Discovery of a cave as the day roost of a rarest fruit bat *Latidens salimalii*

N. Singaravelan and G. Marimuthu*

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

Salim Ali's fruit bat *Latidens salimalii* is one of the three rarest bats in the world. It is endemic to Tamil Nadu in the southern part of India. Even though it was repeatedly mist-netted in the High Wavy Mountains, whether it roosts in foliage or trees or buildings during daytime, similar to sympatric fruit bats, was previously unknown. We report here for the first time that this species roosts in a cave in the High Wavy Mountains. Most of the individuals roosted in clusters in the darkest areas of the cave. We mist-netted 24 individuals during their evening outflights and confirmed their identity. The distance between the day roost and the only known night roost of *L. salimalii* was less than 1 km.

AMONG the 120 species of bats known from the Indian subcontinent, 14 are frugivorous and the remainder are insectivorous[1]. Among fruit bats, the Indian flying fox *Pteropus giganteus*, the fulvous fruit bat *Rousettus leschenaulti* and the short-nosed fruit bat *Cynopterus sphinx* are relatively abundant species found in many parts of India. Salim Ali's fruit bat, *Latidens salimalii*, alone among the remaining 11 species, is endemic to the Tamil Nadu State in the southern part of India. Although Hutton[2] collected this enigmatic species 53 years ago, Thonglongya[3] identified it correctly only 30 years ago. During April 1993 a team from Bombay Natural History Society and Harrison Zoological Museum rediscovered *L. salimalii* at the Kardana Coffee Estate situated in the High Wavy Mountains (9°42′N, 77°24′E). They mist-netted a few individuals of *L. salimalii* especially when the latter visited a shallow rocky chamber during the night. The team suggested that the High Wavy Mountains may be the only habitat harbouring this endemic bat[4]. Later it was entered into the *Guinness Book of World Records* as one of the rarest bats of the world[5]. The International Union for Conservation of Nature and Natural Resources (IUCN) listed *L. salimalii* as 'critically endangered' and it was noted as threatened based on its small distributional range, decline of habitat, and small population size[6]. Recently, Ghosh *et al.*[7] mist-netted a few individuals of *L. salimalii* along with *C. sphinx* and *R. leschenaulti* at the Kalakkad–Mundanthurai Tiger Reserve forest (8°25′N, 77°35′E).

Recently, we mist-netted a few individuals of *L. salimalii* during pre-midnight hours as they visited the same rocky chamber in the High Wavy Mountains[8]. Based on

*For correspondence. (e-mail: gmari@eth.net)

the repeated captures and on the presence of a thick bed of remnants of fruits on the floor of the chamber, it appears that *L. salimalii* routinely uses this site as a feeding roost at night. Although it is reasonably certain that this rare bat visits this rocky chamber at night, its day roost remains unknown. Since its habits are highly secretive, attempts to locate day roosts of *L. salimalii* have not been successful. Although *L. salimalii* looks similar to *C. sphinx*, it is intermediate in size between *C. sphinx* and *R. leschenaulti*[8]. Accordingly we predicted that the day roost of *L. salimalii* may either be in foliage coverings like that of *C. sphinx*[9] or in temples similar to that of *R. leschenaulti*[10]. However, use of a rocky chamber as a night roost[8] suggests that *L. salimalii* may occupy caves during the day. The present study describes our discovery of the day roost of *L. salimalii* in the High Wavy Mountains.

The High Wavy Mountains are situated near the village of Chinnamanur, about 70 km west of Madurai. Kardana coffee estate is situated in broad-leaved montane forest interspersed with coffee plants, at an altitude of about 460 m above mean sea level.

The study was conducted between July and September 2002. Two teams each with two persons combed the forest for a distance of approximately 1 km in all directions surrounding the night roost of *L. salimalii*. Since individuals of *L. salimalii* began to visit the night roost from 1845 h onwards, we presumed that their day roost may be situated at a relatively short distance from the night roost. Thus, we arbitrarily chose to survey the area for 1 km surrounding the night roost. The survey was carried out for four different days from 0700 to 1700 h continuously, resulting in a total of 128 man-hours. Each day we resumed the survey from the site where we stopped during the previous day. Whenever a cave or cavern was sighted we entered it and searched for the presence of bats, particularly *L. salimalii*. A cave is defined as a rocky chamber, typically having only one entrance, several dark chambers deep inside, with relatively constant temperature and humidity and an apparent absence of air flow. In contrast, a cavern has more than one entrance, is relatively well lit with free flow of air[11]. If bats were found in dark areas, we observed them with the aid of a Sony Digital Handycam (DCR-TRV 340E) in its 'nightshot' mode. In addition, direct visual counts were made during the outflights of bats at early evening hours. Counts made independently by the two teams were pooled to derive the mean size of the roost population. The survey was terminated soon after achieving a successful discovery of the day roost of *L. salimalii*. A mist net (2.6 × 6 m; Avinet) was set across the entrance of the day roost to capture a few individuals of outflying bats to verify the identity of *L. salimalii*[1]. The netting session was conducted from 1800 to 1830 h. The entangled bats were removed from the net and released immediately after recording their morphological traits including measurements of forearm length and body mass. Length of the forearm was measured to the nearest 0.1 mm using vernier calipers and body mass was measured to the nearest 0.1 g using a spring balance (Avinet Inc, USA). Temperature and humidity were continuously recorded for five days both inside and outside the day roost, using a digital hygrothermometer.

We examined a total of 39 rocky chambers and approximately 43 trees during the initial three days of the survey. Among the rocky chambers, 12 were caves and the remaining 27 were caverns. Most of the located trees were *Ficus* spp., *Erythrina* spp. and *Grevillea robusta*. We did not find any bat species in any of those trees. There were no buildings within the area surveyed. Single pairs of male *Rhinolophus rouxi* occupied five caves and all other caves and caverns housed no bats. On the fourth day, 24 September 2002, at 0900 h we located a wide-mouthed cave with a stream at foot level, flowing through most parts of its floor. However, the water was knee-deep at the centre of the cave. The dimensions of the mouth of the cave were 11.7 m long and 3.3 m wide and high. The depth of the cave was 22.9 m. Although the height of the ceiling varied at different locations, the maximum height was 13.8 m (Figure 1).

While entering into the cave, we heard faint audible vocalizations that were relatively similar to other mega-

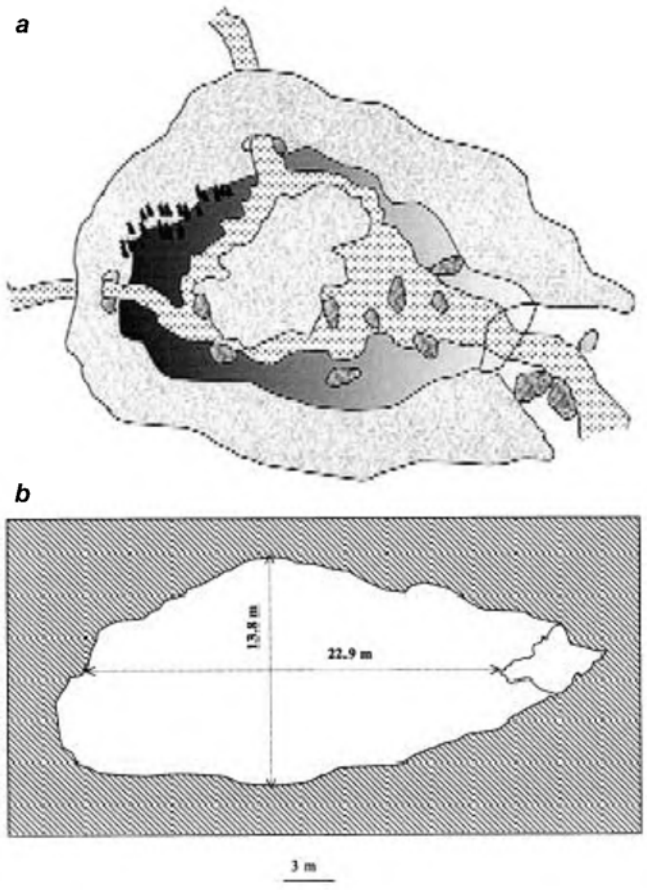

Figure 1. Diagrammatic representation of the topography of the cave (*a*), with its dimensions (*b*). The gradations of shade indicate relative darkness and dotted area depicts the stream. Bats roost at the darkest area in the terminal end of the cave.

chiropteran species. When we moved in a few steps, we presumed that several individuals emitted the vocalizations that were nearly identical to those of a few mist-netted *L. salimalii* in our previous study[8]. The stream flowed through a tunnel on the right side of the cave. We reached the terminal end of the left side by wading through the stream. The vocalizations became louder. Because the area was dark, we were unable to see the bats with our naked eye. However, with the aid of the Handycam we observed the bats on the cave ceiling. Their large eyes indicated that they were megachiropterans. The height of the ceiling from the floor was about 8 m. The bats distributed themselves on the ceiling within an area of approximately 3 m^2. Most of them were aggregated into two clusters, each comprising 50 to 70 individuals. In addition, several individuals hung separately without touching each other. Apart from a pair of male *R. rouxi* roosting in the tunnel, no other species of bats were observed inside the cave.

We counted a total of nearly 350 bats during their out-flights starting from 1815 h, 24 of which were captured in a mist net. Their morphological traits such as the absence of a tail, the lack of a white edge to external ears and presence of only one pair of upper and lower incisors confirmed that they were *L. salimalii*. Their length of forearm and body mass were 68.6 ± 1.24 mm and 68.0 ± 5.70 g respectively. The fur, particularly of the face, was black.

The temperature and humidity inside the cave were 20.6 ± 1.8°C (range 19.5–23.7°C; $n = 5$) and 96.4 ± 3.0% (range 94–99%; $n = 5$), respectively. The ambient temperature and humidity outside the cave were 24.4 ± 2.7°C (range 19.9–26.7°C; $n = 5$) and 71.8 ± 10.1% (range 57–83%; $n = 5$), respectively. Comparisons of temperatures ($t = -2.61$, $P < 0.05$) and humidities ($t = 5.21$, $P < 0.001$) inside and outside the cave showed significant differences. The distance between the cave and the only known night roost of *L. salimalii*[8] was approximately 800 m.

Fifteen species of neotropical and three species of palaeotropical bats are known either to roost in or to make 'tents' in over 80 species of vascular plants[12]. Such tents are usually in eight architectural styles such as conical, palmate umbrella, pinnate, apical, bipid, boat, paradox and stem tents[13]. Bats that construct tents usually belong to the microchiropteran family Phyllostomidae and the megachiropteran family Pteropodidae. However, the roosts of most megachiropterans vary from dense foliage in the darkest parts of trees to open conspicuous areas[12]. For example, *P. giganteus* roosts on branches of trees and expose themselves to broad day light, including the period of sweltering hot weather during summer months in India[14] (Marimuthu, pers. obs.). In contrast, *C. sphinx* often roosts in the foliage of creeper plants like *Vernonia scandens* and the mast tree *Polyalthia longifolia*[9]. Nevertheless a few megachiropterans such as *Dobsonia moluccensis*[15], *Rousettus aegyptiacus* and *Stenonycteris lanosus*[16] typically use dark caves as day roost.

In India, *Eonycteris speleae*, *Rousettus aegyptiacus* and *R. leschenaulti*, among the 14 megachiropterans, are known to occupy caves[1]. However, the latter two species also live in temples and unused buildings[1,10]. The present study, based on our second prediction, describes a cave harbouring the endemic bat *L. salimalii* and forms the first report on its day roosting habits. The fact that the repeated captures of *L. salimalii* at the High Wavy Mountains[2,4], particularly in the vicinity of its night roost[8], suggests that this species has lived in this locality for several decades. Our discovery of the cave that serves as its day roost suggests that it secures *L. salimalii* from dangers, because caves are permanent sites to which bats typically show strong attachment[12]. Furthermore, bats occupying caves show a high degree of roost fidelity compared to foliage roosting bats that generally exhibit higher roost lability[17]. Such site fidelity familiarizes bats with high quality roosts and maintains their social relationships[17]. The short distance of less than 1 km between the day roost and night roost enables *L. salimalii* to avoid costly commuting flights and to minimize risks of predation[12].

Occupation of dark recesses of the cave by *L. salimalii* suggests that sensory systems other than vision may be involved with location of roosting sites. Based on the hypothesis that echolocation evolved due to animals' need to find their way around in caves, the cave dwelling fruit bat *Rousettus*, swiftlet *Collocallia* and the oilbird *Steatornis* orient, at least while flying in dark areas, fly by means of echolocation[18]. Since our observation on the roosting habits of *L. salimalii* is apparently similar to that of *R. aegyptiacus*[1], it invites a detailed study to determine whether *L. salimalii* is also equipped with echolocation.

The relative constancy of temperature and humidity inside the cave forms an ideal day roost for *L. salimalii*. The high humidity prevents their wing membranes from drying out[18]. Moreover microclimatic features are important factors for roost selection, enabling bats to minimize energy expenditure and water loss during the day[19]. Because the cave is located in a highly inaccessible place in the rough terrain of the High Wavy Mountains, the day roost of *L. salimalii* is presumably well-protected from human interference. However, cutting of trees as a part of management of the coffee estate poses a threat to their habitat. Since *L. salimalii* mainly feeds on fruits of *Ficus* spp., *Eleocarpus oblongus* and *Prunus ceylanica*[8], it is vital to protect these plants to preserve the endemic bat. Our discovery of the day roost of *L. salimalii* may possibly enable more detailed studies to be carried out in the future, especially on its roost and social organization, population size, foraging behaviour and breeding pattern. All such studies are relevant for the conservation of this enigmatic bat.

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