

## BRIEF REPORT

### Spider Monkey Sleeping Sites: Use and Availability

COLIN A. CHAPMAN

*Department of Biology, McGill University, Montreal, Quebec, Canada*

The behavior of spider monkeys (*Ateles geoffroyi*) at sleeping sites and the characteristics of these sites were studied in Santa Rosa National Park, Costa Rica. The spider monkeys tended to congregate just prior to dusk at a number of sleeping sites which were repeatedly used (81.6%), but occasionally they slept in trees which were only used once (18.4%). All of the regularly used sleeping trees were not used concurrently, but rather, there was a rotation between sites. In general, males were not encountered at regularly used sleeping sites as often as other age/sex classes, and when they were in all male subgroups, they did not sleep in repeatedly used sites. The trees used as regular sleeping sites tended to be large, but such trees were common in the group's home range. The size of the subgroups attending repeatedly used sleeping trees was large when food was abundant and small when food was scarce. It is suggested that this relationship reflects that the costs of travelling to the sleeping site would be more easily recovered when food was abundant than when food was scarce.

**Key words:** *Ateles geoffroyi*, sleeping trees, subgroup size

#### INTRODUCTION

The patterns of sleeping site use by forest-dwelling primates and the functional significance of these patterns have received relatively little attention. Yet, the choice of these sites could potentially have great impact on primate fitness. In savanna-dwelling primates, the risk of nocturnal predation has been considered a major selective force [Hamilton, 1982; Rasmussen, 1979; Anderson & McGrew, 1984]. In fact, it has been argued that for species living on the savanna, the size of the social group is constrained by restricted access to a limited number of "safe" sleeping sites [Anderson, 1984]. In contrast, the functional significance of sleeping sites in forest-dwelling primates is unclear. Some forest-dwelling primates use many different sleeping sites [e.g., *Alouatta palliata*, Chivers, 1969; *Macaca mulatta*, Lindberg, 1971], while other species have a limited number of sites [e.g., 11 *Callicebus torquatus*, Kinzey et al., 1971; 9 *Macaca nemestrina*, Caldecott, 1986]. If the selection of sleeping sites by forest-dwelling primates functions in

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Address reprint requests to Colin A. Chapman, Department of Biology, McGill University, 1205 Dr. Penfield Ave., Montreal, Quebec, Canada, H3A 1B1.

predator avoidance, some species may have numerous sites so that the predator cannot cue in on their location, while other species may be choosing trees which have very particular characteristics. Alternatively, sleeping site selection may be independent of predator avoidance, and sleeping trees may serve another function.

In this paper, I examine the selection and use of sleeping sites by the spider monkey (*Ateles geoffroyi*) of Santa Rosa National Park, Costa Rica. Spider monkeys are first described as using a small number of sleeping trees and their behavior is documented with respect to these sites. Second, the trees are described in relation to what is available in the community's home range.

## METHODS

Data on the ecology and behavior of the free-ranging spider monkeys of Santa Rosa National Park, Costa Rica, have been collected since 1983, involving a total of 36 months of field observations. Santa Rosa is a 10,800 ha national park situated in the northwest corner of Costa Rica. The vegetation of the park is a mosaic of dry deciduous forest, semi-evergreen forest, and grassland (*Hyparrhenia rufa*). On average, the study community consisted of 42 individuals, and these animals ranged over an area of 1.7 km<sup>2</sup>. Individual recognition of many animals was possible following the darting and tagging of animals, either as a result of the mark placed on the animal or by scars and pelage patterns.

To obtain information on the behavior and foraging success of known individuals, subgroups containing recognizable individuals were located in the morning or early afternoon, and focal animal data were continuously recorded until the monkeys entered the area of the sleeping site. The focal animal sampling regime involved 10-minute sessions. The subject chosen for observation was selected based on a fixed rotation between individuals and/or age and sex classes. When a subgroup was first encountered, a target animal was chosen based on a rotation between the animals in the community which were individually recognizable. If the subgroup split, the new subgroup containing the target animal was followed. Ad libitum observations on the behavior and position of the individuals were collected at the sleeping sites until darkness precluded observations. The following morning, the observers routinely approached the sleeping tree 15–30 minutes before dawn. As soon as there was enough light, observations on the position and behavior of the monkeys were recorded. When the subgroup left the vicinity of the sleeping tree, they were followed, the pattern of subgroup fragmentation was documented, and the direction of travel and composition of all subgroups were determined. If the subgroup split prior to leaving the sleeping site, particular attention was paid to recording the composition of each of the newly formed subgroups and the direction each subgroup headed.

The dominance rank for each identifiable adult ( $n=13$ ) was determined from diadic interactions involving displacements observed in the focal animal sessions ( $n=117$ ) or overt aggressive interactions ( $n=38$ ) observed either during focal animal sessions or at any other time. Since these overt aggressive interactions involved loud vocalizations and often chases, they were very noticeable. Thus, it is likely that all episodes were recorded.

The behavior of the members of the spider monkey community were recorded for 3 weeks. At the end of this period of behavioral observations, the density and distribution of the food resources eaten during the preceding 3 weeks were determined. Subsequently, an additional 3-week period of behavioral observation was started. Over the duration of the study, 26 sample periods involving collection of both behavioral and ecological data were completed. In the ecological sampling, the location, size, and phenological status of all adult trees for which the spider

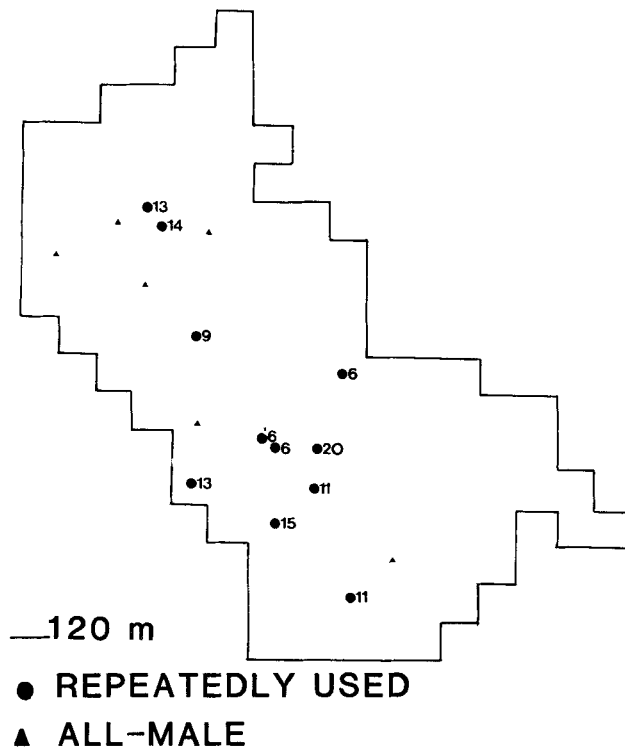


Fig. 1. The home range of the spider monkey community studied in Santa Rosa National Park, Costa Rica. Circles depict the repeatedly used sleeping sites; the number of times that the sleeping tree was used is beside the location of the tree; and triangles depict the locations where all-male subgroups slept.

monkeys ate some part were determined in three 4-ha grids. Each grid was 200 m by 200 m and consisted of 400 cells, each cell 10 m by 10 m in size. An adult tree was considered as any individual with a diameter measured at breast height (DBH) larger than the smallest individual seen to bear fruit. Previous studies have demonstrated that DBH reflects the reproductive capacity of fruiting trees [Peters et al., 1988]. Thus, tree density weighted by DBH may more closely reflect food abundance than plant density [Chapman, 1988].

## RESULTS

Spider monkey subgroups were followed into sleeping sites on 152 occasions. On 42% of these occasions the same subgroup was watched the next morning. In these instances, no subgroup was ever known to join or leave the sleeping tree between the time when the observers left the site and when they returned. Thus, data from all 152 observations were used in the subsequent analyses.

There appeared to be 2 distinct classes of trees which spider monkeys used as sleeping sites: repeatedly used trees and trees used only once (Fig. 1). On 81.6% of the evenings that spider monkeys were followed to a sleeping site, they chose a tree which was repeatedly used. These sites were observed being used between 6 and 20 times (Fig. 1). On the remaining 18.4% of the evenings, the spider monkeys selected sleeping trees which were never used prior to or following that night. Large piles of dung and seeds were found under the repeatedly used sleeping trees,

suggesting that these trees were used more frequently than the following of subgroups would suggest. These piles occasionally contained many thousands of seeds of species with large seeds, such as *Mastichodendron capiri* [Chapman, 1989].

Observations of the spider monkeys at sleeping trees suggest that they treated repeatedly used sites and sites only used once differently. When individuals slept in a tree which was observed to be used on only 1 occasion, they tended to be in small subgroups (mean size = 2.9 animals, SD = 1.303, significantly smaller than the size of the subgroups at repeatedly used sites,  $n = 28$ ,  $t = 7.07$ ,  $P < .001$ ). The average size of the subgroups using the repeatedly used sleeping trees was 6.7 individuals (SD = 5.3, range 1–27,  $n = 124$ ).

The data collection protocol was designed to obtain information on all members of the community. As individual spider monkeys used only a small portion of the community's home range [Fedigan et al., 1988], the observers did not often follow animals to a particular sleeping tree over a number of consecutive nights. However, based on direct observations and repeat visits to sleeping sites to search for fresh dung under the tree, it was estimated that an average of 8 of the repeatedly used sleeping sites were used each month (range 4–10, based on the 1987–1988 field seasons). The frequency of use of sleeping sites per month exhibited a clumped distribution pattern [mean CD = 1.63,  $n = 26$ , Sokal and Rohlf, 1981]. This depicts the fact that most sites were used heavily in some months, while in other months they were not used at all. On average, the repeatedly used sites were not used for 6 months of the year (range 3–9 months). This suggests that there was a gradual rotation between sites, with trees being reincorporated into the current repertoire and old trees falling out of favor. Observations on the foraging route and selection of sleeping sites suggests that this rotation may have been related to spider monkeys selecting the repeatedly used sleeping sites closest to their current feeding area. By considering those instances in which spider monkeys were feeding primarily on a single large fruiting tree (e.g., *Ficus* spp.) which they were repeatedly using day after day, it is possible to determine if they attempted to minimize travel distances by selecting the sleeping site nearest to this feeding area. On 77% of the occasions ( $n = 52$ ), the spider monkeys went from these food trees to the nearest sleeping site.

There was a tendency for subgroups to unite just prior to entering a sleeping site. The rate at which subgroups fused was 8 times higher in the last 2 hours of the day than at any other time ( $t = 7.33$ ,  $P < .001$ ). Movements of subgroups appear to be coordinated by the use of the spider monkey's long-range call, the whinny. The rate with which these calls were given was 2.6 times greater in the last 2 hours of the day than in any other hour (2 hours presunset vs. the remainder of the day,  $t = 4.25$ ,  $P < .001$ ). When a subgroup entered an unoccupied sleeping site, it would often give a series of whinnies. On occasion, if a response was not received, they travelled to the next nearest sleeping tree.

If the four adult males in the community were ranging together with females and young, the females and their associated young left the males and moved to one of the regularly used sites ( $n = 5$ ). The males stayed in the areas in which they were feeding and chose one of the neighboring trees to sleep in. If only 1 or 2 males were ranging with the females, they followed the females to 1 of the regularly used sleeping sites. On 6 occasions the subgroup containing only the 4 adult males was followed until they settled down for the night. On all of these occasions, the males did not use 1 of the repeatedly used sleeping sites, but rather, they slept in trees that no member of the community was seen to use prior to or subsequent to that evening (Fig. 1).

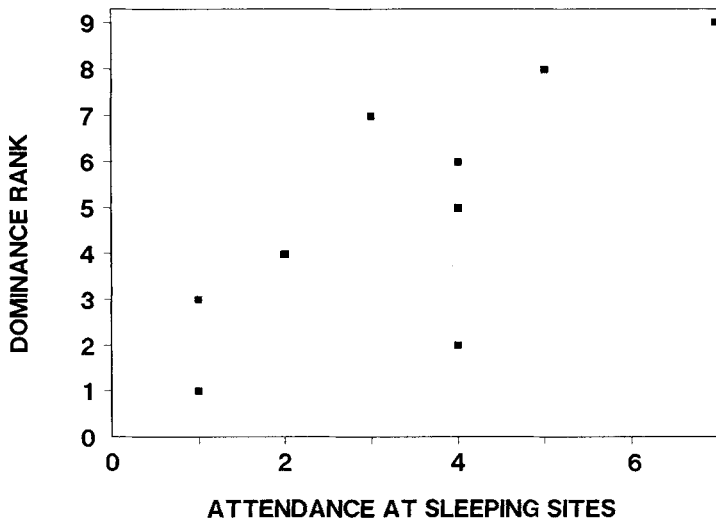


Fig. 2. A scattergram of the dominance rank of identifiable adult females and the number of times that they used a regularly used sleeping site.

There was a tendency for dominant females and their affiliated young to attend the repeatedly used sleeping sites more than subordinate females (rank vs. attendance, spearman rank correlation  $\rho = .924$ ,  $P < .01$ ,  $n = 9$  adult females, Fig. 2). The subordinate females may have been attempting to avoid increased levels of intraspecific competition associated with congregating at one of these repeatedly used sleeping sites.

The size of the subgroups observed at the sleeping sites was related to the density of current food trees ( $r = .345$ ,  $P < .01$ ,  $n = 26$  sample periods) and the density of food trees weighted by their size ( $r = .561$ ,  $P < .001$ ,  $n = 26$  sample periods). Considering the subgroups for which appropriate data were available (1987–1988), the probability that subgroups united at these sleeping sites was positively related to the density of the food resources ( $r = .825$ ,  $P < .01$ ,  $n = 8$  sample periods, Fig. 3).

The trees used as sleeping sites were all large. The mean diameter of these trees, measured at breast height, was 75.1 cm. Eight of the 11 major sleeping sites were emergent trees at the base of steep-sided valleys. The remaining 3 trees were tall emergent trees standing at least 5 m above the neighboring canopy. All trees appeared to be difficult to enter. Entry was generally made by climbing up into the sleeping tree from lower neighboring trees. Generally, it was necessary for animals to grasp small terminal branches and pull themselves into the tree. On most occasions all individuals followed the same route of entry. Occasionally, young animals would refuse to make the crossing into the sleeping site by themselves. Instead, they would call until their mother returned and either carried them into the sleeping tree or bridged for them, making entry easier. Even though trees used as sleeping sites appeared to be difficult to enter, their physical characteristics did not appear to be uncommon. Based on the sampling of the grids, it was estimated that there were a minimum of 688 trees in the group's home range with a diameter at breast height (DBH) equal to or greater to the mean size of the trees used as sleeping sites. (This estimate was based on the density of trees on which the spider monkeys fed and thus represents a minimum estimate.) It is difficult to assess

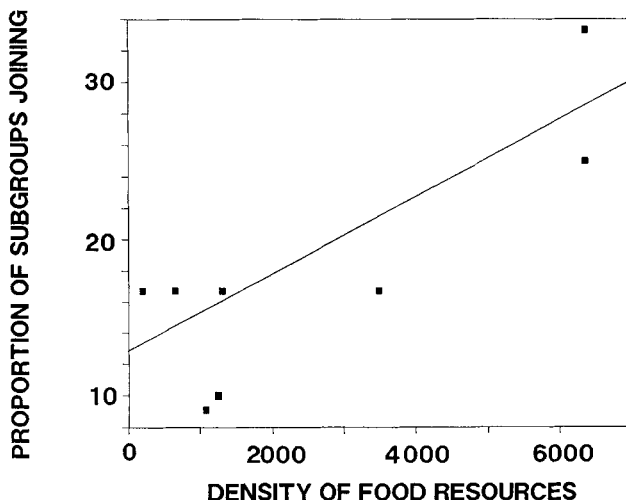


Fig. 3. The proportion of the subgroups observed at a sleeping site that joined with another subgroup in relation to the density of food resources (cm DBH of food-bearing trees per hectare, measured in the 3-week periods in 1987–1988).

whether such large trees would also be difficult to enter, but many of the other trees appeared to have access similar to that of those trees used as sleeping sites.

## DISCUSSION

The spider monkeys of Santa Rosa repeatedly used a small number of sleeping sites. The physical characteristics of these trees did not appear to be uncommon. They tended to be large emergent trees, but such trees were abundant in the group's home range. Why then, if such trees are common, did spider monkeys choose to repeatedly use only a small number of the available sites? The use of a small number of sites with fixed locations may have increased the chances that a number of subgroups would congregate at 1 site. Congregating at a sleeping site may have a number of functions. In Santa Rosa National Park there are a number of potential predators that may be nocturnally active. The park has 5 species of cats (*Felis onca*, *F. concolor*, *F. pardalis*, *F. wiedii*, *F. yaguaroundi*), a large predatory weasel (*Eira barbara*), and snakes (e.g., *Boa constrictor*) which could potentially prey on monkeys [Chapman, 1986]. The available data from captured spider monkeys in Santa Rosa indicate that males are up to 25% heavier than females [Glander et al., in prep.], and males are reported to be more aggressive than females [Fedigan and Baxter, 1984]. Thus, one could speculate that males may be more capable of deterring or escaping predators than females and young. If this is so, it would not be as advantageous for males to attend sleeping trees as it would be for females and young, if sleeping sites functioned to decrease the risk of predation. This may explain the sex differences in sleeping site attendance observed at Santa Rosa. Alternatively, if sleeping sites serve to fulfill some social function (e.g., facilitate the formation of grooming relationships), the sex difference in attendance may reflect differences in the sex-segregated nature of spider monkey societies [Fedigan and Baxter, 1984].

Carpenter [1935], Coelho et al. [1977], van Roosmalen [1980], and Fedigan and Baxter [1984] described communities where spider monkeys congregated at night. In contrast, Klein [1972] and White [1986] described situations where the

members of the community did not assemble into larger units before nightfall. Why do such discrepancies exist between geographical locations? One possible explanation is related to differential costs associated with travelling consistently to one sleeping site. If costs of travelling to a communal sleeping site are prohibitively high, animals may seek out different sites closer to their respective feeding areas. By comparing the Santa Rosa population over time, it was shown that the density of food resources was related to the size of subgroups observed at sleeping sites and the probability that subgroups would join at these sites. Thus when food availability was high, the spider monkeys assembled into large subgroups at sleeping sites. (Travel costs could easily be recovered.) When there was little food available, they did not tend to congregate in large subgroups at night. Similarly, differences in food availability between sites may account for the observed geographical differences. However, more information on different populations is required to examine this explanation.

## CONCLUSIONS

1. The spider monkeys repeatedly used 11 sleeping trees (81.6% of the observations), but occasionally (18.4%) they visited sites that were not revisited.
2. In general, males did not attend the repeatedly used sleeping sites when they were ranging in all-male subgroups.
3. The regularly used sleeping trees were large (mean = 75.1 cm DBH). However, within the home range of the community, there were at least 688 trees larger than the average size of the regularly used sleeping trees.
4. The size of the subgroups encountered at sleeping sites was related to the density of the spider monkey's food resources.
5. These observations suggest that spider monkeys congregate at night but that the size of the subgroup and the number of sites used are related to the foraging needs of the individuals.

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