Sleeping Site Selection in Relation to the Distribution of Food Resources in Gibbons (*Hylobates lar*)

Principal Investigator:  
*Jamie Berner*  
Department of Anthropology, Southern Illinois University  
Carbondale, 1000 Faner Drive, Carbondale, Illinois 62901, USA  
email: bernerjamie@gmail.com

Co-researcher:  
*Prof. Dr. Ulrich H. Reichard*  
Department of Anthropology, Southern Illinois University  
Carbondale, 1000 Faner Drive, Carbondale, Illinois 62901, USA  
email: ureich@siu.edu

Collaborating Thai Researchers or Thai Institutions:  
*Prof. Dr. Suchinda Malaivijitnond*  
Primate Research Unit, Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand  
email: Suchinda.M@chula.ac.th

*Khao Yai National Park, Thailand*  
Mr. Manoch Ganpanakngan  
Park Chief  
Khao Yai National Park, Thailand

Research Agencies:  
Southern Illinois University Carbondale

Co-Research Agencies:  
Khao Yai National Park  
Chulalongkorn University, Bangkok

Official Agency in Thailand Involved in the Research:  
Khao Yai National Park

Research Duration:  
July 2010 – November 2010

Research Location:  
Khao Yai National Park
Executive Summary

Commonly, five non-exclusive hypotheses are thought to explain the selection of sleeping sites in primates: predation avoidance, food access, parasite avoidance, comfort/thermoregulation, and range/resource defense. Among these, the assumption of optimized access to food often features prominently in studies despite little quantitative data. We tested the food access hypothesis through a multi-functional approach for the selection of 59 sleeping sites in a population of wild white-handed gibbons (*Hylobates lar*) at Khao Yai National Park, Thailand from July-November 2010. We investigated the relationship between sleeping site location and important food sources visited throughout four partially over-lapping home ranges. Important sources were defined retrospectively as trees in which gibbons fed for longer than the average feeding duration in all sources visited that day. We found that the distance traveled between the last important feeding tree and the sleeping tree was significantly shorter than the average distance traveled between all other important feeding trees that day. Also, the time spent feeding at the last source was significantly longer than the average time spent feeding in other important food sources. Throughout our study, a sleeping tree was only once reused despite repeated use of the same last important food source suggesting that reducing predation risks may be an additional factor influencing sleeping site selection. In agreement with other studies we conclude that white-handed gibbons select sleeping trees strategically to maximize access to important food trees but that factors like predation risk additionally influence where gibbons spend the night.

Acknowledgement

I would like to thank Dr. Ulrich Reichard for all of his support throughout every step of my project, Dr. Suchinda Malaivijitnond for her assistance and aid while I was in Thailand, The National Research Council of Thailand [NRCT], and The National Park Wildlife and Plant Conservation Department [DNP] for granting permits for me to conduct my research at Khao Yai.

List of Collaborating Thai researchers and institutions

**Prof. Dr. Suchinda Malaivijitnond**  
Primate Research Unit, Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. email: Suchinda.M@chula.ac.th

**Khao Yai National Park, Thailand**  
Mr. Manoch Ganpanakngan, Park Chief, Khao Yai National Park, Thailand
Background and Rationale

The selection of sleeping sites is an important and understudied aspect of primate behavioral ecology (Anderson 1984). Primates spend over half of their lifetime in sleeping sites, yet adequate information on site choice and sleep related behavior is very limited. Across primate species, sleeping sites vary greatly in overall characteristics and specific features which suggest that many factors, both ecological and social, may influence the selection of suitable sites (Fruth and McGrew 1998). Because adequate sleeping is generally important for an animal’s wellbeing (Walker 2009), it may also influence daily activities such as foraging or travel patterns. Without studies of sleeping site selection, the reason for the selection of specific locations along with other daily behavioral activities may not become fully understood.

At present there are five prominent hypotheses regarding primate sleeping tree selection. To increase our understanding of the significance of sleeping site selection in primates, this study will focus primarily on sleeping site selection in relation to the distribution of food resources. The rational of the food access hypothesis is straightforward as it suggests that primates should choose sleeping trees that maximize access to important food sources (Qihaï et al 2009). The distribution of food in tropical environments is usually variable and primate diets vary accordingly over time and space (Chapman et al. 2002). Since food distribution and the essential nutrients gained from consuming foods directly impact primate behavior including daily travel, reproduction and sociality (Savini et al 2008; Sterck and Watts 1997; von Hippel 1998) it is important to understand if a causal relationship between the spatio-temporal distribution of food and the use of sleeping trees exists. Varying the location of sleeping sites, for example, may allow primates to remain close to important food sources and thus maintain better access to resources they need (Chapman et al. 1989; von Hippel 1998).

In addition to the Food Access Hypothesis (H1), four other non-exclusive hypotheses are commonly discussed in the context of night-tree selection in primates: (H2) predation avoidance, (H3) parasite avoidance, (H4) range defense, (H5) and comfort/thermoregulation (Anderson 1998).

Objective of research

We want to test the idea that gibbons, *Hylobates lar*, select night sleeping places based on the distribution of important food resources. Gibbons are a suitable model to investigate sleeping site selection in primates for three reasons: (1) gibbons are highly frugivorous primates (Elder 2009). Thus fruit bearing trees are an important resource to them. (2) The selection of night sleeping places is less influenced by predation pressure in gibbons compared to other primates, because predation plays a negligible role in gibbons (Uhde & Sommer, 2000). (3) Gibbons are strictly territorial. Thus, resource defense plays an important role in gibbons. Consequently, selecting a sleeping tree located close to an important food source may aid in resource defense.

In this project, we address the Food Access Hypothesis, by testing the following specific predictions:
(A) The last and first important food sources of the day will be closer to the night-sleeping tree than the average distance between important food sources visited during the day.

(B) The time spent feeding in the last and first important feeding sites of the day will be longer than the average duration spent feeding at other important food sources during the day.

(C) If both the last and first feeding trees are important in selecting a location of the sleeping tree, it will act as a break between these two especially important feeds. There will therefore be a negative relationship between these distances.

(D) The type of food consumed at the last important feeding site will reflect the animals’ need to sustain the night. Gibbons will feed more on leaves at the last important feeding site of the day, because leaves are higher in slowly metabolized protein and dietary fiber compared to fruits.

Research Methodology

All behavioral data are collected through non-invasive night tree to night tree animal follows using binoculars from the ground. No samples, i.e. hair, bone, or feces, were collected.

Data were collected from July 1 to November 1, 2010 in the Mo Singto study site in Khao Yai National Park, Thailand (Figure 1). Four habituated groups of white-handed gibbons (A, B, C, and T) in partially over-lapping home ranges were observed for a total of ~350 hours during 57 days of follows (34 days of night tree to night tree follows; 13 partial days of observation resulting in follows to the night tree; 10 days of partial observations that did not result in locating the night tree). Overall, 59 sleeping trees were observed during the 47 successful days of following groups to a night tree [Group A (n=18) Group B (n= 15) Group C (n= 11) Group T (n=12)] (Figure 2). Only on one occasion was a sleeping tree reused on a different date.

Testing the Food Access Hypothesis depends critically on quantifying how far away gibbons sleep from important food sources. The selective advantage of sleeping close to an important food source is that such source will return disproportionally large amounts of energy to a feeding gibbon. An Important Food Resource in this study is defined as a single tree crown or woody climber crown in which the gibbons forage for longer than the average of all feeding duration of all sources visited during a single day. Daily feeding time was measured with a stop watch as the time from entering until leaving a food source.

Coordinates of sleeping trees and all important feeding sites were recorded using a GPS receiver. The straight-line distances traveled between the morning sleeping tree, important feeding sites, and the sleeping tree selected at night were calculated based on GPS coordinates. All distances were calculated as straight-lines irrespective of possible path variation. Then the average distance between important food sources were compared to the distance between the last important food source in the afternoon and first important food source of the following morning, respectively to test the prediction that sleeping trees are chosen in close spatial proximity to important food sources.
Foods consumed at important feeding sites were recorded by type and placed into one of seven categories: (1) fruit, (2) young leaves, (3) mature leaves, (4) insects/arthropods, (5) flowers, (6) stems/shoots, (7) other.

**Research results**

(A) The last and first important food sources of the day will be closer to the night-sleeping tree than the average distance between important food sources visited during the day.

The average distance traveled within one day by gibbons between all important feeding trees and sleeping trees, from both the morning and the evening, were calculated in order to assess the relationship of sleeping tree location relative to that of the first and last important food sources. The distance between the sleeping tree and the first feeding tree of the morning (163.3m) was on average shorter than the average traveled between all important feeding trees of a single day (183.2), but not at a significant level (p=.421; t=.809; df= 78) (Figure 3). However, the distance traveled between the last important feeding tree and the sleeping tree was, on average, significantly shorter than the average distance traveled between all other important feeding trees (p= <0.001; t= 4.045; df= 92).

(B) The time spent feeding in the last and first important feeding sites of the day will be longer than the average duration spent feeding at other important food sources during the day.

129 different important feeding trees were identified, tagged and the location recorded. These important feeding trees were visited and often revisited up to 7 different times by either one or two groups for a total of 253 feeds at important feeding trees. On average, gibbons fed 14.3 times a day; 5.4 of these daily feeds were considered to be important based on duration of feeding bouts. The average length of time spent feeding at all important feeding trees was compared to the length of time spent feeding at both the last and first important feeding trees to determine if these specific feeds were especially important for storing energy and replenishing it as a result of losing energy and not gaining any during sleep, respectively. The average feeding length at all important feeding trees was 820.6 seconds. On average, the first feed of the day was shorter (808.3 seconds) than the average of all other important feeds (p=.875; t=0.158; df=92)(Figure 4). The last feed (1100.1 seconds) was, on average, significantly longer than the average feeding bout (p=.004; t=3.057; df= 92).

(C) If both the last and first feeding trees are important in selecting a location of the sleeping tree, it will act as a break between these two especially important feeds. There will therefore be a negative relationship between these distances.

In order to test if the last feeding tree of the night and the first feeding tree the next day are both important locations to sleep near, suggesting the sleeping tree acts as a break between the two, these distances to the sleeping tree were compared and analyzed with an independent paired t-test (p=.359; t=-.926; df=49) (Figure 5). There is no relationship between these two distances, supporting the hypothesis that only one of these two feeding locations influences the selection of a sleeping tree.

(D) The type of food consumed at the last important feeding site will reflect the animals’ need to sustain the night. Gibbons will feed more on leaves at the last important feeding site of the
day, because leaves are higher in slowly metabolized protein and dietary fiber compared to fruits.

Foods consumed at important feeding trees were fruits (n=99), young leaves (n=21), mature leaves (n=5), or were unidentifiable (n=4). A chi-square goodness of fit test was used in order to evaluate if certain foods were selected at the last important feeding tree relative to the types of foods consumed at all other important food sources during a day. On average fruits were consumed 84.2% of the time, young leaves 13.8% of the time, and mature leaves 1.9% of the time. At the last feeding tree fruit, young leaves and mature leaves were consumed 80.9%, 14.9%, and 4.2% of the time, respectively (p = 0.082; \(x^2=5.008; \text{df}=2\) (Table 1). The diet at the last feeding tree did not change significantly, suggesting that gibbons do not alter their diet in order to fulfill specific dietary needs before sleeping.

Conclusions and recommendations

The last important feeding tree appears to act as an especially important tree in determining the location of the sleeping tree. This can be particularly important for gibbons in order to conserve energy that would be wasted by traveling long distances to select a tree. By feeding for a long time at the last important feeding tree and traveling a short distance before retiring for the night, white-handed gibbons are able to accumulate energy from their food and store most of it for the extended period of time that they spend in their night tree. Although the type of food that they consume at this last tree is not altered significantly from the rest of the day, the sheer quantity of food consumed at that location may be adequate enough for an individual to sustain the night. Moreover, a further quantification of foods that are consumed throughout the day at a species specific level may allow for greater insight on which foods provide explicit nutritional needs.

In addition to the distribution of food resources having a direct effect on the selection of a suitable sleeping site, it is likely that selection is influenced by a number of factors. Reichard (1998) suggested that sleeping trees of white-handed gibbons were selected in order to avoid predators, which is further supported within this study. A sleeping tree was reused on a different date on only one occasion within this study, resulting in a reuse rate of 1.7%. Interestingly, the same last important feeding tree was reused on 6 different occasions, or a reuse rate of 12.8%. In order to avoid predators, it is likely that gibbons are using different sleeping trees during a short period of time in order to avoid creating a detectable pattern by predators. If predation avoidance was not important, it is likely that individuals would select familiar sleeping trees and the sleeping tree reuse rate would be more similar to that of the last important feeding tree reuse rate.

Sleeping near food sources and avoiding predators while asleep are both key to survival, and are shown here to be substantial influences on the selection of a suitable sleeping tree. However, it may be likely that additional factors, such selecting a tree that is comfortable of that allows for resource defense, influence where and how sleeping trees are selected. Although sleeping marks a period when social behavior is only minimally observable, the selection of trees is highly dependent on behavior exhibited throughout the day by individuals. Further studies on the factors that influence sleeping tree
selection would greatly benefit our current understanding of the behavior and ecology of the white-handed gibbon.

References


Appendices

Fig 1. Home Ranges of white-handed gibbon study groups A, B, C, and T and their neighbors, Khao Yai National Park, Thailand

Fig 2. Map of sleeping site locations of study groups A, B, C, and T in Khao Yai National Park, Thailand during July-November 2010
Average distance traveled between all feeding trees and sleeping trees by four groups of white-handed gibbons

Fig 3. The average distance traveled (m) between all feeding trees and sleeping trees in study groups A, B, C, and T at Khao Yai National Park, Thailand during July-November 2010
Fig 4. The average time spent feeding (s) at all feeding trees in study groups A, B, C, and T at Khao Yai National Park, Thailand during July-November 2010.

Table 1. The average observed and expected types of food consumed at the last important feeding tree in study groups A, B, C, and T at Khao Yai National Park, Thailand during July-November 2010.

<table>
<thead>
<tr>
<th>Food type consumed at last important feeding tree</th>
<th>Observed N</th>
<th>Expected N</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>mature leaves</td>
<td>2</td>
<td>.5</td>
<td>1.5</td>
</tr>
<tr>
<td>young leaves</td>
<td>7</td>
<td>6.6</td>
<td>.4</td>
</tr>
<tr>
<td>fruit</td>
<td>38</td>
<td>39.9</td>
<td>-1.9</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 5 Distance traveled (m) between the last important feeding tree and the sleeping tree compared to the distance traveled (m) between the sleeping tree and the first important feeding tree the next day in study groups A, B, C, and T at Khao Yai National Park, Thailand during July-November 2010.

Traveled distance between the last important feeding tree to the sleeping tree at night vs. the distance traveled between the sleeping tree and the first feeding tree the following morning in four groups of white-handed gibbons.

- Last feeding tree to sleeping tree
- Sleeping tree to first feeding tree