phthora spp. is helpful for identification of Indian isolates of *P. nicotianae* based on similarities with *P. nicotianae*[8] and disimilarities with SCRI isolates published earlier as *P. infestans*.

Furthermore, both the isolates were identified morphologically at the Indian Agricultural Research Institute, New Delhi as *P. parasitica* (Accession number: ITCC-5232 and ITCC-5233; the name of *P. parasitica* has been corrected as *P. nicotianae* Breda de Haan), which supported our molecular identification studies.

Bonants *et al.*[10] suggested that detection of fungal pathogens by PCR is at least 10-fold more sensitive than ELISA. Moreover, serological techniques developed to detect the *Phytophthora* are generally genus-specific[11]. Molecular identification studies of the pathogen causing leaf rot of betelvine will be helpful to develop PCR-based diagnostics for sensitive, rapid and reliable detection of *Phytophthora* spp. directly from *P. betle* leaves as well as soil samples which may contribute an important role for implementation of the efficient control strategies.

1. Balasubrahmanyam, V. R., Johri, J. K., Rawat, A. K. S., Tripathi, R. D. and Chaurasia, R. S., Betelvine (*Piper betle* L.) National Botanical Research Institute, Lucknow, 1994.
2. Saksena, S. B., *Indian Phytopathol.*, 1977, **30**, 1–16.
3. Johri, J. K., Singh, H. B. and Srivastava, M., *Advances in Plant Disease Management* (eds Udit Narayan, Kumud Kumar and Mukesh Srivastava), Advance Publishing Concepts, New Delhi, 2000, pp. 175–183.
4. Kistler, H. C., Momol, E. A. and Benny, U. A., *Phytopathology*, 1991, **81**, 331–336.
5. White, T. J., Bruns, T., Lee, S. and Taylor, J., in *PCR Protocols: A Guide to Methods and Applications* (eds Innis, M. A. *et al.*), Academic Press, New York, 1990, pp. 315–322.
6. Feinberg, A. P. and Vogelstein, B., *Anal. Biochem.*, 1983, **132**, 6–12.
7. Cooke, D. E. L. and Duncan, J. M., *Mycol. Res.*, 1997, **101**, 667–677.
8. Cooke, D. E. L., Duncan, J. M., Williams, N. A., Hagenaar-de Weerdt, A. and Bonants, P. J. M., OEPP/EPPO Bulletin, 2000, vol. 30, pp. 519–523.
9. Cooke, D. E. L., Drenth, A., Duncan, J. M., Wagels, G. and Brasier, C. M., *Fungal Genet. Biol.*, 2000, **30**, 17–32.
10. Bonants, P., deWeerdt, M. H., VanGent-Pelzer, M., Lacourt, I., Cooke, D. and Duncan, J., *Eur. J. Plant Pathol.*, 1997, **103**, 345–355.
11. Grote, D. and Gabler, J., *J. Plant Dis. Protect.*, 1999, **106**, 445–454.

ACKNOWLEDGEMENTS. We thank Shaukat Hussain and J. Duncan, SCRI, Dundee, UK for providing DNA of *Phytophthora infestans* and ITS4 and ITS6 primers as a gift to S.K.R., and also for valuable suggestions. We also thank the Director, National Botanical Research Institute, Lucknow for his keen interest and for providing facilities.

Received 28 May 2002; revised accepted 26 November 2002

A. TRIPATHI
R. SINGH*
S. K. RAJ*
A. P. SINGH
J. K. JOHRI†

Plant Protection and Quarantine, and
**Molecular Virology Division,*
National Botanical Research Institute,
Lucknow 226 001, India
†For correspondence
e-mail: jjohri@rediffmail.com.

Mist net captures of the rarest fruit bat *Latidens salimalii*

Next to rodents, bats are the most numerous mammals in the world. Koopman[1] recognized a total of 888 species of bats. However, numbers from 800 to 1000 are frequently quoted for the bat species[2–4]. According to Mickleburgh *et al.*[5], there are 1001 species of bats in the world. India is relatively rich in bat fauna comprising approximately 120 species, out of which 14 are fruit-eating and the remaining are insect-eating bats[6]. Among fruit bats, the Indian flying fox *Pteropus giganteus*, the fulvous fruit bat *Rousettus leschenaulti* and the short-nosed fruit bat *Cynopterus sphinx* are widely distributed in the Indian subcontinent.

While surveying for reptiles and mammals at the High Wavy Mountains of Tamil Nadu in southern India, Hutton[7] collected four species of bats namely *P. giganteus*, *C. sphinx*, the painted bat *Kerivoula picta*, and the yellow bat *Scotophilus heathii*. He collected only one of the several *C. sphinx* captured, presuming that it was not uncommon in India, and deposited it in the Bombay Natural History Society (BNHS), Mumbai. More than two decades later when working on the specimens of megachiropterans at BNHS, Thonglongya[8] noticed that the specimen labelled *C. sphinx,* collected at the High Wavy Mountains, was wrongly identified. He identified it as a new genus *Latidens* and named the species *salimalii*, after India's eminent ornithologist Salim Ali[8]. *Latidens salimalii* Thonglongya, 1972 is endemic to south India. The International Union for Conservation of Nature and Natural Resources (IUCN) listed this bat as 'critically endangered' and remarked as threatened by small distribution area, decline of habitat and small population size[9]. On 8 April 1993, a team from BNHS and Harrison Zoological Museum rediscovered *L. salimalii* at the High Wavy Tea and Coffee Estates (Kardana Coffee Estate) and suggested that it is the only habitat harbouring this endemic bat[6,10,11]. Recently, it entered the *Guinness Book of World Records* as one of the three rarest bats in the world[10]. Since the habitat of *L. salimalii* is highly cryptic, a study related to its ecology or ethology has not been made so far. We made an attempt to capture this enigmatic species by setting mist nets during night hours in the estate area.

The High Wavy Mountains are situated near Chinnamanur, about 70 km away from Madurai (9°58′N, 78°10′E) towards the west. Kardana Coffee Estate is situated in the broad-leaved montane forest, interspersed with coffee bushes, at an altitude of about 460 m above mean sea level[6].

Netting sessions were carried out on 24 July and 17 August 2002 during entire nights between 1830 and 0430 h, for a total of 51 net hours. Three mist nets

(2.6 m × 6 m and 2.6 m × 9 m) were erected at different heights, more specifically in the altitudes at which *L. salimalii* were captured earlier[6,10]. A shallow rocky chamber with a wide mouth, situated 200 m downhill inside the Kardana Coffee Estate was chosen. One net was placed covering the mouth of the chamber and the other two were set 50 m above and 10 m below the chamber. The dimensions of the mouth of the chamber were 7.1 m (length) × 7.0 m (width/depth) × 2.3 m (height). There was a stream at a distance of about 25 m opposite the chamber mouth. The chamber site was chosen mainly due to the presence of accumulated dried remnants of wild fruits and fecal pellets on the floor, presumably of bats, indicating the possibility of bats using the place as feeding roost. During the course of the second netting session, the net at the chamber site was set at 1930 h, in order to observe bats that had already entered the chamber. Bats entangled in the mist nets were gently removed and transferred individually into soft cotton bags. Adult bats were collared with elastic rubber rings with plastic, coloured beads. Each ring was loaded with one to three beads. Each colour denotes a specific number from 0 to 9. Thus all possible sequential arrangements of the beads provided 999 tags[12]. Since the size of the collars may not be suitable for growing juveniles, they were marked with plastic, coloured, numbered and split rings on the forearm. Before releasing the bats, their sex was noted and forearm length was scaled 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). Juvenile and adult stages[13] and reproductive status[14] were also assessed. Morphological characters such as absence of external tail, lack of white edge at the ears and presence of only one pair of upper and lower incisors were noted to verify the identity of *L. salimalii*[6].

We captured a total of 28 individuals of *L. salimalii* in the mist net placed at the mouth of the chamber. Among them 22 were adult males, three were adult females and the remaining three were juvenile females. The epiphyseal gap in the fourth metacarpal phalangeal joints of the latter enabled us to classify them as juveniles. Other morphological characters of the captured bats confirmed that they were indeed *L. salimalii* (Figure 1). Although of the same size as *C. sphinx*, they were intermediate in size between *C. sphinx* and *R. leschenaulti*. Forearm length and body mass of adults of these three species are given in Table 1.

The number of bats captured was relatively more at 2000 h, it steadily decreased until 0100 h and thereafter the captures were nil (Figure 2). All bats captured during the initial period were adults, and juveniles were captured after 2300 h. Bats visited the chamber mostly in groups ranging from four to 12 individuals.

Figure 1. Close-up view of *Latidens salimalii*.

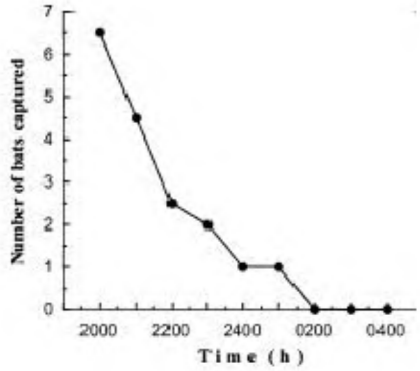

Figure 2. Average number of *L. salimalii* captured with mist nets during two nights.

However, we noticed that bats avoided the mist nets on several occasions and flew away. Visual observations made by using dim red light until 1930 h at the chamber during the second netting session showed that bats began to visit the chamber from 1900 h. Soon after entering the chamber the bats exhibited circling flights and a few of them flew out after about 10 s ($n = 11$). The bats still staying inside hung from the ceiling of the chamber, swivelled for one or two minutes and left the place to resume foraging sallies, at an altitude of 25 m above the chamber ($n = 7$). Two bats were munching away some fruits while staying inside the chamber. On the following morning we collected fresh remains of fruits and ejecta pellets found on a thick bed of dried remnants at the floor of the chamber. The fruits were later identified as *Prunus ceylanicus*, *Eleocarpus oblongus*, *Ficus glomerata*, *Ficus macrocarpa* and *Ficus beddomi*. We did not recapture any marked bats during the second netting. Fruit bats other than *L. salimalii* were not captured. However, 12 insectivorous bats (ten *Pipistrellus* and two *Myotis*) were caught during the two netting sessions. No bats were captured in the other two mist nets placed above and below the chamber.

Since *L. salimalii* is not found in any other part of the world, it is endemic to Tamil Nadu. Recently, scientists from Zoological Survey of India collected ten specimens of *L. salimalii* at Agastiyamalai hill complex in Tirunelveli district, Tamil Nadu (Source: *Handbook of Conservation Assessment and Management Plans*. Workshop on Chiroptera held at Madurai Kamaraj University, January 2002). Our observations on *L. salimalii* flying at 25 m height suggest that they

Table 1. Forearm length and body mass of *L. salimalii*. Values for two other pteropodid bats *C. sphinx* and *R. leschenaulti* are given for comparison

	Male		Female	
Bat species	Forearm (mm)	Body mass (g)	Forearm (mm)	Body mass (g)
Cynopterus sphinx	69.15 ± 1.75 ($n = 30$)	48.5 ± 3.17 ($n = 30$)	68.99 ± 2.26 ($n = 30$)	48.8 ± 3.71 ($n = 30$)
Rousettus leschenaulti	82.65 ± 1.24 ($n = 10$)	95.83 ± 6.77 ($n = 10$)	80.5 ± 1.37 ($n = 10$)	86.58 ± 6.09 ($n = 10$)
Latidens salimalii	68.6 ± 1.14 ($n = 22$)	68.9 ± 2.39 ($n = 22$)	68.6 ± 0.66 ($n = 3$)	65.33 ± 1.04 ($n = 3$)
			55.7 ± 0.95* ($n = 3$)	29.5 ± 1.32* ($n = 3$)

*Juveniles of *L. salimalii*.

forage on fruits from relatively taller trees compared to *C. sphinx* (Singaravelan, unpublished). Our successful nettings of *L. salimalii* at the entrance of the chamber in the Kardana Coffee Estate and an accumulation of remnants of fruits, ejecta pellets and fecal pellets indicate that these bats routinely use this site for *ex situ* feeding as well as for night roosting. Night roosts promote digestion and energy conservation, and often act as a retreat from predators, serve as centres for information transfer about the location of food patches and facilitate social interactions[15]. Association of their visits in groups with *ex situ* feeding agrees with similar observations on *C. sphinx*[16] (Singaravelan, unpublished). The fact that *L. salimalii* avoids mist nets is further evidence that fruit bats have a well-developed visual system[4].

Generally, juveniles of *C. sphinx* and *R. leschenaulti* attain 40% of body mass of adults at 55 to 65 days of age and begin to fly. Complete weaning occurs at the age of 75 days (Elangovan, unpublished). Interestingly, the body mass of the three juvenile *L. salimalii*, captured on 17 August 2002, was 45% of that of the adults. This indicates that postnatal growth of *L. salimalii* may apparently be similar to that of the other two pteropodid bats. If this is true, parturition in *L. salimalii* presumably occurred some time between end of May and beginning of June. Since the gestation period for several pteropodids is approximately 120 days[6], we suggest that copulation in *L. salimalii* might have occurred during end of January.

Even though the present study confirms their existence in the High Wavy Mountains, whether *L. salimalii* roost in caves or foliages or man-made structures during the day is still unknown. Location of day roosts might reveal their population size. A study on their foraging behaviour would pave the way to identifying the varieties of plants which they visit for fruits and nectar. Such proposals invite future studies which are important not only to protect *L. salimalii* but also the plants which rely on these bats for pollination, dispersal and propagation of seeds.

1. Koopman, K. F., *Bat Res. News*, 1984, **25**, 25–27.
2. Fenton, M. B., *Bats*, Facts on file, Oxford, 1992.
3. Altringham, J. D., *Bats: Biology and Behaviour*, Oxford University Press, Oxford, 1996.
4. Neuweiler, G., *The Biology of Bats*, Oxford University Press, Oxford, 2000.
5. Mickleburgh, S. P., Hutson, A. M. and Racey, P. A., *Oryx*, 2002, **36**, 8–34.
6. Bates, P. J. J. and Harrison, D. L., *Bats of the Indian Subcontinent*, Harrison Zoological Museum, England, 1997.
7. Hutton, A. F., *J. Bombay Nat. Hist. Soc.*, 1949, **48**, 454–460.
8. Thonglongya, K., *ibid*, 1972, **69**, 151–158.
9. Baillie, J. and Groombridge, B., *IUCN Red List of Threatened Animals*, The IUCN Species Survival Commission, Gland and Washington, 1996, p. 368.
10. Muni, M., *Hornbill*, 1994, **1**, 28–32.
11. Bates, P. J. J., Harrison, D. L., Thomas, N. M. and Muni, M., *Bonn. Zool. Beitr.*, 1994, **45,** 89–98.
12. Balasingh, J., Suthakar Isaac, S. and Subbaraj, R., *Bat Res. News*, 1992, **33**, 6.
13. Racey, P. A., in *Ecology of Bats* (ed. Kunz, T. H.), Plenum Press, New York, 1982, pp. 57–104.
14. Racey, P. A., in *Ecological and Behavioural Methods for the Study of Bats* (ed. Kunz, T. H.), Smithsonian Institution Press, Washington D.C., 1988, p. 31.
15. Kunz, T. H., see ref. 13, pp. 1–55.
16. Elangovan, V., Marimuthu, G. and Kunz, T. H., *J. Trop. Ecol.*, 1999, **15**, 681–687.

ACKNOWLEDGEMENTS. We dedicate this paper to Prof. M. K. Chandrashekaran on the occasion of his 65th birthday. We are grateful to Mr C. Brindhavan for permitting us to work in his estate. We thank Dr T. Sriganesan for identifying the fruits and Mr K. Nathar and Mr Rajan for assistance. We thank the two anonymous referees for providing valuable suggestions on the earlier version of the manuscript. This work was supported by Bat Conservation International (BCI-USA) Student Fellowship to N.S. and a research grant from the Ministry of Environment and Forests, Government of India to G.M.

Received 11 September 2002; revised accepted 18 October 2002

N. SINGARAVELAN
G. MARIMUTHU*

Department of Animal Behaviour and Physiology,
School of Biological Sciences,
Madurai Kamaraj University,
Madurai 625 021, India
**For correspondence.*
e-mail: gmari@eth.net