagged (Jan.)	Date lost (Jan.)	Roosts used	Roost days
719	F	38.1	15.2	9	10	—	0
753	F	37.5	15.7	9	10	—	0
764	F	37.8	15.3	9	20	3	9
783	F	40.0	15.4	9	12	1	2
803	F	38.9	14.5	10	11	—	0
812	F	39.9	15.8	10	20	2	10
824	F	37.9	15.1	11	12	—	0
835	M	38.2	12.8	11	14	4	2
845	M	38.1	14.8	11	12	0	0
852	F	38.8	13.0	13	17	6	3
865	Fsa	37.3	12.5	13	20	7, 9	4
873	F	37.9	13.0	13	20	5	7
926	F	38.0	14.0	18	19	—	0
946	Flact	38.4	14.5	18	20	2	2
951	F	37.7	14.0	17	18	—	0
962	M	37.9	17.7	16	20	8	4
982	M	37.5	14.1	15	16	—	0

together suggest that *S. lilium* should roost relatively close to the areas in which they forage. The purpose of this study was to locate the day roosts used by *S. lilium* near Lamanai, a Mayan archaeological site in Orange Walk County, Belize (17°45.119′N, 88°39.247′W). We used radiotelemetry to locate tagged bats between 9 and 22 January 1999, commencing six days after the full moon, a time when sunset occurred at *ca* 1755 h. The vegetation in our study area was tall, broadleaved deciduous forest rich in lime-loving species, adjoining cleared areas used in agriculture.

MATERIALS AND METHODS

Over the course of five nights, we captured 65 *S. lilium* (19.5% of the total bats caught) and put radio transmitters on 17 individuals (Table 1), 4 males and 13 females (1 lactating). Adult bats were distinguished from subadults by the degree of ossification in the metacarpal–phalange joint of the third finger. Most bats that received radio tags were caught between 1800 and 1830 h. We netted *S. lilium* along trails and roads in the forest (12 bats that received radio tags), at the margins of forests, and in agricultural or other artificial clearings (5 bats). We used Holohil LB- 2 radio transmitters (0.47 g, always < 4% of the bat's body mass; Table 1) attached to the mid-dorsum of the bats using Skin Bond® adhesive and released radio-tagged bats within 30 minutes of capture at the site of capture. We located roosts everyday by walking slowly along existing trails while scanning for signals on the frequencies of all of radio transmitters attached to bats. Observers, in touch by walkie-talkies and equipped with Lotek SRX 400 receivers operated with Yagi 5 element antennae, searched the area for radio-tagged bats. The effective range of the transmitters varied. When the observers were scanning from atop one of the Mayan temples, the range was 1.5 km; from ground level, 500 m was more common, and in some cases, <100 m.

By stationing observers at known roosts before dusk, we used visual observation to estimate the numbers of bats emerging from roosts. The number of observers per roost varied according to the situation. In some cases, the roost entrance was obvious, and one observer could document the emergence. In other situations, for example, when bats were roosting among tangles of vines, two or three observers were required to count emerging bats.

RESULTS

We could not locate the roosts used by eight of the radio-tagged bats (six females, two males), which appeared to have left the study area. From an aircraft, we detected the signal from one of these bats in an area of forest *ca* 3.2 km south of its capture site. A faint signal from another was detected once from forest habitat west of a Mayan temple, but in neither case could we locate these bats' day roosts from the ground. The transmitter of a third bat was shed three days after it had been attached. Another radio-tagged bat was caught, killed, and buried intact by an unknown predator. Our roost data come from nine of the radio-tagged bats (Table 1).

The radio-tagged bats roosted in hollows of trees (*N* = 5), in vine tangles (*N* = 3), or at the bases of palm fronds (*N* = 1; Table 2). The small sample sizes precluded statistical analysis, but while one male roosted in a tangle and the other in a hollow tree, females used all three roost situations; the lactating female roosted in a hollow tree. We tracked radio-tagged bats for a total of 43 roost days (one bat with a radio transmitter in a roost on one day = one roost day). Each of three radio-tagged females returned to the same roost seven (hollow tree), nine (palm), and ten (vine tangle)

TABLE 2. *The characteristics of the roosts used by radio-tagged* Sturnira lilium. *For each roost (numbered), the roost situation, the scientific name(s) of the plants involved (when available), the circumference at breast height (CBH) when the roost was in a tree or a palm, the height of the roost opening, and the nature of the entrance to the roost are provided. The number of nights we counted emergences from roosts and the numbers of bats emerging each night are shown.*

Roost no.	Type	Scientific name	CBH (m)	Height of roost opening (m)	Entrance	No. of emergences	No. of bats
1	Hollow tree	*Bursera simarubra*	2.2	7.9	Branch hole	2	1, 1
2	Vine tangle			2.9		7	1, 1, 3, 1, 1, 2, 2
3	Palm	*Attalea cohune*	1.4	7.6	Palm fronds	4	10, 5, 2, 1
4	Vine tangle	*Distictis* sp.				3	3, 3, 1
		Solanum sp.		2.1	Small gap		
5	Hollow tree	*Guazuma ulmifolia*	1.0	—		2	1, 1
6	Hollow tree	*G. ulmifolia*	1.0	6.1	Branch hole	3	1, 1, 1
7	Hollow tree	*Pimenta officinalis*	1.3	4.5	Crack and branch hole	2	3, 4
8	Hollow tree	*Pithecellobium arboreum*	3.3	7.0	Woodpecker hole	4	1, 1, 1, 1
9	Vine tangle			2.0		0	
				16.0			

consecutive days, respectively. One individual, a subadult female, changed roosts during the lifetime of the transmitter. It first roosted in a hollow of an allspice tree (roost 7; Tables 1 and 2) for two days (14 and 15 January); we then lost the signal for three days, after which the bat roosted in a vine tangle (roost 9) during the day on 19 and 20 January. Otherwise, bats used the same roosts repeatedly during the study (43 roost days).

The bats were very inconspicuous in their day roosts. In spite of tracking *S. lilium* to specific vine tangle roosts, we never spotted roosting bats in these situations, even though we could approach them to within 1 m. Furthermore, in the vine tangle roosts, the bats were not easily disturbed. Only if we literally "beat the bushes" within 1 or 2 m of the bats could we flush them from their roosts. Similarly, we never saw bats roosting in the tree hollows.

The appearance and disappearance of the signals from bats such as the one noted above and the complete disappearance of some radio-tagged bats suggest that *S. lilium* have relatively large home ranges. The longest movement we recorded was the 3.2 km noted above. Other bats had moved 50–1400 m ($\bar{x} = 636 \pm 511$ m; $N = 9$) between their points of capture and their roosts.

The *S. lilium* that we radio-tagged tended to roost alone or in small groups, based on the numbers of bats observed emerging from known roosts (Table 2). Bats with radio tags emerged significantly later than untagged animals (47.7 ± 13.9 min after 1730 h, $N = 25$ vs. 22.9 ± 10 min after 1730 h, $N = 23$) that we observed ($t = 7.46$, df $= 22$; $P < 0.01$); however, since we observed roosts until the radio-tagged individuals left (or until it was too dark to see), it is possible that other animals left the roosts after we terminated our observations.

DISCUSSION

Our results, obtained during a two-week period in the dry season, indicated that *S. lilium* roosted alone or in small groups inside hollows, at the bases of palm fronds, or within tangles of vegetation. Our data generally agreed with Wohlgenant's (1994) report that *S. lilium* preferred shallow to deep roosts (*i.e.*, roosted close to the entrances). Furthermore, roosting *S. lilium* were not particularly sensitive to disturbance. This combination of circumstances and the fact that roosts tended to be at least 2 m above the ground, may explain why there are so few reports of roosting *S. lilium* despite concerted efforts to find roosts (*e.g.*, Simmons & Voss 1998). In other species, height of the roost above the ground can affect group size (Morrison 1980), and for those in foliage, this will influence the conspicuousness of the bats. Other bats have been reported roosting in vine tangles, including both frugivores (*e.g.*, *Cynopterus* species; Kunz 1982) and insectivores (*e.g.*, *Lasiurus* species; Constantine 1966, Barclay 1984).

Radio-tagged *S. lilium* often moved >1 km between capture sites and roosts, similar in magnitude to movements reported between feeding areas and roosts for the similarly sized *C. perspicillata* (Heithaus & Fleming 1978, Fleming & Heithaus

1986). Capture sites, however, are an interruption of normal flight activity; thus it is difficult to put these data in perspective to foraging area. Larger fruit-eating bats moved greater distances from roosts to foraging areas (2.5 km for *Artibeus lituratus,* 60 g, and *Vampyrodes caraccioli,* 40 g; Morrison 1980). Similarly sized (15 g) aerial-feeding insectivorous species appeared to cover much larger areas when foraging (*e.g.,* Fenton & Rautenbach 1986, Brigham 1991, Robinson & Stebbings 1997, Wilkinson & Barclay 1997); many gleaners were more sedentary, like the fruit eaters (*e.g.,* Fenton *et al.* 1990).

Radio transmitters can affect the maneuverability of bats (Aldridge & Brigham 1988), and even small tags can increase the cost of flight in pigeons (Gessaman & Nagy 1988, Obrecht *et al.* 1988). The tags we used were below the "five-percent rule" recommended by Aldridge and Brigham (1988). At the same time, however, radio transmitters may not have an obvious effect on foraging efficiency of the aerial-feeding insectivore *Lasiurus cinereus* (Hickey 1992). Our observation that radio-tagged *S. lilium* emerged significantly later than untagged bats suggests a previously unreported effect of transmitters.

The *S. lilium* we studied were as "roost-faithful" as some other phyllostomids (Vehrencamp *et al.* 1977, Heithaus & Fleming 1978, Morrison 1979, McCracken & Bradbury 1981, Fleming & Heithaus 1986). Other phyllostomids are much less roost-faithful, moving frequently between roosts (*e.g.,* Heithaus & Fleming 1978; Morrison 1979, 1980; Wilkinson 1985; Fleming & Heithaus 1986; Brooke 1990; Lewis 1992). Radio-tagged *S. lilium* were very roost-faithful compared to other species roosting in hollow trees elsewhere (Fenton & Rautenbach 1986; Brigham 1991; Vonhof & Barclay 1996, 1997). While some foliage-roosting species return to the same general area repeatedly (*e.g.,* Morrison 1980, Fenton *et al.* 1985), tent-making species (*e.g.,* Lewis 1992) appear to move between a suite of roosts, in a manner similar to the use of hollow trees by certain vespertilionids (*e.g.*, Fenton & Rautenbach 1986, Brigham 1991, Vonhof & Barclay 1996). Patterns of roost-fidelity may affect/reflect the social structure of the species involved (*e.g.*, Wilkinson 1992). Lewis (1995, 1996) suggested that roost-fidelity appeared to reflect the relative abundance and permanence of roosts, but our data from one season for *S. lilium* provide equivocal support for this proposal (tangles and fronds vs. hollows).

Radio-tracking studies have revealed the wide range of roosts used by a variety of temperate and tropical bats, from birds' nests (*e.g.,* Schulz 1995) to crevices in rocks (*e.g.,* Brigham 1991, Lewis 1996), or under the bark of trees (*e.g.,* Vonhof & Barclay 1996, 1997; Brigham *et al.* 1997; Rabe *et al.* 1998). Some species use a wide range of roosts (*e.g.*, Morrison 1979, Vonhof & Barclay 1997), while others use a smaller selection (*e.g.*, Fenton 1983, Fenton & Rautenbach 1986, Cloutier & Thomas 1992, Simmons & Voss 1998). It is not clear if the different roosts used by *S. lilium* and *A. jamaicensis,* for example, offer temperature regimes appropriate to different situations facing the bats. In other species, pregnant and lactating females use different roosts than males and nonreproductive females (Kunz 1982, Hamilton & Barclay 1994).

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LITERATURE CITED

Aldridge, H. D. N., and R. M. Brigham. 1988. Load carrying and maneuverability in an insectivorous bat: a test of the 5% rule of radio-telemetry. J. Mammal. 69: 379–382.

Barclay, R. M. R. 1984. Observations on the migration, ecology, and behaviour of bats at Delta Marsh, Manitoba. Can. Field-Nat. 98: 331–336.

Brigham, R. M. 1991. Flexibility in foraging and roosting behaviour by the big brown bat (*Eptesicus fuscus*). Can. J. Zool. 69: 117–121.

———, M. J. Vonhof, R. M. R. Barclay, and J. C. Gwilliam. 1997. Roosting behavior and roost-site preferences of forest-dwelling California bats (*Myotis californicus*). J. Mammal. 78: 1231–1239.

Brooke, A. P. 1990. Tent selection, roosting ecology, and social organization of the tent-making bat, *Ectophylla alba,* in Costa Rica. J. Zool. 221: 11–19.

Brosset, A., P. Charles-Dominique, A. Cockle, J.-F. Cosson, and D. Masson. 1996. Bat communities and deforestation in French Guiana. Can. J. Zool. 74: 1974–1982.

Cloutier, D., and D. W. Thomas. 1992. *Carollia perspicillata.* Mammal. Species 417: 1–9.

Constantine, D. G. 1966. Ecological observations on lasiurine bats roosting in Iowa. J. Mammal. 47: 34–41.

Fenton, M. B. 1983. Roosts used by the African bat *Scotophilus leucogaster* (Chiroptera: Vespertilionidae). Biotropica 15:129–132.

———, Acharya, D. Audet, M. B. C. Hickey, C. Merriman, M. K. Obrist, D. M. Syme, and B. Adkins. 1992. Phyllostomid bats (Chiroptera: Phyllostomidae) as indicators of habitat disruption in the Neotropics. Biotropica 24: 440–446.

———, R. M. Brigham, A. M. Mills, and I. L. Rautenbach. 1985. The roosting and foraging areas of *Epomophorus wahlbergi* (Pteropodidae) and *Scotophilus viridis* (Vespertilionidae) in Kruger National Park, South Africa. J. Mammal. 66: 461–468.

———, and I. L. Rautenbach. 1986. A comparison of the roosting and foraging behaviour of three species of African insectivorous bats. Can. J. Zool. 64: 2860–2867.

———, C. M. Swanepoel, R. M. Brigham, J. E. Cebek, and M. B. C. Hickey. 1990. Foraging behavior and prey selection by large slit-faced bats (*Nycteris grandis*; Chiroptera: Nycteridae). Biotropica 22: 2–8.

Fleming, T. H., and E. R. Heithaus. 1986. Seasonal foraging behavior of *Carollia perspicillata* (Chiroptera: Phyllostomidae). J. Mammal. 67: 660–671.

Gannon, M. R., M. R. Willig, and J. K. Jones Jr. 1989. *Sturnira lilium.* Mammal. Species 333: 1–5.

Gessaman, J. A., and K. A. Nagy. 1988. Transmitter loads affect the flight speed and metabolism of homing pigeons. Condor 90: 662–668.

Goodwin, G. G., and A. M. Greenhall. 1961. A review of the bats of Trinidad and Tobago. Bull. Am. Mus. Nat. Hist. 122: 187–302.

Hamilton, I. M., and R. M. R. Barclay. 1994. Patterns of daily torpor and day-roost selection by male and female big brown bats (*Eptesicus fuscus*). Can. J. Zool. 72: 744–749.

Heithaus, E. R., and T. H. Fleming. 1978. Foraging movements of a frugivorous bat, *Carollia perspicillata* (Phyllostomidae). Ecol. Monogr. 48: 127–143.

Hickey, M. B. C. 1992. Effects of radio tags on attack success of hoary bats, *Lasiurus cinereus.* J. Mammal. 73: 344–346.

Kunz, T. H. 1982. Roosting ecology. *In* T. H. Kunz (Ed.). Ecology of bats, pp. 1–56. Plenum Press, New York, New York.

Lewis, S. E. 1992. Behavior of Peter's tent making bats, *Uroderma bilobatum,* at maternity roosts in Costa Rica. J. Mammal. 73: 541–546.

———. 1995. Roost fidelity of bats: a review. J. Mammal. 76: 481–496.

———. 1996. Low roost-site fidelity in pallid bats: associated factors and effect on group stability. Behav. Ecol. Sociobiol. 39: 335–344.

McCracken, G. F., and J. W. Bradbury. 1981. Social organization and kinship in the polygynous bat, *Phyllostomus hastatus.* Behav. Ecol. Sociobiol. 8: 11–34.

Morrison, D. W. 1979. Apparent male defense of tree hollows in the fruit bat, *Artibeus jamaicensis.* J. Mammal. 60: 11–15.

———. 1980. Foraging and day-roosting dynamics of canopy fruit bats in Panama. J. Mammal. 61: 20–29.

Obrecht, H. H., C. J. Pennycuick, and M. R. Fuller. 1988. Wind tunnel experiments to assess the effect of back-mounted radio transmitters on bird body drag. J. Exp. Biol. 135: 265–273.

Rabe, M. J., T. E. Morrell, H. Green, J. C. de Vos Jr., and C. R. Miller. 1998. Characteristics of ponderosa pine snags used by reproductive bats in northern Arizona. J. Wildl. Manage. 62: 612–621.

Robinson, M. E., and R. E. Stebbings. 1997. Home range and habitat use by the serotine bat, *Eptesicus serotinus,* in England. J. Zool. 243: 117–136.

Schulz, M. 1995. Utilization of suspended bird nests by the golden-tipped bat (*Kerivoula papuensis*) in Australia. Mammalia 59: 280–283.

Simmons, N. B., and R. S. Voss. 1998. The mammals of Paracou, French Guiana: a Neotropical lowland forest fauna. Part 1. Bats. Bull. Am. Mus. Nat. Hist. 237: 1–219.

Vehrencamp, S. L., F. G. Stiles, and J. W. Bradbury. 1977. Observations of the foraging behavior and avian prey of the Neotropical carnivorous bat, *Vampyrum spectrum.* J. Mammal. 58: 469–478.

Villa-R., B. 1966. Los murciélagos de MéZxico. Instituto de Biología. Universidad Nacional Autónoma de México. 492 pp.

Vonhof, M. J., and R. M. R. Barclay. 1996. Roost-site selection and roosting ecology of forest- dwelling bats in southern British Columbia. Can. J. Zool. 74: 1797–1805.

———, and ———. 1997. Use of tree stumps as roosts by the western long-eared bat. J. Wildl. Manage. 61: 674–684.

Wilkinson, G. S. 1985. The social organization of the common vampire bat. I. Pattern and cause of association. Behav. Ecol. Sociobiol. 17: 111–121.

———. 1992. Communal nursing in the evening bat, *Nycticeius humeralis.* Behav. Ecol. Sociobiol. 17: 123–134.

Wilkinson, L. C., and R. M. R. Barclay. 1997. Differences in the foraging behaviour of male and female big brown bats (*Eptesicus fuscus*) during the reproductive period. *f*coscience 4: 279–285.

Wohlgenant, T. 1994. Roost interactions between the common vampire bat (*Desmodus rotundus*) and two frugivorous bats (*Phyllostomus discolor* and *Sturnira lilium*) in Guanacaste, Costa Rica. Biotropica 26: 344–348.