



Use of sleeping trees by golden langurs (*Trachypithecus geei*)

The selection of secure and stable sleeping places and the abundance of such sites in the forest can impact each individual's chances of survival and reproductive success (Cheyne *et al.*, 2013). The avoidance of predators is often stressed as a major influence on the selection of sleeping places in non-human primates (Xiang *et al.*, 2010). The effect of predators on sleeping site selection has been revealed in many cases: e.g. Hamadryas baboons (*Papio hamadryas*) in Saudi Arabia slept on easily accessible slopes when predators were scarce. In addition, sleeping sites may be selected to reduce the time and energy needed to find food and water resources (Chapman, 1989; Anderson, 1998), or to shelter from rain (baboons: Hamilton, 1982). Work on the African apes has suggested that a likely factor in nest location choice is the abundance of food sources in the area (Goodall, 1962) for arboreal primates, features of a tree such as tree height, diameter, stability, and safety likely influence its suitability for sleeping.

Here we have investigated the characteristics of sleeping sites selected by the golden langur (*Trachypithecus geei*) in an isolated region of Western Assam, the Kakoijana Reserve Forest (KRF). The KRF is located in the Bongaigaon District of western Assam, India (6°24' N, 90°36.5' E) with a total area of ~17000 km². The region has a tropical monsoon climate receiving an annual average rainfall of ~1000 mm with a temperature range of 10–36 C°. Altitudinal variation ranges from 35–60 m a.s.l. The KRF is bounded on the east by the River Aie and on the east by the River Kujia and its tributaries. Paddy fields occur along the other boundaries. The golden langurs are listed as Endangered on the IUCN Red List with decreasing population trends. No data are available on the possible effects of sleeping site availability at KRF. Therefore, this paper will describe the characteristics of sleeping trees chosen by golden langurs. We hypothesize that

langurs will select sleeping sites according to food availability, tree stability, tree health, density of canopy cover and predator avoidance. Specifically, the choice of sleeping trees by langurs will be influenced by (1) the presence of food, (2) tree stability and tree health, and (3) predator avoidance.

One golden langur group has become habituated the presence of people and has been followed since April, 2013. Data collection on the selected group averages 3–5 days/month, and upon encountering the group, they were followed from morning (06:00) to evening (18:00) and their behaviours were noted using 5-minute scan sampling (Altmann, 1974). The group was followed in each month as far as possible. Data are presented on 22 tree species in which golden Langurs were observed to sleep, between April 2013 and March 2014. All sleeping trees were identified to species level (Table 1). Each sleeping tree and all trees ≥10 cm diameter at breast height (DBH), tree height and golden langur sleeping height were measured using visual estimation and a clinometer along with percentage of young and mature leaves. 10×10m quadrats were laid in non-roosting areas and trees falling inside the quadrat were measured for all the above variables. Each tree's DBH was measured using a standard diameter tape. Data were analyzed using independent t –test and statistical tests were carried out using SPSS and simple statistics.

Site Fidelity: The study group slept together in one to four neighboring trees (=one sleeping site), with an average of 1.2 trees used per night (range 1–6). On 6 out of 44 nights (13.64%), the group was found to sleep on a single tree.

Tree families: Golden langurs used 22 tree species of 15 different families in different locations as sleeping sites. The families which were most frequently used by golden Langurs were Moraceae (*n*=5) followed by Anacardiaceae (*n*=3), Verbenaceae (*n*=2) others constitute (*n*=1) each.

Table 1: List of sleeping trees used by golden langur at KRF

Family	Tree	% of use
Miliaceae	<i>Cedrela toona</i>	20.3
Caesalpiniaceae	<i>Tamarindus indica</i>	13.6
Dipterocarpaceae	<i>Shorea robusta</i>	7.9
Verbenaceae	<i>Tectona grandis</i>	7.1
Apocynaceae	<i>Alostonia scholaris</i>	6.1
Poaceae	<i>Bambusa sp.</i>	5.8
Euphorbiaceae	<i>Mallotus philippinensis</i>	4.6
Moraceae	<i>Ficus religiosa</i>	4.1
Combretaceae	<i>Terminalia bellerica</i>	3.9
Anacardiaceae	<i>Odina wodier</i>	3.4
Moraceae	<i>Ficus hispida</i>	3.3
Lauraceae	<i>Litsaea sebifera</i>	2.9
Moraceae	<i>Ficus glomerata</i>	2.2
Mimosaceae	<i>Albizia lebbek</i>	2.8
Verbenaceae	<i>Gmelina arborea</i>	2.8
Moraceae	<i>Ficus rumphii</i>	2.0
Anacardiaceae	<i>Spondias pinnata</i>	1.4
Bombacaceae	<i>Bombyx cebia</i>	1.4
Bruseraceae	<i>Bursera serrata</i>	1.1
Anacardiaceae	<i>Mangifera indica</i>	1.1
Moraceae	<i>Hevea brasiliensis</i>	1.0
Papilionaceae	<i>Erythrina variegata</i>	1.0

Location of feeding site: The golden langurs may have chosen sleeping areas based partially on the location of feeding sites. Groups tended to sleep in trees in the same location as their last bout of feeding. A bout of feeding was recorded when more members of a group were feeding than were engaged in any other activity. Over the study period in all the cases in which a morning bout of feeding was observed and in which the same focal group had been observed the night before, the group was feeding in or around its sleeping tree(s). In addition, groups often slept in trees near frequented feeding sites. Sleeping trees were closer to the last feeding tree of the evening than to the first feeding tree in the morning. The distance of settlements in and around the Reserve forest is greater from roosting areas (911 m \pm 828.8) than non-roosting areas (790.7 m \pm 732.0). Moreover, the trees used for sleeping have a higher percentage of young leaves with an average of 41.2% \pm 20.1, than in non-roosting trees (11.5% \pm 14.1). Golden langurs selected sleeping sites where tree species richness (7.0 \pm 3.0) and tree species diversity (1.5 \pm 0.5) is more than in non-roosting areas; (2.7 \pm 2.5) and (0.7 \pm 0.7) respectively, indicating the food access hypothesis.

Sleeping tree characteristics: The langurs preferably selected taller and sturdier trees with DBH >60 cm (69.8 \pm 29.5) and average height of 47.7 \pm 16.2 while the mean DBH and mean height in non-roosting areas were 43.1 \pm 31.7 and 39.3 \pm 19.0 respectively. Langurs almost always slept in trees that extended into mid and upper canopies. It has been observed that individuals slept in mid and upper parts of these trees; indeed, the tall trees typically did not have branches near the ground. Tall trees have wide branches, which provide stable sleeping sites, perhaps to minimize the danger of falling. During the study, there were two incidents of daytime falls of two individuals, one sub adult female and one adult female, who fell from heights of ~7 m while resting due to branches breaking. Both survived, although one got injured in her belly, indicating that nighttime falls are also a risk due to breaking branches or wind.

Golden langurs are highly selective in their choice of sleeping trees; from this work we have determined that (1) food access, (2) stability, and (3) predator avoidance play a major role in golden langur's choice of sleeping sites. The present data shows that groups selected the sleeping sites where tree species richness and tree species diversity is more than non roosting areas along with a higher percentage of edible resource. This strongly supports the access to food hypothesis as they select sleep sites in close proximity to food sites used during the day, sleep in food species and forage in sleeping trees prior to or following sleep. This population of golden langur minimized their travel costs by selecting sleeping trees near their feeding areas or by sleeping directly in feeding trees on most nights. The sleeping tree preference by golden langur is usually from the Moraceae and Anacardiaceae families. They prefer species of the Moraceae family because they feed both on the fruits and the leaves which are found throughout the year. Species of Anacardiaceae and other families are all seasonal. This strategy often allowed the langurs to stay in their sleeping trees until late morning and feed before having to move, which suggests an energy saving strategy (e.g. Teichroeb *et al.*, 2011).

It has been suggested that primates may not sleep in food trees that are fruiting because these trees may also attract predatory animals that use fruit as an indication that prey species are nearby (Teichroeb *et al.* 2011). However, a

majority of the trees in tropical forests are foliated most of the time, so the presence of leaves does not necessarily indicate the presence of prey to predators. Hence for folivores, sleeping in food trees may not carry the same kind of threat that it does for frugivores or granivores. This may explain why golden langur often slept directly in food trees (Teichroeb *et al.*, 2011).

Predation avoidance is the most prevalent explanation for sleep sites in the primate literature (e.g. *Papio* sp. in Hamilton, 1982; *Hylobates lar* in Reichard, 1998). Although food was an important consideration of sleeping tree choice for golden langurs, this study also provides support for the predation avoidance hypothesis, as evidenced by the fact that small feeding trees were never slept in. Sleeping trees were always the large trees. By sleeping high in the canopy, away from the main trunk (Anderson & McGrew, 1984), and away from village settlements they appear to be concealing themselves from predators. The only predator of the golden langur in KRF is domestic dogs, *Canis familiaris*. The threat from dogs is probably enough selective pressure to lead to the continued selection of sleeping sites that are safe from predation. However, it is possible that stronger support for the food hypothesis was found in this study because the threat of predation has been relaxed at this site.

The results of this study suggests that access to food and predation avoidance, were all important considerations of sleeping site selection, though we found the strongest support for the food hypothesis. We did not test some other hypotheses for sleeping site choice, such as the comfort hypothesis (Anderson, 1984), the security hypothesis (Di Bitetti *et al.*, 2000), and the parasite avoidance hypothesis (Hausfater & Meade, 1982), but these may also influence the sleeping site ecology of golden langurs. For instance, this primate species preferred hardwood tree species as sleeping sites, which has been suggested to be due to the resulting increased security against branches breaking during the night and frequently changing sleeping site location has been linked to parasite avoidance (Anderson, 1984; Hausfater & Meade, 1982). The sleeping site ecology of any animal will be influenced by adaptation to a host of factors that influence survival and reproductive success, which makes all hypotheses for sleeping site choice non-mutually

exclusive and potentially important depending on species ecology.

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