

**ECOLOGY OF ASSAMESE MACAQUES (*Macaca assamensis*) AT PHU PHIEO  
WILDLIFE SANCTUARY, THAILAND**

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**ABSTRACT**

Important aspects of macaque biology like their physiology and cognition have been extensively studied in captivity and a wealth of behavioral data from captive or food provisioned groups is also available. There is, however, a general lack of knowledge in macaque ecology. In this paper we report results from the first field study on the Eastern Assamese Macaque (*Macaca assamensis assamensis*) in its natural habitat at Phu Khieo Wildlife Sanctuary. After approximately one year of habituation starting in August 2005 we collected 12 months of instantaneous group scan data from a group of 54 macaques. Data on location of the group were collected throughout the study period. Over the course of one year the fully habituated macaques used an area of almost 5km<sup>2</sup> calculated as the 95% Kernel. The monthly means of day journey length varied only slightly around 1.9km/day with shorter distances during the late rainy and the dry season. Across age-sex classes Assamese macaques spent about 40% of their activity time on the ground and in the lowest stratum of the forest. The canopy was used only rarely. Across age classes and seasons macaques spent a third of their activity time feeding. The largest part of feeding time was spent on fruits. However, leaves and animal matter made up more than 20% of the feeding time each. The animal diet included mammals, birds, reptiles, amphibians, spiders, insects, and mollusks. These results represent an important first step in describing the ecology of Thai Assamese macaques in their natural habitat. To deepen our understanding of important interactions between the macaques and their environment we collect data on climate, food abundance, food distribution in botanical plots, focal animal data on individual food intake, and individual ranging behavior.

**Key words :** *primates, monkey, ranging behavior, diet composition*

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## INTRODUCTION

Macaques (genus *Macaca*; Primates: Cercopithecidae) are an ecologically extremely adaptive primate taxon that is distributed more widely than any other non-human primate genus. After a split-off from the baboons, mandrills, drills and mangabeys the macaques moved out of Africa and today only the Barbary macaque (*Macaca sylvanus*) is still found in Africa. All other extant macaque species occur in Asia, ranging from Pakistan, India and Tibet in the West to the Northeastern tip of Japan in the North and just south of the Wallace line in the Southeast (Thierry et al. 2004). Macaques are found in tropical rainforests across Asia but may live at high altitudes in the Himalayas and other temperate regions with long snowy winters.

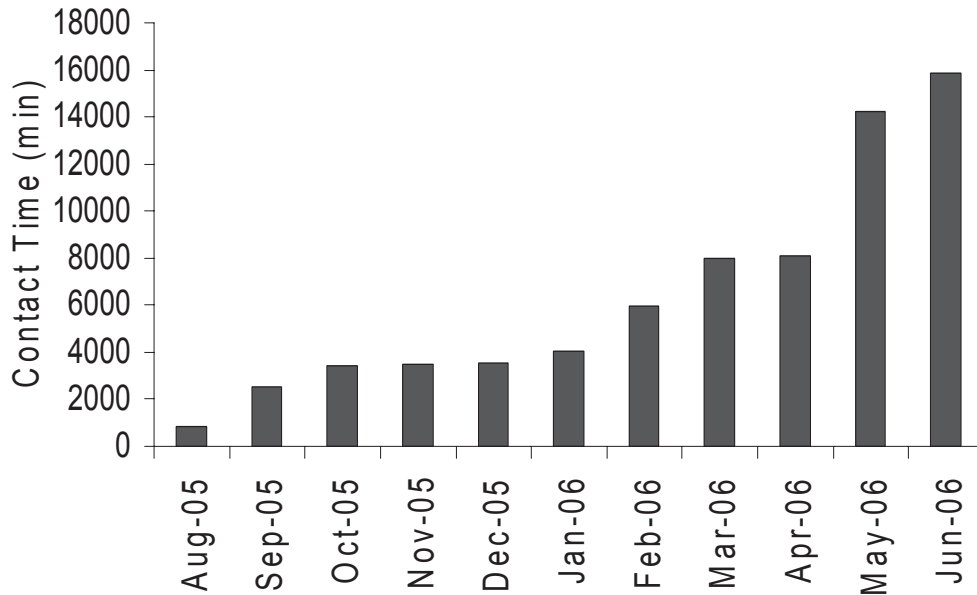
On the species level macaque distribution can either be as wide as in the rhesus macaque (*M. mulatta*) that can be found from Pakistan in the West to the Pacific coast of China or be very restricted as in the case of the lion-tailed macaque (*M. silenus*) in the Western Ghats of Southern India or the Mentawai macaque (1 species *M. pagensis* or 2 species *M. siberu* and *M. pagensis* Roos et al. 2003) on some small Indonesian islands. The biogeography of Southeast-Asian macaques is a matter of ongoing debate (Hamada 2005, Tosi et al. 2003, Ziegler et al. 2007). Thailand is of particular interest in that respect, because it was the passage way for dispersal from mainland Indochina into island Southeast Asia or Sundaland (Abbegg and Thierry 2002, Eudey 1980, Fooden 1975).

Currently, little is known about the ecology of macaques living in Thailand. With this paper we aim at providing the first data on terrestriality, ranging behavior, and diet composition of the Eastern Assamese Macaque (*Macaca assamensis assamensis*) living in its natural habitat without contact to humans. These data are compared to published information on sympatric Phayre's leaf monkeys (*Trachypithecus phayrei*). Data on the Northeast Indian population of Assamese macaques are available for unprovisioned monkeys from Jokai RF (Sakar in prep. cited in Srivastava 1999, cited hereafter as Srivastava 1999). We have not included data on Assamese macaques from Nepal here (Chalise 1999, Chalise 2010) because the ecology of the troops studied is influenced by interactions with humans.

## MATERIALS AND METHODS

The study was carried out at Phu Khieo Wildlife Sanctuary, Northeastern Thailand at 16°05-35'N and 101°20-55'E. The sanctuary covers an area of 157,300 ha at elevations of 300-1300m above sea level. The forest at the study site Huai Mai Sot Yai (16°27'N, 101°38'E, 600-800m a.s.l.) comprises mainly hill and dry evergreen forest with patches of dry dipterocarp and bamboo forest (Borries et al. 2002). The sanctuary harbors four of the five macaque species living in Thailand (*M. arctoides*, *M. assamensis*, *M. mulatta*, and *M. nemestrina leonina*, but not *M. fascicularis*) as well as one species of leaf monkeys (*T. phayrei*), one gibbon (*Hylobates lar*) and one loris species (*Nycticebus coucang*, Borries et al. 2002, Kumsuk et al. 1999, Malaivijitnond et al. 2005).

Work on Assamese macaques began in 2005 with efforts to habituate the first group. For approximately 20 days every month we slowly walked a trail system established earlier (Koenig et al. 2004) watching and listening for signs of the presence of monkeys and after identifying them as Assamese macaques tried to keep contact for as long as possible. The habituation process is illustrated in Figure 1 where we plotted the cumulative contact time with Assamese macaques per month. Contact time increased slowly until we were able to continuously follow the group after 11 months. Whenever in contact with the group, we recorded locations either with a handheld GPS (Garmin GPS60 with external antenna) or relative to the marked trail system.



**Figure 1.** Increase in monthly contact time with Assamese macaques during the habituation phase.

The data analyzed here were recorded at 30min intervals. Day journey length was calculated for days the group was followed continuously from leaving their sleep site in the morning to entering the next sleep site in the evening (all day follow) as the sum of straight line distances between consecutive locations of the group. For the period from June 2006 through July 2007 these data were available for  $16.2 \pm 5.7$  days on average per month; 211 days in total. We transferred data on group location collected during all day follows into ArcView GIS for analysis with the Animal Movement extension (Hooge et al. 1999). The home range area for one year from July 2006 to June 2007 was estimated using the Kernel method and a smoothing factor of 100 (Worton 1989).

In July 2007 the study group AS had 54 members (Table 1) including 12 adult females and 6 large adult males. We were able to reliably identify all individuals in the group from body size, shape of beards and tails, fur coloration, bent and stiff fingers and toes, facial scars, as well as holes and cuts in ears. In other publications we have subdivided the subadult male age class into large and small subadults with large subadults having reached adult body length but not adult body mass (Fürtbauer et al. 2011, Ostner et al. 2011, Schülke et al. 2010); six of the 11 subadult males in Table 1 were large

subadults. The size of our study group thus falls within the range of the Assamese macaque group studied by Cooper and Bernstein (2002) at a temple site in Assam, India comprising 64 individuals and exceeds that reported by Fooden (1982) who counted 20 groups in Thailand with 12 to 50 individual.

**Table 1.** Group composition of study group AS in July 2007

Age-class	Females	Males	Total
Adult	12	6	18
Subadult		11	11
Juvenile	5	13	18
Infant	4	3	7
<b>Total</b>	21	33	54

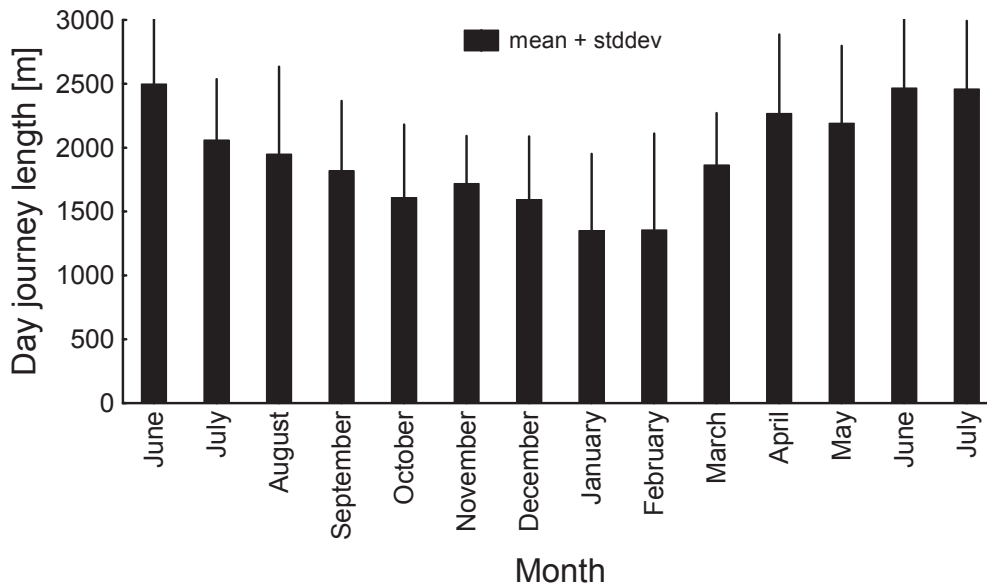
On 9-21 days per month ( $15.6 \pm 4$  days) from July 2006 through June 2007 (187 days total) we conducted scan sampling (Martin & Bateson 1993) with 30 minute intervals. In each scan, we recorded data on general activity (feeding, traveling, social, solitary), positional behavior, height (ground, low storey, mid storey or canopy), and details of feeding behavior from as many individuals as possible. The height category ground was recorded when the individual was on the soil, rocks or leaf litter. Above the ground the forest was divided into three equally large categories with the bottom most one called low storey, the middle one mid storey and the top one, forming the roof of the forest, canopy. These categories were strictly relative to the bit of forest the individual was using. Sitting in a small 10cm dbh tree at 8m either may have been recorded as the mid storey in some parts of the forest or as the canopy at another location if there were no larger trees above the small one. Feeding included handling, ingesting, chewing of food as well as searching for food (may be labeled foraging). In a total of 3,978 scans we observed on average  $16.8 \pm 6.8$  individuals per scan (Table 2) summing up to 50,055 raw data points. These data were broken down into frequencies (or proportions) per age-sex class or per age-sex class and month. We supplemented these quantitative data with a list of animal food items that has been compiled from the beginning of the study in 2005 until August 2011.

**Table 2.** Mean (and standard deviation) number of individuals observed per scan in each age sex class and total in all scans.

	Adult females	Adult males	Subad. males	Juvenile females	Juvenile males	Infants	All
Mean	4.2	2.5	3.1	2.4	2.2	2.4	16.8
Stddev	2.1	1.4	2.2	1.7	1.7	1.8	6.8
Total	12,643	7,320	9,280	7,172	6,566	7,074	50,055

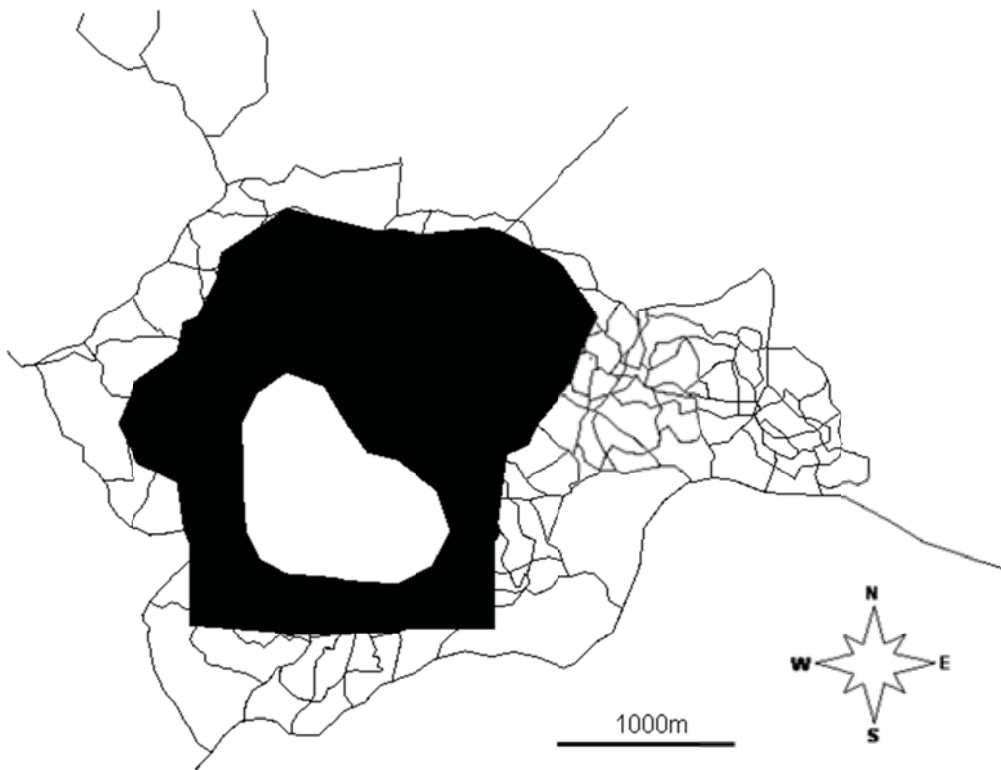
## RESULTS AND DISCUSSION

Day journey length varied markedly between an overall maximum of 6.4km during the habituation period to a minimum of 0.6km. In the first year after complete habituation between June 2006 and July 2007 monthly means of day journey length also varied markedly between 1.3km and 2.5km per day with an average of  $1.9 \pm 0.3$ km per day. The tendency was for the Assamese macaque group to travel less during the period from September/October to February which corresponds with the late rainy and most of the dry season at Phu Khieo WS (Grassmann et al. 2005). Day journeys are long if compared to the Phayre's leaf monkeys (*T. phayrei*) living in Huai Mai Sot Yai that travel 1.1km/day (Koenig et al. 2004) and to Indian Assamese macaques that travel 1km/day (Srivastava 1999).



**Figure 2.** Monthly averages of day journey length between June 2006 and July 2007.

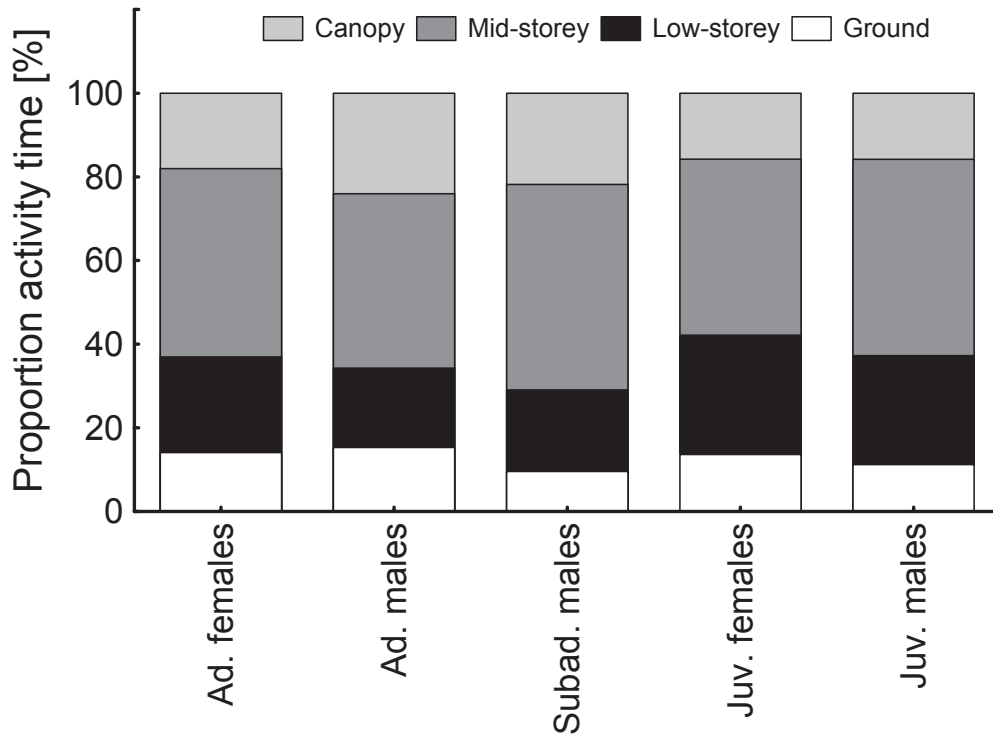
Over the course of one year the group used an area of 4.7km<sup>2</sup>, estimated as the 95% Kernel, that encompasses the area within which the probability to encounter the group is 95%. The group spent 50% of its time in one core area of 1.0km<sup>2</sup>. The 95% Kernel home range of sympatric Phayre's leaf monkeys is about six times smaller with 0.8km<sup>2</sup> (Koenig et al. 2004). Indian Assamese macaques also use much smaller home ranges of 1-2.3km<sup>2</sup> (Srivastava 1999). The average day journeys of other macaque species have been reported to vary between 100m and 3km and home ranges to range "between some dozen hectares and a few square kilometers" (Thierry 2007, p. 227). Hence, Assamese macaques at Phu Khieo WS seem to fall well into the range of the macaque species that have been studied to date.



**Figure 3.** Map of the study site Huai Mai Sot Yai with trail system (black lines) and home range of Assamese macaque group AS from July 2006 to June 2007 (black polygon 95% Kernel, white area 50% Kernel, i.e. core area).

Use of forest strata was not distributed uniformly. The macaques spent almost 50% of their activity time in the midstorey and less than 20% in the canopy. A little less than 40% of the activity time was spent either in the lowest forest stratum or on the ground. There has been a notion that larger bodied macaques are more terrestrial than smaller species (Thierry 2007). Among the species with known body mass, Assamese macaques represent the average species with 11kg male and 7kg female body mass (Thierry 2007). However, with almost 90% arboreality, i.e. time spent off the ground, Assamese macaques at Phu Khieo Wildlife Sanctuary are a close match to the very small lion-tailed macaques and hence, are less terrestrial than may be expected from their size.

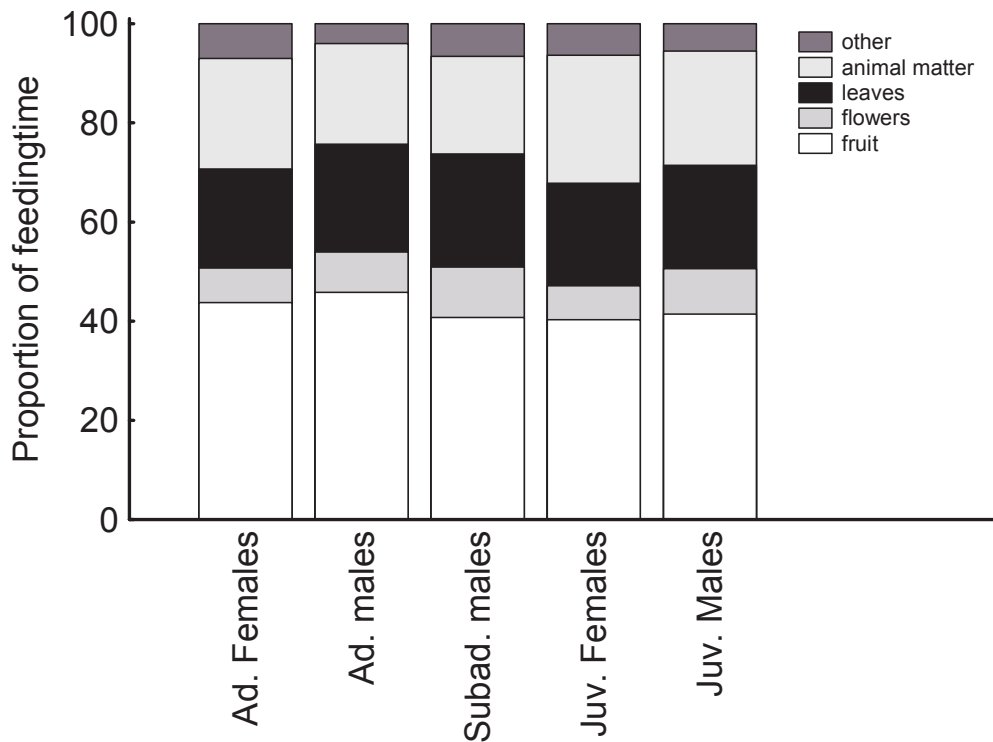




**Figure 4.** Use of forest strata by members of different age-sex classes (ad.: adult, subad.: subadult, juv.: juvenile).

Feeding time showed no clear seasonal variation. Adult females fed for  $34.0 \pm 6.4\%$  of their activity time on average across month; adult males fed for  $30.6 \pm 5.0\%$  of activity time. Between March and November the Assamese macaques spent  $31.2\%$  of their time feeding compared to  $29.2\%$  in Phayre's leaf monkeys in Huai Mai Sot Yai (sum of feeding and foraging in Koenig et al. 2004) and as much as  $40\%$  (Srivastava 1999) in Indian Assamese macaques. Diet composition according to the plant part eaten seemed to be rather similar for different age-sex classes. The single most important food category was fruit with more than  $40\%$  of the feeding time ( $42.4\%$  on average across age-sex-classes) but leaves and animal matter also made up for over  $20\%$  of the feeding time each ( $21.2\%$  leaves and  $22.2\%$  animal matter across age-sex-classes). The main difference between Assamese macaques and

Phayre's leaf monkeys at Huai Mai Sot Yai was that the macaques spent only half as much time as the langurs (39.4%) on leaves and included animal matter instead.



**Figure 5.** Diet composition in different age-sex classes (ad.: adult, subad.: subadult, juv.: juvenile).

Feeding time for fruit was rather similar with 42.4% in Assamese macaques and 35.6% in Phayre's leaf monkeys. However, conclusive comparisons of diet composition between sympatric species need focal animal data on the amount of food ingested. This also applies for comparison with Indian Assamese macaques that spend only 11% of their feeding time on fruit and as much as 52% on leaves and 37% on flowers and flower buds (Srivastava 1999). Ingestion rates can differ dramatically between food items and categories and will strongly influence the importance of different food items in the overall diet (Schülke et al. 2006). The importance of animal matter was especially difficult to estimate via scan sampling because long periods of foraging, searching and handling may be followed by very short events of ingestion possibly of small amounts of matter at a time. Although the Assamese

macaques spent a significant amount of their feeding time searching for and feeding on animal matter, the proportion of fresh weight ingested is probably much less than 20% of the overall intake. Indian Assamese macaques spend only 2% of feeding time on animal matter which is likely due to differences in scan sampling and the ethogram used.

The animal diet of Phu Khieo Assamese macaques included vertebrate as well as invertebrate prey. Most of the animal diet is obtained opportunistically. However, the macaques are regularly observed to consume large amounts of mollusks when they collect aquatic snails from creeks and water holes and suck the animals out of their shells. The monkeys also systematically search for social spiders on tree trunks, and for ant nests in rolled-up leaves on low shrubs. Seasonally occurring caterpillars that infest *Quercus* spec. trees are also consumed in large numbers. Opportunistic consumption of different insects, including ants, termites, and caterpillars, arachnids, mollusks, reptiles (small snakes, lizards), amphibians (frogs), birds (immature and adult jungle fowl *Gallus gallus* and other species) and bird eggs from ground nests or tree nests (jungle fowl and other unidentified species), as well as mammals including rats, flying squirrels, and squirrels (variegated squirrel *Sciurus variegatoides* and black giant squirrel *Ratufa bicolor*) has been observed on more than one occasion. Feeding on birds has also been reported for Indian Assamese macaques (Srivastava 1999). At Phu Khieo some prey have been hunted (and wounded) but not killed and consumed. These included birds (greater coucal *Centropus sinensis*, Siamese fireback *Lophura diardi*), ungulates (mousedeer *Tragulus javanicus*, barking deer *Muntiacus muntjak*), and a carnivore (juvenile masked palm civet *Paguma larvata*).

Regarding niche separation between sympatric species, comparisons between species should also take into account the relative timing of consumption and the specific part and ripeness of a fruit or leaf that is consumed. Hence, all comparisons made here must be regarded as preliminary. Ongoing research on the macaques of Phu Khieo Wildlife Sanctuary will significantly deepen our understanding of inter-specific competition between primates from the same and different genera in Thailand.

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