Sleeping site selection in wild stump-tailed macaques

Primates spend about half their time at sleeping sites[1–4]. Hence the selection of these sites is likely to have considerable fitness consequences[3], considering the defencelessness of sleeping individuals[5–9]. Since the selection of sleeping sites is crucial for the survival of individuals[10], primates appear to be highly selective about these sites[8,9,11,12]. Most macaques choose a cluster of tall trees or a ledge in the middle of a cliff as sleeping sites[13–15]. The patterns of sleeping site use and their functional significance have received considerable attention and the choice of sleeping sites seems to be multifactorial[16]. The stump-tailed macaque (*Macaca arctoides*; I. Geoffroy Saint-Hillaire, 1830) is found in North-East India and from South China to West Malaysia, Thailand and North Myanmar. In India, its population is critically endangered[17].

The primary aim of this study was to identify the sleeping sites selected by a group of stump-tailed macaques and to examine their functional significance. The study group had several potential predators, including leopards (*Panthera pardus*), leopard cats (*Prionailurus bengalensis*) and Himalayan black bear (*Ursus thibetanus*).

A group of stump-tailed macaques was followed for eight months (January to August) at Bualpui 'V' forest (23°06′N, 92°48′E), located on the southern side of Mizoram, NE India (Figure 1). The study group, the only troop at the study site, consisted of 18 individuals, including 4 adult males, 5 adult females, 3 juvenile males, 2 juvenile females and 2 mother–infant pairs. Other primates found in the study site included Western Hoolock Gibbon (*Hoolock hoolock hoolock*) and Phayre's Leaf Monkey (*Trachypithecus phayrei*). Since the local people depend on shifting cultivation, the study site consists of a mosaic of primary forest, regenerating farmland (secondary forest) and woodland. The study site is located adjacent to cultivated areas. The group ranged in the altitudes between 410 and 985 m (recorded using a GPS receiver). The average monthly rainfall during the study period was 192.8 mm, ranging from 0 to 539.3 mm. The mean monthly temperature ranged from 18°C (January) to 33°C (June).

Behavioural data were collected using the focal sampling method[18] whenever the study group was encountered between January 2012 and August 2012. The study group was followed for an average of 14 days per month. 'Sleeping tree' was defined as a tree in which monkeys stayed overnight; 'sleeping site' was the location of sleeping trees in the home range[19]. Based on GPS locations where troops were recorded during the study, the home range was estimated to be about 14 sq. km. Sleeping sites were determined directly when the group was found early in the morning ($N = 28$ days), and were also identified by the large concentration of fresh faecal matter under certain trees when contact with the study group could not be maintained ($N = 67$ days). Therefore, the identity of the sleeping trees for the study group was recorded on 95 days. All sleeping trees measured more than 40 cm in DBH (diameter at breast height). Therefore, we took the same measurements for all other trees, ≥40 cm DBH, within the home range of the group ($N = 320$ trees). These 'unused' tall trees served as a comparative sample to the sleeping trees. The altitude of sleeping sites was recorded using a GPS receiver and the height of the trees was measured using clinometers (Suunto PM-5/1520).

Independent sample *t*-test was used to determine: (i) the differences in physical characteristics between sleeping trees and non-sleeping trees; (ii) the differences in physical characteristics among tree species used as sleeping trees; (iii) differences between the number of consecutive nights reused. For all the tests, the significant level was set at 0.05 and analyses were done using SPSS 17.0.

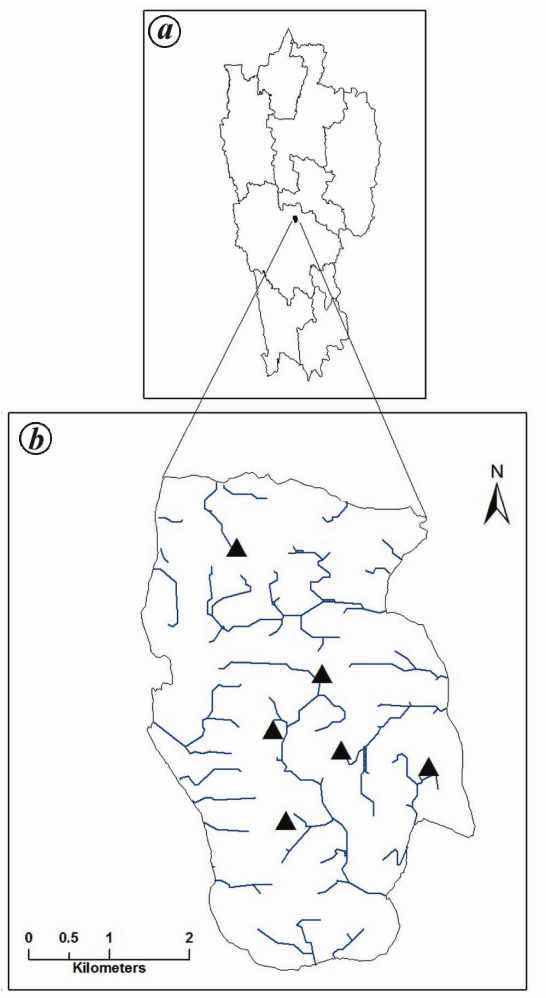

Figure 1. ***a***, Map of Mizoram. ***b***, Map of study area and spatial locations of the sleeping trees.

Table 1. Physical characteristics and use of sleeping trees in stump-tailed macaques

Sleeping tree	Altitude (m)	Month/consecutive nights	Diameter at breast height (cm)	Height of tree (m)
Ficus religiosa	697	January (9)	105	35.8
Ficus bengalensis	710	January (7) February (11)	98	34.7
Ficus bengalensis	720	March (13) April (9)	135	36.2
Ficus religiosa	750	May (6) June (7)	110	41.3
Ficus bengalensis	820	June (6)	122	36.3
Ficus religiosa	715	July (15) August (12)	128	35.8

The stump-tailed macaques used six sleeping trees belonging to two different species – *Ficus bengalensis* (46 nights) and *Ficus religiosa* (49 nights). The group reused four sleeping trees and each sleeping tree was used at an average of 9.5 (± 3.1) consecutive nights (Table 1). The distance between two adjacent sleeping trees was about 1.33 (± 0.56) km and all sleeping trees were in non-fruiting phase. The group did not show a difference in the number of consecutive nights of reuse for *F. bengalensis* and *F. religiosa* (mean ± SD: 9.2 ± 2.8 versus 9.8 ± 3.7; $t = -0.28$, $df = 8$, $P > 0.05$). Table 1 gives the physical details of trees used for sleeping. Sleeping trees had a significantly larger DBH than large trees not used for sleeping (112.7 cm ± 13.2 versus 79.2 cm ± 23.7; $t = 8.96$, $df = 328$, $P = 0.001$). However, there was no difference in DBH between the two species of sleeping trees ($t = 0.29$, $df = 8$, $P > 0.05$). Sleeping trees were also significantly taller than the other large trees (36.7 m ± 2.7 versus 29.2 m ± 2.9; $t = 5.90$, $df = 328$, $P = 0.001$), but there was no difference in height between *F. bengalensis* and *F. religiosa* ($t = 0.09$, $df = 8$, $P > 0.05$). Stump-tailed macaques always slept in the middle part of the tree crown (mean ± SD: $n = 10$, 22.0 ± 1.7 m) and never near or on the trunk.

The reduced awareness of sleeping primates makes them more vulnerable to predation[16]. The literature indicates that predation avoidance is the most prevalent explanation for sleep site selection in primates[3,4,10,20–22]. Predation avoidance has also been suggested to explain sleeping site choice among the macaques[11,19]. In the present study, use of large and tall trees, and sleeping away from the main trunk on branches strongly support the predation avoidance hypothesis. Busse[23] reported that a leopard had a fresh adult female baboon kill 15 m upon a tall *Diospyros mespiliformis* tree. However, leopards were unable to capture baboons that took refuge on small branches. Sleeping trees were large emergent with greater DBH and higher than other large trees in the home range. Sleeping in the high canopy away from the main trunk on branches probably allows *M. arctoides* to conceal themselves from predators[3,4,7]. As suggested by Struhsaker[24] and Di Bitetti *et al.*[9], use of the same sleeping trees consecutively might allow animals to improve their familiarity with a sleeping location that could be useful for escaping from a predatory attack at night. Thus, our findings suggest that predation avoidance is an important factor influencing the selection of sleeping sites in stump-tailed macaques. The present study also highlights the need for conservation of tree species used for sleeping for the conservation and management of stump-tailed macaques.

1. Chapman, C. A., *Am. J. Primatol.*, 1989, **18**, 53–60.
2. Zhang, S., *Am. J. Primatol.*, 1995, **36**, 327–335.
3. Day, R. T. and Elwood, R. W., *Ethology*, 1999, **105**, 1035–1051.
4. Teichroeb, J. A., Holmes, T. D. and Sicotte, P., *Primates*, 2012, **53**, 287–296.
5. Anderson, J. R., *Adv. Stud. Behav.*, 1984, **14**, 165–229.
6. Anderson, J. R., *Am. J. Primatol.*, 1998, **46**, 63–75.
7. Anderson, J. R. and McGrew, W. C., *Am. J. Primatol.*, 1984, **6**, 1–14.
8. von Hippel, F. A., *Am. J. Primatol.*, 1998, **45**, 281–290.
9. Di Bitetti, M. S., Vidal, E. M. L., Baldovino, M. C. and Benesovsky, V., *Am. J. Primatol.*, 2000, **50**, 257–274.
10. Reichard, U., *Am. J. Primatol.*, 1998, **46**, 35–62.
11. Ramakrishnan, U. and Coss, R. G., *Folia Primatol.*, 2001, **72**, 51–53.
12. Liu, Z. and Zhao, Q., *Primates*, 2004, **45**, 241–248.
13. Suzuki, A., *Primates*, 1965, **10**, 103–148.
14. Zhao, Q. K. and Deng, Z. Y., *Int. J. Primatol.*, 1988, **9**, 37–47.
15. Ansorge, V., Hammerschmidt, K. and Todt, D., *Am. J. Primatol.*, 1992, **28**, 271–280.
16. Anderson, J. R., *Sleep. Med. Rev.*, 2000, **4**, 355–373.
17. Molur, S. *et al.*, Report, Zoo Outreach Organisation/CBSG-South Asia, Coimbatore, 2003, pp. 105–109.
18. Altmann, J., *Behaviour*, 1974, **49**, 227–267.
19. Albert, A., Savini, T. and Huynen, M. C., *Am. J. Primatol.*, 2011, **73**, 1222–1230.
20. Cui, L. W., Quan, R. C. and Xiao, W., *J. Zool.*, 2006, **270**, 192–198.
21. Wang, S., Luo, Y. and Cui, G., *Primates*, 2011, **52**, 51–60.
22. Phoonjampa, R., Koenig, A., Borries, C., Gale, G. A. and Savini, T., *Am. J. Primatol.*, 2011, **72**, 17–625.
23. Busse, C., *Botswana Notes Rec.*, 1980, **12**, 15–20.
24. Struhsaker, T. T., *Ecology*, 1967, **48**, 891–904.

ACKNOWLEDGEMENTS. We thank the University Grants Commission, New Delhi for financial support, and Julie A. Teichroeb for valuable comments. We also thank Department of Zoology, Mizoram University, for academic and infrastructure support.

Received 25 May 2015; revised accepted 17 September 2015

ZOTHANSIAMA*
G. S. SOLANKI

Department of Zoology,
Mizoram University,
Aizawl 796 004, India
**For correspondence.*
e-mail: zothans@gmail.com