

WHITAKER, J. O., JR., and W. J. HAMILTON, JR. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York, 583 pp.
WHITAKER, J. O., JR., D. W. SPARKS, and V. BRACK, JR.

2004. Bats of the Indianapolis International Airport Area, 1991–2001. Proceedings of the Indiana Academy of Science, 113: 151–161.

Received 21 December 2005, accepted 19 February 2006

Acta Chiropterologica, 8(1): 263–269, 2006

PL ISSN 1508-1109 © Museum and Institute of Zoology PAS

Erratum: "*M. Sylvaticus*" in page 263 is not correct. It should be "*M. sylvatica*".

Hiding low in the thicket: roost use by Ussurian tube-nosed bats (*Murina ussuriensis*)

HIROFUMI HIRAKAWA¹ and KUNIKO KAWAI²

¹Forestry and Forest Products Research Institute, Sapporo 062-8516, Japan; E-mail: hiroh@affrc.go.jp

²Institute of Low Temperature Science, Hokkaido University, Sapporo 060-0819, Japan

Key words: *Murina ussuriensis*, day roost, foliage roost, dead leaves, bamboo grass thicket

INTRODUCTION

The Ussurian tube-nosed bat *Murina ussuriensis*, a forest-dwelling insectivore, is distributed in the Kurile islands, Sakhalin, Southeastern Siberia (Ussuri) and Korea and is the northernmost species of the genus *Murina* (Koopman, 1994; Simmons, 2005). In Japan, it ranges from Hokkaido Island in the north to Yakushima Island in the south. Although this population is classified as *M. sylvaticus* in Yoshiyuki (1989), Koopman (1994), and Simmons (2005), we regard it to be *M. ussuriensis*, following Maeda (1980, 2005).

Various types of day roosts have been reported for the species, including tree cavities, under tree bark, among the foliage of trees and thickets, and beneath the roofs of houses (Imaizumi, 1949; Endo, 1961; Yukawa, 1966; Kuroda, 1969; Honda, 2002; Yoshiyuki and Karube, 2002). In late spring, they have also been found in torpor in the lingering snow of deep-snow area (Hattori,

1966; Ogawa *et al.*, 2002). All of these roost reports are based on incidental observations, with the exception of the one by Yoshiyuki and Karube (2002).

To investigate the types of roosts used by this species, how often it changes roosts, and the distances between roosts, we attached radio transmitters to two adult female Ussurian tube-nosed bats in September 2004 at the Hitsujigaoka Experimental Forest, Sapporo, Japan. In this paper, we report on the roosts used by these bats and discuss the implications.

MATERIALS AND METHODS

The Hitsujigaoka Experimental Forest of the Forestry and Forest Products Research Institute is a 155-ha research forest located in Sapporo, Hokkaido, Japan. The altitude ranges between 122 m and 262 m, and the topography is a mild slope inclined toward the north. Temperatures occasionally exceed 30°C in summer and fall below -10°C in winter. The average annual precipitation is about 1,000 mm. Between December and April the ground is usually

covered in snow which can be over 1.0 m deep. The forest is a mosaic of stands of either naturally regenerated or artificially restocked deciduous or coniferous trees. The main tree species are Japanese white birch (*Betula platyphylla*), Mongolian oak (*Quercus crispula*), Sakhalin fir (*Abies sachalinensis*), and Sakhalin spruce (*Picea glehnii*). Most of the forest floor is covered with thickets of bamboo grass (either *Sasa kurilensis* or *S. senanensis*) 1.0–2.0 m in height.

On 16 September 2004, at ca. 18:40 hrs, we captured 2 females *M. ussuriensis* using a mist net placed over the Urauchinai stream. The bats had the following measurements: bat 1) forearm length 31.1 mm and body mass 9.2 g, and bat 2) forearm length 31.5 mm and body mass 6.0 g. We attached a 0.23 g radio transmitter (Blackburn Transmitters, Nacogdoches, Texas, USA) to the hair between the bats' scapula using surgical adhesive (Skin Bond; Pfizer Hospital Products Group, Largo, Florida, USA). The bats were released at the capture site at ca. 21:30 hrs on the same night. We used Yaesu FT-290mkII receivers and portable folding, 4-element Yagi antennas to locate the bats' day roosts. We also used a large rotatable Yagi antenna equipped with four 3.7 m booms, each with nine 1.04 m elements. This was fixed to the rooftop of our office building, ca. 500 m NNW of the capture site.

RESULTS

The transmitter battery attached to bat 1 lasted 12 days but we could determine its roosts up to day 13 because the bat remained in the roost it had used on day 12. The transmitter signal could not be located on three of 13 days (days 1, 3, and 4). The transmitter battery attached to bat 2 lasted 15 days, but we determined its roosts up to day 20 because this bat continued to use the roost that it had used on day 15. All day roosts were determined within this 20 day period.

Seven roost sites were located for bat 1 (Table 1). Two of those were in tree crowns and we could not determine individual trees or the bats' exact roost locations: one of the two sites was at a small stand (0.06 ha) of Japanese horse chestnut (*Aesculus turbinata*), and the other was at the edge of a dense stand of Sakhalin fir. The remaining five roosts were in dead leaves (or leaf

clusters), three of which had fallen and were suspended in thickets of bamboo grass approximately 1 m from the ground. One was lying on the ground beneath a thicket of bamboo grass and one hanging from a broken branch of a fallen tree lying on the ground of another thicket. The species of leaves or leaf clusters used as roosts were linden (*Tilia maximowicziana*), Japanese horse chestnut, Mongolian oak, and Castor-leaved aralia (*Kalopanax pictus*). Bat 1 changed roost sites every day up until day 10 (excluding the unknown roosts from days 1, 3, and 4), and then used the same roost for four consecutive days up to day 13 (Table 1). All of the observed roost sites were within 150 m of the capture site, and the shortest and the longest distances between consecutive roosts (not considering the unknown roosts) were ca. 5 m and 200 m, respectively (Fig. 1).

Over a 20-day period, bat 2 used seven roosts (Table 1). For the first three days, it used three different roosts in tree crowns all at the edge of Sakhalin fir stands, but we did not determine the individual trees or the roosts. All of these roosts were in the same or adjacent stands and close to each other (within a 80 m radius) and were within 230 m from the capture site. On day 4, bat 2 was found roosting over 700 m from the preceding roosts (Fig. 1). From this day onwards (days 4–20) this bat used four different roosts in the vicinity (within a 60 m radius), the first roost for one day and each of the other three for 7, 2, and 7 consecutive days. The roosts were all in fallen dead leaves (or leaf clusters) suspended in thickets of bamboo grass under naturally regenerated broadleaf stands and all less than 1 m above the ground (Table 1). The species of leaves or leaf clusters used as roosts were Crimson glory vine (*Vitis coignetiae*), Japanese cucumber tree (*Magnolia obovata*), and Castor-leaved aralia. At 18:30 hrs (60 min after sunset) on day 6, bat 2 was not in the

TABLE 1. Roosts used by two *M. ussuriensis* in the Hitsujigaoka Experimental Forest, Sapporo. Explanations: Bat 1: caught 16th September, last observation 29th September 2004; Bat 2: caught 16th September, last observation 6th October 2004; Height — the roost height in cm; Distance 1 — the distance from the preceding roost in m; Distance 2 — the distance from the capture site in m; Roost sites 5 and 7 used by bat 2 were approximately 3 m apart

#Day	#Roost	Days	Type	Leaf species	Height	Location	Distance 1	Distance 2
Bat 1								
1	not found	1	—	—	—	—	—	—
2	1	1	single leaf	linden sp.	102	in bamboo grass thicket	—	90
3–4	not found	2	—	—	—	—	—	—
5	2	1	unidentified	unidentified	?	in tree crowns	—	90
6	3	1	single leaf	Japanese horse chestnut	0	on the ground under a thicket	<10	80
7	4	1	leaf cluster	Mongolian oak	73	in bamboo grass thicket	200	150
8	5	1	leaf cluster	Mongolian oak	129	in bamboo grass thicket	<10	150
9	6	1	unidentified	unidentified	?	in tree crowns	90	80
10–13	7	4	single leaf	Castor-leaved aralia	95	in bamboo grass thicket	150	140
Bat 2								
1	1	1	unidentified	unidentified	?	in tree crowns	—	220
2	2	1	unidentified	unidentified	?	in tree crowns	70	170
3	3	1	unidentified	unidentified	?	in tree crowns	80	230
4	4	1	single leaf	Crimson glory vine	90	in bamboo grass thicket	730	950
5–11	5	7	leaf cluster	Japanese cucumber tree	95	in bamboo grass thicket	50	990
12–13	6	2	leaf cluster	Castor-leaved aralia	66	in bamboo grass thicket	40	1000
14–20	7	7	single leaf	Castor-leaved aralia	68	in bamboo grass thicket	40	990

roost that it had used earlier that day, but it was observed using the same roost on the next day, indicating that it was active during the night. At 23:10 hrs on day 19, bat 2 was found in the roost that it had used earlier that day, and also found using the same roost on the next day. Hence, it is not known if it left its roost that night.

The bats in dead foliage roosts suspended in thickets of bamboo grass had their heads downwards and their ventral side in contact with the leaf (Fig. 2). When bat 1 was observed on a dead leaf on the ground, it was clinging to the upper side of a curled, tube-shaped leaf lying horizontally on the ground. This leaf was one segment of a palmately compound leaf of the Japanese horse chestnut.

DISCUSSION

Murina ussuriensis in this study often used dead foliage roosts close to the ground. Roosts situated close to the ground were actually used far more frequently than roosts in tree crowns (25 days versus five days, respectively; see Table 1). To our knowledge, such frequent use of roosts close to the ground has not been reported in other foliage-roosting microchiropterans studied to date, such as *Artibeus lituratus*, *Vampyroides carracioli*, *Syconycteris australis*, *Murina florium*, and *Lasiurus borealis* (Morrison, 1980; Law, 1993; Menzel, 1998; Schulz and Hannah, 1998; Mager and Nelson, 2001; see also Kunz and Lumsden, 2003). It is surprising that despite the high

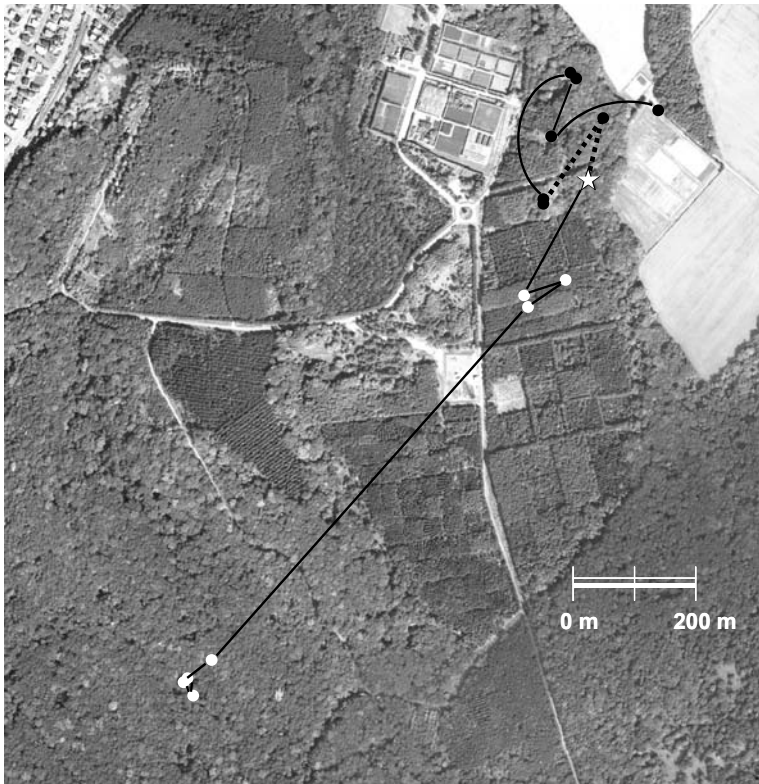


FIG. 1. The location of roost sites and movements between roosts. The capture site is indicated by a star. The roost sites for bat 1 are indicated by white circles with black centres; those for bat 2, by black circles with white centres. The connecting lines indicate changes between roost sites. The dashed lines indicate the missing roost sites on days 1, 3, and 4 for bat 1

potential of risk due to terrestrial predators, in some roosts the bats did not conceal themselves completely (Fig. 2). Their light brown fur and lack of movement in the roosts probably provide satisfactory camouflage.

Other reports over the use of similar roosts by this species exist. In September 1996, Yoshiyuki and Karube (2002) observed five *M. ussuriensis* within a 40 m radius, roosting in dead curled leaves of *Ligularia dentata* in Gifu, central Honshu. *Ligularia dentata* is a community-forming butterbur-like perennial herb, 40–120 cm in height. Honda (2002) also found this species on a dead leaf of a large-leaved liana (*Pueraria lobata*) at a height of 1.5 m in Gifu on 27 August 2001. The common use of dead foliage close to the ground at two sites about 1,000 km apart from each other suggests that such roosting behaviour is widely practiced by this species.



FIG. 2. Bat 2 in an exposed position on a single leaf roost on day 19

Another notable observation in the present study is that one individual roosted on the ground. Hattori (1966) also found a female on the ground under a thicket in Naie on 9 July 1963 and another female under leaf litter in the forest around Moiwa Mountain in Sapporo on 6 October 1963. The former is ca. 60 km NE, and the latter, ca. 6 km WNW of the present study site. Roosting in leaf litter has also been observed in *Lasiurus borealis*, a foliage roosting species in North America (Mager and Nelson, 2001; Boyles *et al.*, 2003). Hence, this roosting behaviour may be found more commonly in a wider variety of species.

Murina ussuriensis appears to be quite flexible in roost site selection because it has been reported roosting in a wide range of situations; for example, in the foliage of trees, in tree hollows and woodpecker holes, under exfoliating bark and under house roofs (Imaizumi, 1949; Endo, 1961; Yukawa, 1966; Kuroda, 1969). It is interesting that *L. borealis* has also been found in a wide variety of roosts similar to that of *M. ussuriensis*, including roosts on or close to the ground (MacLure, 1942; Constantine, 1958; 1959; Downes, 1964; Fassler, 1975; Mager and Nelson, 2001).

When we approached *M. ussuriensis* bats roosting in dead foliage near the ground, they showed no noticeable movements in response to our disturbance, which included noise, camera flash light, and the swinging of the roost foliage. Even when we intentionally or accidentally touched the bats or the antenna, there was still no reaction. This is possibly due to the torpor they were in. The body surface temperatures of bat 2 measured on three occasions using a radiation thermometer (PM133A: Yokogawa M&C Corporation, Tokyo) were 19.6°C at 16:03 hrs on day 7, 16.9°C at 16:24 hrs on day 9, and 17.2°C at 14:10 hrs on day 14, respectively. The corresponding air temperatures measured at a meteorological

station located 3.2 km NE of the study site were 20.2, 17.4, and 18.2°C, respectively. Thus, the bat's body surface temperatures were almost the same as the ambient temperatures, indicating that this bat was actually in deep torpor at those hours.

Although the bats were observed using some roosts on several consecutive days, thus, indicating an apparent high roost fidelity, this result may partly be attributed to their nocturnal inactivity. In future studies, it will be necessary to check the presence or absence of bats during the night from roosts used earlier in the day, otherwise their nocturnal inactivity could be misinterpreted as roost fidelity. This is particularly important in autumn, when nocturnal foraging activity becomes less profitable in energy balance.

ACKNOWLEDGEMENTS

We thank Sachiko Yasui and her colleagues for their helpful advice and kind supply of research materials. Gratitude is also due to Kishio Maeda for his advice and encouragement, Gen Takao and Masayoshi Takahashi for their technical help in mapping the data on an aerial image, and Gabby Novotny for her linguistic help.

LITERATURE CITED

- BOYLES, J. B., J. C. TIMPONE, and L. W. ROBBINS. 2003. Late winter observations of red bats, *Lasiurus borealis*, and evening bats, *Nycticeius humeralis*, in Missouri. *Bat Research News*, 44: 59–61.
- CONSTANTINE, D. G. 1958. Ecological observations on Lasiurine bats in Georgia. *Journal of Mammalogy*, 39: 64–70.
- CONSTANTINE, D. G. 1959. Ecological observations on Lasiurine bats in the North Bay area of California. *Journal of Mammalogy*, 40: 13–15.
- DOWNES, D. W. 1964. Unusual roosting behavior in red bats. *Journal of Mammalogy*, 45: 143–144.
- ENDO, K. 1961. The first record of propagation, including flight behavior on *Murina aurata ussuriensis* Ognev in Japan. *Journal of Mammalogical Society of Japan*, 2: 14–16. [in Japanese with English title].
- FASSLER, D. J. 1975. Red bat hibernating in a woodpecker hole. *American Midland Naturalist*, 93: 254–254.
- HATTORI, K. 1966. The insectivorous bat in Hokkaido. Report of the Hokkaido Institute of Public Health, 16: 69–77. [in Japanese with English title].
- HONDA, N. 2002. The roosts of the Ussurian tube-nosed bat. *Bat Study and Conservation Report*, 10: 5–5. [in Japanese].
- IMAIZUMI, Y. 1949. Taxonomy and ecology: a pictorial guide to the mammals of Japan. Yoyoshobo Publishing, Tokyo, 348 pp. [in Japanese].
- KOOPMAN, K. F. 1994. Chiroptera: systematics. Handbuch der Zoologie. Volume VIII, Mammalia, Part 60 (J. NIETHAMMER, H. SCHLIEMANN, and D. STARCK, eds.). Walter der Gruyter, Berlin, vii + 217 pp.
- KUNZ, T. H., and L. F. LUMSDEN. 2003. Ecology of cavity and foliage roosting bats. Pp. 3–89, in *Bat ecology* (T. H. KUNZ and M. B. FENTON, eds.). University of Chicago Press, Chicago, 779 pp.
- KURODA, N. 1969. On the discovery of the hibernating place of *Murina aurata ussuriensis* in Hokkaido. *Journal of Mammalogical Society of Japan*, 4: 125–126. [in Japanese with English title].
- LAW, B. S. 1993. Roosting and foraging ecology of the Queensland blossom bat, *Syconycteris australis*, in north-eastern New South Wales: flexibility in response to seasonal variation. *Wildlife Research*, 20: 419–439.
- MACLURE, H. E. 1942. Summer activities of bats (genus *Lasiurus*) in Iowa. *Journal of Mammalogy*, 23: 430–434.
- MAEDA, K. 1980. Review on the classification of little tube-nosed bats, *Murina aurata*, group. *Mammalia*, 44: 531–551.
- MAEDA, K. 2005. Chiroptera. Pp. 25–64 and 159–169, in *A guide to the mammals of Japan* (H. ABE, ed.). Tokai University Press, Tokyo, xvi + 206 pp. [in Japanese and English].
- MAGER, K. J., and T. A. NELSON. 2001. Roost-site selection by eastern red bats (*Lasiurus borealis*). *American Midland Naturalist*, 145: 120–126.
- MENZEL, M. A., T. C. CARTER, B. R. CHAPMAN, and J. LAERM. 1998. Quantitative comparison of tree roosts used by red bats (*Lasiurus borealis*) and Seminole bats (*L. seminole*). *Canadian Journal of Zoology*, 76: 630–634.
- MORRISON, D. W. 1980. Foraging and day-roosting dynamics of canopy fruit bats in Panama. *Journal of Mammalogy*, 61: 20–29.
- OGAWA, M., T. YAGIHASHI, and N. TANAKA. 2002. Discovery of *Murina ussuriensis* Ognev on remaining snow in Mt. Naeba, central Japan.

- Bulletin of the Asian Bat Research Institute, 2: 13–15. [in Japanese with English title].
- SCHULZ, M., and D. HANNAH. 1998. Relative abundance, diet, and roost selection of the tube-nosed insect bat, *Murina florium*, on the Atherton Tablelands, Australia. *Wildlife Research*, 25: 261–271.
- SIMMONS, N. 2005. Order Chiroptera. Pp. 312–529, in *Mammal species of the World: a taxonomic and geographic reference*. 3rd edition (D. E. WILSON and D. M. REEDER, eds.). The Johns Hopkins University Press, Baltimore, xxxv + 2142 pp.
- YOSHIYUKI, M. 1989. A systematic study of the Japanese Chiroptera. National Science Museum, Tokyo: 1–242.
- YOSHIYUKI, M., and H. KARUBE. 2002. New habitat of Japanese little tube-nosed bat, *Murina silvatica* Yoshiyuki, 1983. *Animate*, 3: 15–16. [in Japanese with English title].
- YUKAWA, M. 1966. Notes on some habits of lesser tube-nosed bat (*Murina aurata ussuriensis* Ognev). *Miscellaneous Reports of the Hiwa Museum for Natural History*, 10: 11–13. [in Japanese with English title].

Received 26 December 2005, accepted 20 January 2006

Depositing masticated plant materials inside tent roosts in *Cynopterus sphinx* (Chiroptera: Pteropodidae) in Southern India

RAMAN RAJASEKAR¹, BALAJI CHATTOPADHYAY¹, and KANDULA SRIPATHI^{1, 2}

¹Department of Animal Behaviour and Physiology, School of Biological Sciences, Madurai Kamaraj University, Madurai 625 021, Tamil Nadu, India

²Corresponding author: E-mail: sribat@rediffmail.com

Key words: *Cynopterus sphinx*, tent-making, roost-protection hypothesis, ectoparasites, microorganisms

INTRODUCTION

To date, at least 19 species of bats are known to either roost in or construct tents in more than 80 species of vascular plants (Kunz *et al.*, 1994; Stoner, 2000; reviewed in Kunz and Lumsden, 2003). The short-nosed fruit bat *Cynopterus sphinx* is one among the three tent-making bats of the Old World family Pteropodidae (Goodwin, 1979). Adult males are known to construct tents by modifying various parts of at least six plant species (Goodwin, 1979; Balasingh *et al.*, 1995; Bhat and Kunz, 1995). Once a tent is made, male typically defends it against other competing males and also defends the females

who join his tent (Balasingh *et al.*, 1995). Harem males deposit saliva on the interior of the stem tents constructed in the veins of *Vernonia scandens* and it has been suggested that the deposited saliva may serve to repel other conspecific males or may facilitate females to identify particular male's tent (Balasingh *et al.*, 1995). Given that, only males were known to take part in 'tent-making' and subsequent defense, females always seems to depend on males to acquire safe diurnal roost. Thus, the mating system associated with *C. sphinx* and other tent making/roosting bats is thought to be a form of resource defense polygyny (Brooke, 1990; Balasingh *et al.*, 1995; Kunz and McCracken, 1996; Tan