Primate Conservation 2022 (36): 173-189

Activity Budget and Diet of Phayre's Langur (*Trachypithecus phayrei*) in Satchari National Park, Bangladesh

Habibon Naher[1], Tonmoy Mondal[1], Md. Sabbir Hasan[1], Shawkat Imam Khan[2] and Sabir Bin Muzaffar[3]

[1]*Department of Zoology, Jagannath University, Dhaka, Bangladesh*
[2]*Department of Natural History, Bangladesh National Museum, Dhaka, Bangladesh*
[3]*Department of Biology, United Arab Emirates University, Al-Ain, United Arab Emirates*

Abstract: There are few studies of the Critically Endangered Phayre's langur (*Trachypithecus phayrei*) in Bangladesh. An understanding of their diet and activity budget is important for the elaboration of conservation management plans. In this study, we obtained data on the activity budget and dietary composition of different age-sex classes in a group of seven Phayre's langur in the Satchari National Park, Bangladesh. We studied them for four months, from December 2017 to March 2018, recording their behavior by instantaneous scan sampling. They spent most of their time foraging and feeding (40.7% of the total scans), followed by traveling (31.8%), resting (18.3%), grooming (7.8%) and playing (1.4%). The sub-adult male spent the most time foraging and feeding (44.6% of their total scans) and the adult female the least (36.8%). For traveling (locomotion), the juvenile was the most active (37.4%) and the adult male the least (27.7%). The adult female rested more than other group members (24.2%), the juvenile the least (14.9%). The sub-adult female groomed most (18.6%), the sub-adult male the least (5.96%). Leaves were the principal food item (50% of feeding records), followed by fruits (18.6%), flowers (16.2%), buds (8.8%) and bamboo shoots (6.4%). Foraging and feeding was predominant in their activity budget, followed by traveling, in all months except March when the reverse was true due to food scarcity. The composition of their diet varied monthly according to the availability of food items in their habitat. Twenty-two species of plants were identified included in the diurnal activities, including six in the family Moraceae, four in the Fabaceae and three in the Malvaceae. Their diet included items from 17 plant species.

Keywords: Phayre's langur, *Trachypithecus phayrei*, diurnal activities, diet, food items, Bangladesh

Introduction

Habitat loss and degradation caused by human encroachment, overgrazing, construction of roads through forests, deforestation, agriculture, fire, and the exploitation of forest resources, and hunting for food, medicinal purposes and artifacts for socio-cultural practices, and religious and cult ceremonies are the major causes of the decline of primate populations worldwide (Marsh and Mittermeier 1987), and most particularly in South Asia (Molur *et al*. 2003; Kumar and Solanki 2004; Minhas *et al*. 2010). Populations of six of Bangladesh's nine native primates are threatened; four of them, including *Trachypithecus phayrei*, are categorized as Critically Endangered on the IUCN Red List of Threatened Species (IUCN Bangladesh 2015).

Time allocation to various activities is a critical aspect of the behavioral ecology of an animal (Decemson *et al*. 2018). Activity patterns, the proportion of time spent in different activities and the distribution of those behaviors throughout the day, month and year, are closely linked to diet and food acquisition, movement (daily distances traveled and home range) and, ultimately, survival (Chalmers 1968; Mandal and Kabir 2014). Physiological and anatomical factors such as energy balance, body size and food influence activity budgets besides resource availability that is integral to the survival and reproduction of a species. Patterns of activity

are determined by the dispersion of important tree species and the abundance, seasonality and quality of their food sources (Clutton-Brock 1974; Leighton and Leighton 1983; Lambert 2007; Jaman and Huffman 2008). Much of the remaining forest habitat for primates in Bangladesh today comprises scattered, small, isolated forest patches with reduced tree species richness, and an understanding of the patterns of abundance and dispersion of their food resources in this circumstance is essential for informed conservation measures on their behalf. Colobines obtain their protein from leaves, particularly young leaves (Jolly 1985; Solanki *et al*. 2008) but their diet can differ greatly among closely related taxa, intra-specifically among populations inhabiting different habitats or areas within a forest and inter annually within a single group (Chapman and Chapman 1999; Harris *et al*. 2010; Chaves and Bicca-Marques 2013). Food availability depends on the profile of the forest in terms of plant species diversity and the dispersion and seasonality of food resources (Feeroz 1999; Neha *et al*. 2020). A plant's phenological stages control the food choices of leaf- and fruit-eating primates and even affect the abundance of insects for the more insectivorous species (Freeland and Janzen 1974; Milton 1980; Solanki *et al*. 2008). The study of activity budgets is vital for an understanding of habitat use, habitat suitability, and niche separation (Rave and Baldassarre 1989) and is consequently an invaluable aid for managing habitats for primate populations.

Phayre's langur (*Trachypithecus phayrei*) is restricted in its range to eastern Bangladesh, northeastern India (states of Assam, Mizoram and Tripura), China and Myanmar (Molur *et al.* 2013; Roos *et al.* 2014). It is Critically Endangered in Bangladesh (IUCN Bangladesh 2015) and Endangered globally (IUCN 2021; Chetry and Ahmed 2021). In Bangladesh, it is found in the semi-evergreen and semi-deciduous forests of the Sylhet, Chittagong and Chittagong Hill tracts (Ahmed *et al*. 2009; IUCN Bangladesh 2015). It lives in small groups; group size varies from 3 to 19 (Kabir 2002; Al-Razi and Naher 2021). Both uni-male (Al-Razi and Naher 2021) and multi-male groups are found in different forests of Bangladesh (Kabit 2002) and India (Bose 2003).

Previous research on Phayre's langur has focused mostly on population status, in Bangladesh (Khan and Ahsan 1981, 1986; Gittins and Akonda 1982; Ahsan and Khan 1984; Molur *et al.* 2003; Ahmed *et al*. 2009; Al-Razi and Naher 2021) and India (Raman *et al.* 1995; Choudhury 1996, 2001; Gupta 2001; Bose 2003; Adimallaiah *et al.* 2014) but there is little information on diet and habitat use (Gupta and Kumar 1994; Aziz and Feeroz 2009; Decemson *et al.* 2018). Field studies on this species are few in Bangladesh and other countries due to its shyness (Nigam *et al.* 2014) and its tendency for seasonal dispersal. There is mounting evidence that primates change their activity patterns in shrinking habitats, often increasing travel time in denuded forests to locate suitable trees and vines for feeding and resting (see, for example, Cristóbal-Azkarate and Arroyo-Rodríguez 2007, Riley 2007). We collected quantitative data on activity patterns and the diet of Phayre's langur in Satchari National Park, aiming to obtain more information on time allocation and the plants used by this species in Bangladesh. Since forest patches in Bangladesh tend to have reduced tree diversity, we expected that the Phayre's langurs would spend more time traveling than would be the case in larger forests that are not fragmented.

Methods

Study area

Satchari National Park (243 ha, 24°7.595'N, 91°26.732'E) is situated in the Raghunandan Hill Reserve Forest of Paikpara Union in Chunarughat Upazila of the Habiganj District in Bangladesh (Fig. 1). It is 130 km (81 mi) from Dhaka, the capital city of Bangladesh. The semi-evergreen forest of Satchari National Park is in a transition zone between the Indian subcontinent and the Indo-Chinese ecological regions (Sharma 2006). The topography of the park is undulating with slopes and hillocks, locally called *tila*, ranging from 10–50 m in elevation, running from south to north. They are composed of upper tertiary rocks in which sandstone is largely predominant (Rizvi 1970). The soil of the park area is mostly sandy loam, and the humus of the topsoil is shallow due to the rapid decomposition of the leaf litter and debris under the moist warm tropical conditions (Rizvi 1970). Soils are more acidic than in adjoining ecological zones (Mukul *et al.* 2006).

The national park has a patch of 120 ha of natural forest and the remaining area is covered by a short-rotation plantations of *Eucalyptus* and *Acacia* and a long-term plantation of oil palm. More than 245 plant species have been identified in the forested area, including 86 species of herbs, 46 species of shrubs, 73 species of trees, 37 species of vines and lianas, and 3 species of epiphytes (Arefin *et al*. 2011). The dominant families are Moraceae (18 species) and Poaceae (12 species) (Arefin *et al*. 2011). *Amomum aromaticum* (Zingiberaceae), *Aquilaria agallocha* (Thymelaeaceae), *Cymbidium aloifolium* (Orchidaceae), *Globba multiflora* (Zingiberaceae), *Holigarna longifolia* (Anacardiaceae), *Rauvolfia serpentina* (Apocynaceae), *Steudnera colocasioides* (Araceae), *Cyathea gigantea* (Cyatheaceae), *Gnetum oblongum* (Gnetaceae), *Lagerstroemia speciosa* (Lythraceae), *Tectona grandis* (Lamiaceae), *Xylia xylocarpa* (Fabaceae), *Artocarpus chama* (Moraceae), *A. lacucha* (Moraceae), *Dipterocarpus* spp. (Dipterocarpaceae), *Terminalia bellirica* (Combretaceae), *Syzygium* spp. (Myrtaceae), *Ficus* spp. (Moraceae), and several bamboos and rattans are notable species in this forest (Arefin *et al*. 2011). Six primates are present in the area: rhesus macaque *Macaca mulatta*; northern pig-tailed macaque *M. leonina*; Bengal slow loris *Nycticebus bengalensis*; western hoolock gibbon *Hoolock hoolock*; Phayre's langur *Trachypithecus phayrei*; and capped langur *T. pileatus* (Al-Razi and Naher 2021).

There is a village of the Tripura ethnic community (about 24 families) inside the park (Mukul 2007; Al-Razi and Naher

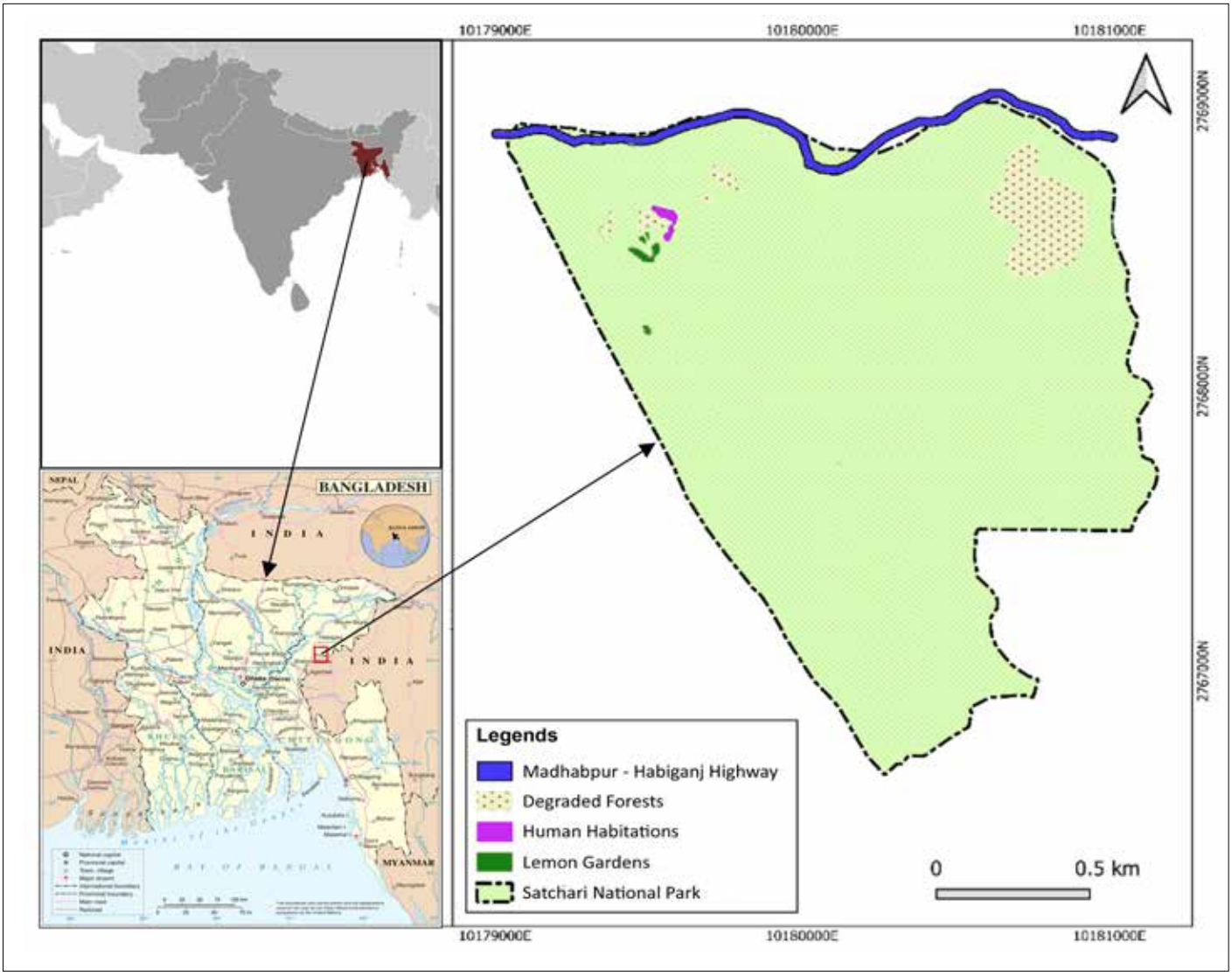

Figure 1. Location of Satchari National Park in Bangladesh.

2021), and the area is surrounded by several industrial tea estates (Ahmed and Naher 2021). Local people, nearby villagers and tea estate laborers are dependent on this forest for their livelihoods (Mukul 2007). A road passes through the fragmented forest habitat (Ahmed and Naher 2021). Illegal logging, fuelwood collection, roadkill, monoculture practice, expansion of lemon orchards, livestock grazing, cane and exotic tree plantations, and uncontrolled visitor activities have been recorded as threats to this forest (Ahmed and Naher 2021; Al-Razi and Naher 2021).

Data collection

The behavior of the langurs was recorded using instantaneous scan sampling (Altmann 1974) for five minutes at five-minute intervals. Over five days we were able to select and habituate a group of seven individuals to our presence: one adult male, one adult female, two sub-adult males, one sub-adult female, and two juveniles). The langurs were already largely habituated to human presence and activities—local people in and around this area regularly visit the forest for their daily needs, there are numerous tourists, especially in the winter, and noisy local festivals with loudspeakers, chatter and shouting and fireworks in and around the national park (Ahmed and Naher 2021; Al-Razi and Naher 2021).

We recorded data on all individuals of the group during each five-minute scan to record their activities and diet. If we failed to see one or more individuals within the five minutes, we still used the records in the analysis (Ruppert *et al*. 2018). We summed and averaged the data for the two sub-adult males and, separately, the two juveniles. The study group was followed from the moment they left the sleeping tree in the morning until they arrived at the sleeping tree at the end of the day. Activities were classified into: foraging (when an individual was moving in different branches of the same tree to collect food) and feeding (when an individual was collecting, chewing, or swallowing food), traveling (when an individual was moving across different trees), resting (when an individual was motionless,

including sleeping), grooming (when an individual was engaged in normal social activity with a conspecific, except playful behavior) and playing (when an individual was engaged in playful behavior) according to Ma *et al*. (2017). Food types were classified as: (i) mature leaves, (ii) young leaves, (iii) ripe fruits, (iv) unripe fruits, (v) flowers, (vi) shoots and (vii) buds. Left-over plant parts were collected to identify what they were eating, and the species. The age-sex categories were juvenile (JUV), sub-adult male (SAM), sub-adult female (SAF), adult female (AF) and adult male (AM). They were categorized based on the morphological characters and differences described by Bhattacharya and Chakraborty (1990) and Adimallaiah *et al.* (2014). In adults, sex was determined by the sex organs and the white ocular marking around the eyes. In the males, the marking was circular or elliptical, and in the females, it was triangular or cone shaped (Choudhury 1987; Gupta 2001). This marking was not prominent in juveniles (Adimallaiah *et al.* 2014). The juveniles were identified based on their closer contact with their mothers when they took rest and roost (Adimallaiah *et al.* 2014) and their body size, which was almost half of an adult male. In the sub-adult female, the nipples were generally prominent with visible teats, and in the sub-adult male, the nipples were not prominent.

Daily observations were divided into morning (07:00–09:30), late morning (09:31–12:00), noon (12:01–15:30) and afternoon (15:31–18:00). The plant species used during the different activities were also recorded. A total of 1670 records were collected from 10 days and 53 hours of observation. Data were collected on the study group on 2–3 days per month from December 2017 to March 2018.

Data analysis

Percent of time spent on an activity during the day or on any food item during feeding was estimated using the formula $T_a = (n_a \times 100)/N$ (Altmann 1974), where T_a = % of time spent on activity or food item a; n_a = number of records with activity or food item a; and N = total number of records.

Results

Diurnal activity budget

Most of the langurs' time was spent foraging and feeding, followed by traveling, resting, grooming and playing (Fig. 3). The time spent on different activities varied according to age-sex classes. The sub-adult males spent most of their diurnal time in feeding and foraging (44.6% of their total scans), and the adult female spent the least time (36.8% of their total scans) in feeding and foraging (Fig. 4). Juveniles spent most of their time moving about (37.4%), and the adult male spent the least time doing so (27.7% of the total scans). The adult female spent relatively more time in resting (24.2%) compared to juveniles (14.9%). Time spent grooming was highest for the sub-adult female (8.9%) and

Figure 2. Adult male Phayre's langur, *Trachypithecus phayrei*, resting. Satchari National Park, Bangladesh. Photograph by Tania Akhter.

lowest in the sub-adult males (5.96%). The juveniles played the most (3% of the scans). The adult male was not seen playing.

The percentage of time spent in different activities varied during the day. Times spent in resting and grooming were highest in the late morning while foraging and feeding and traveling were the lowest. Time spent on foraging and feeding was highest in the afternoon while resting and grooming was the lowest (Fig. 5). Most traveling occurred around noon (Fig. 5). Playing was seen mostly in the morning and noon (Fig. 5).

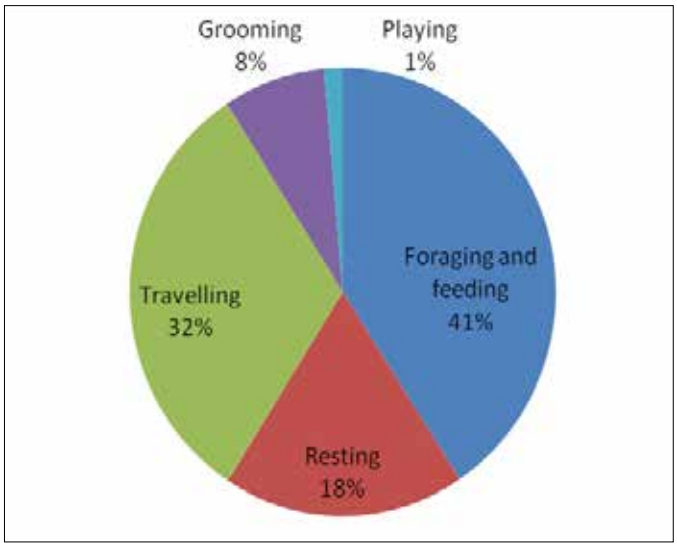

Figure 3. Percentage of time spent in different diurnal activities: Phayre's langur in Satchari National Park.

Time spent in different activities varied according to age-sex classes. All of the langurs spent most of their time in foraging and feeding in the afternoon (Fig. 6) and all, except for the adult male, rested most in the late morning; the subadult males rested more in the morning. Time spent traveling and moving about was highest at noon for all individuals except for the sub-adult males, which were more active in the afternoon. Most grooming occurred in the morning in all individuals except the adult male and the sub-adult female.

The proportion of time spent in the various activities varied between months. All activities were highest in December, except playing (Fig. 7). They spent the most time in foraging and feeding followed by traveling in all months except in March when they traveled more than foraging and feeding. Comparing individuals in the different months, the sub-adult males and the sub-adult females spent more time in foraging and feeding in all months. The adult female, sub-adult male and the juveniles rested more in

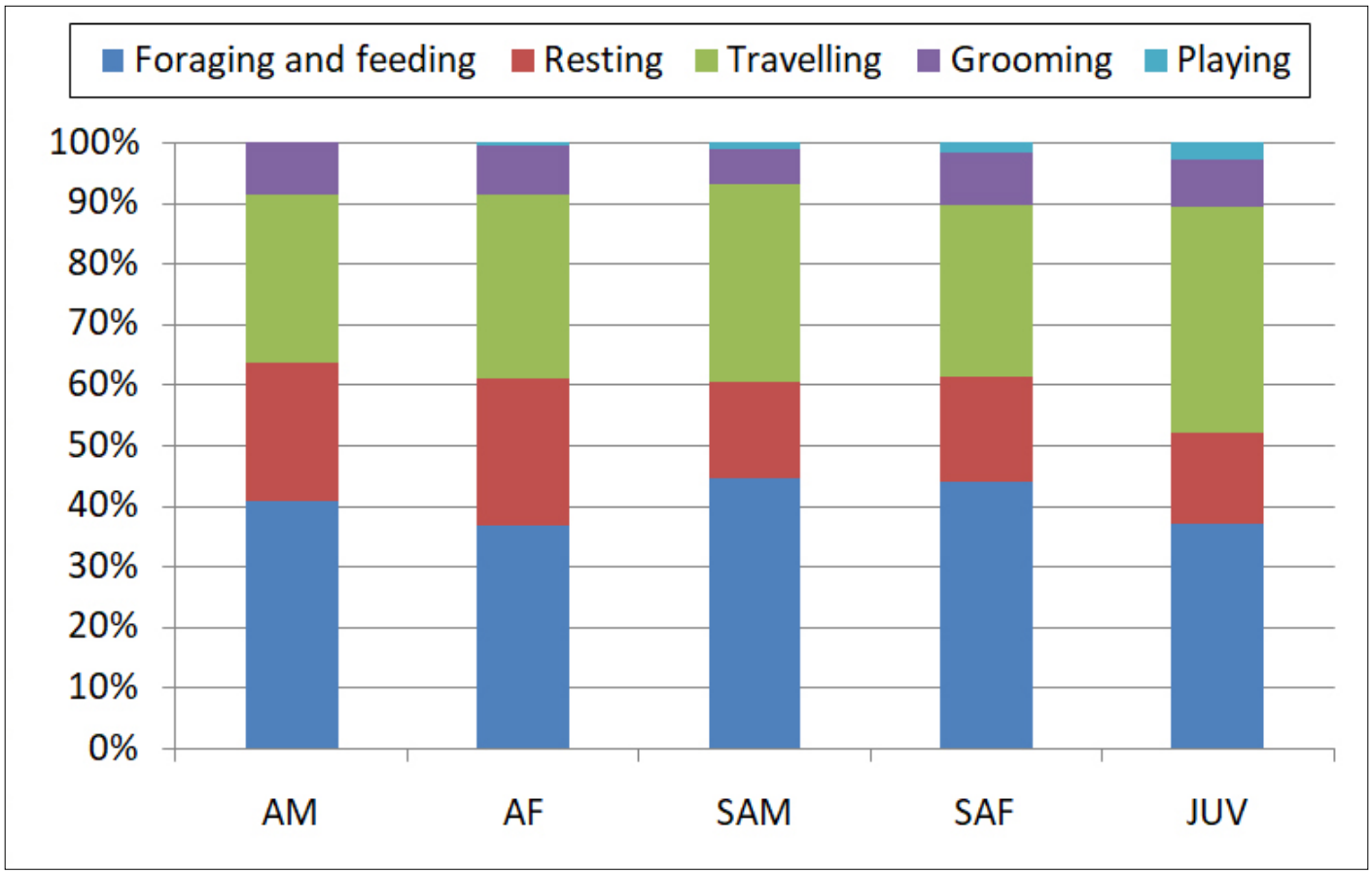

Figure 4. Diurnal activities according to age-sex classes: Phayre's langur in Satchari National Park.

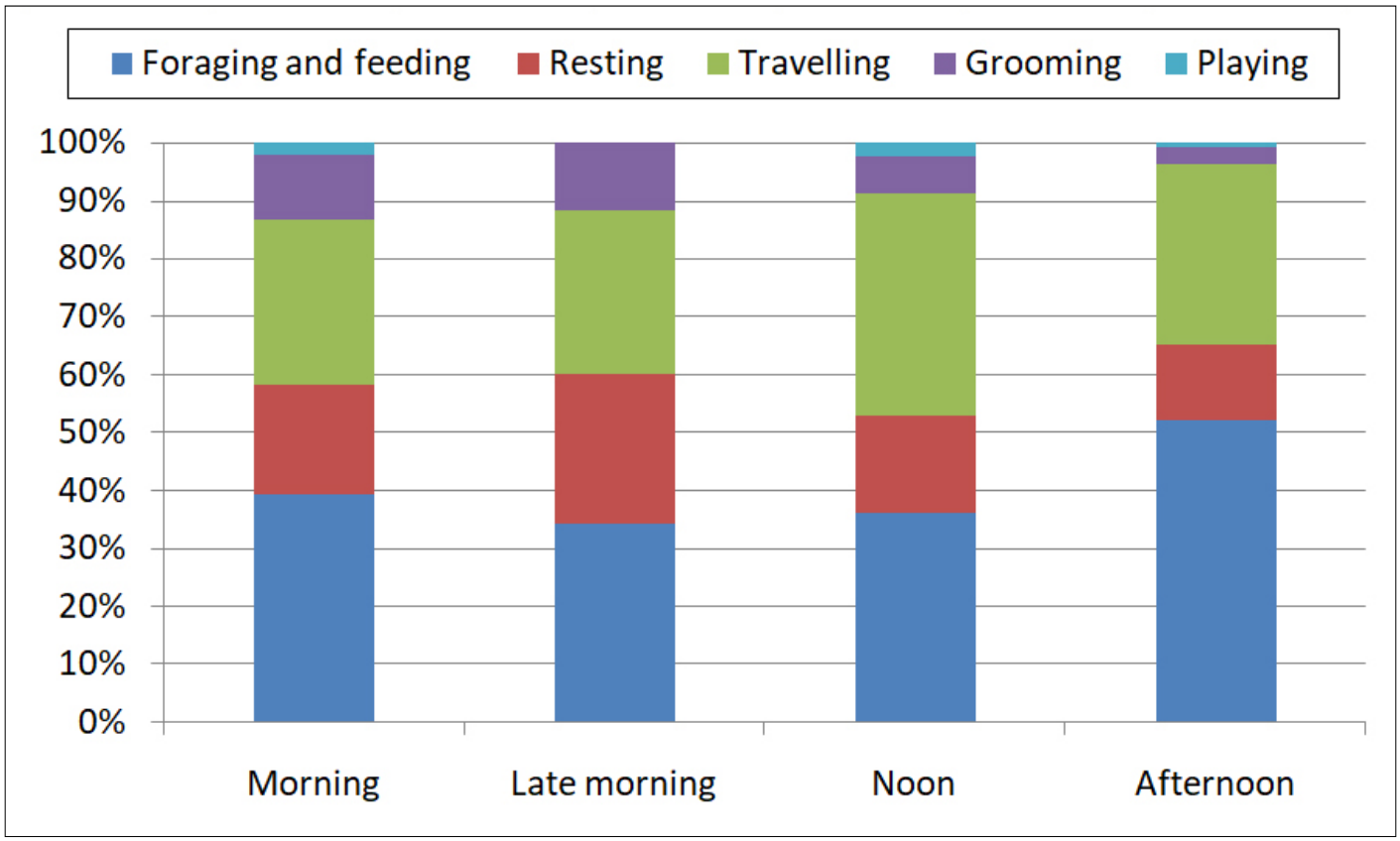

Figure 5. Diurnal activities at different times of the day: Phayre's langur in Satachari National Park.

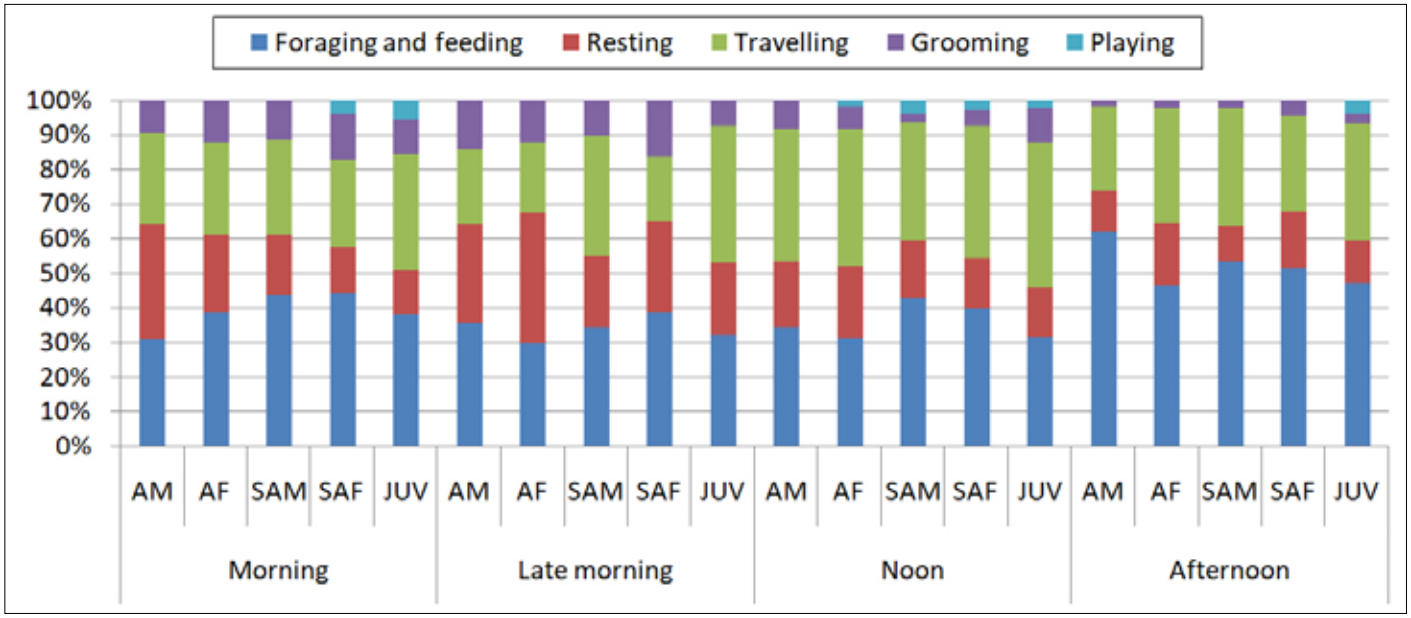

Figure 6. Diurnal activities according to age-sex classes at different times of the day: Phayre's langur in Satchari National Park.

December whereas the adult male rested more in February and the sub-adult female in March. All individuals traveled and were more active in March. In December, grooming was mostly recorded for the adult male and sub-adult female and in January, for the sub-adult female and juveniles, and in February, for the adult female. Playing was mostly seen in February, for sub-adult female and juveniles. Grooming and playing were not observed in March (Fig. 8).

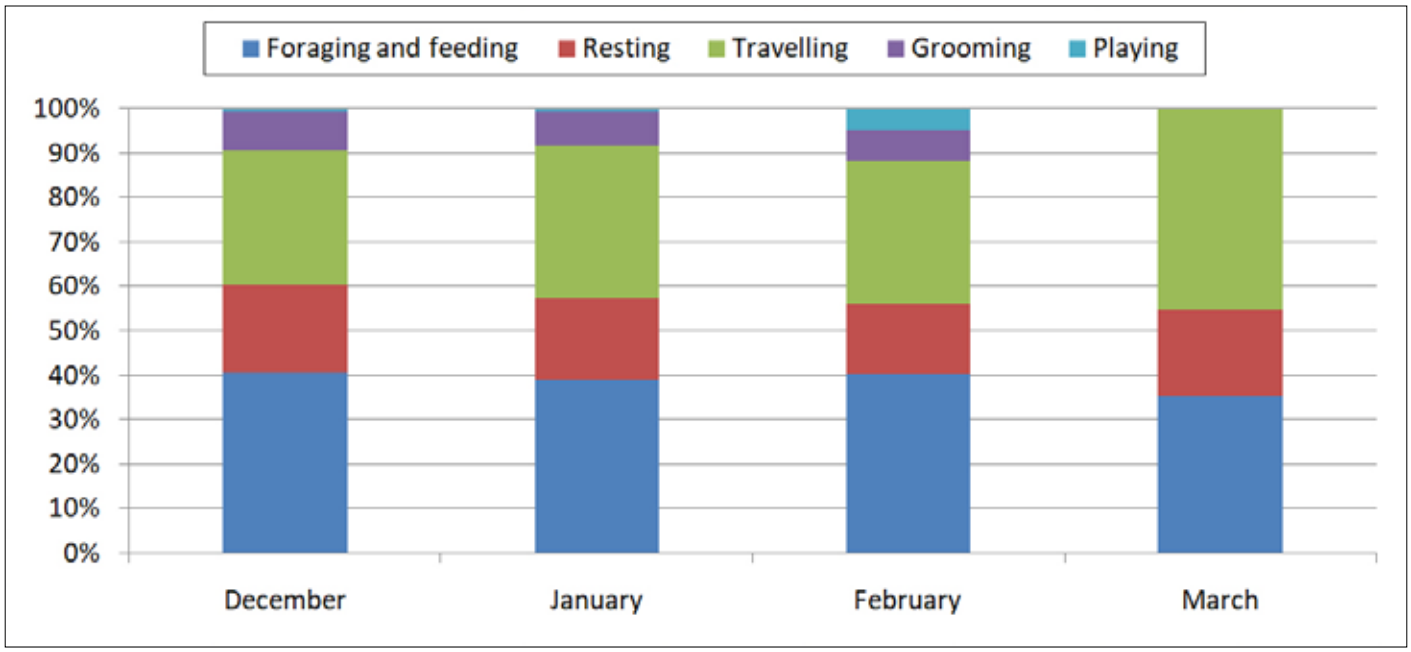

Figure 7. Monthly diurnal activities in each month: Phayre's langur in Satchari National Park.

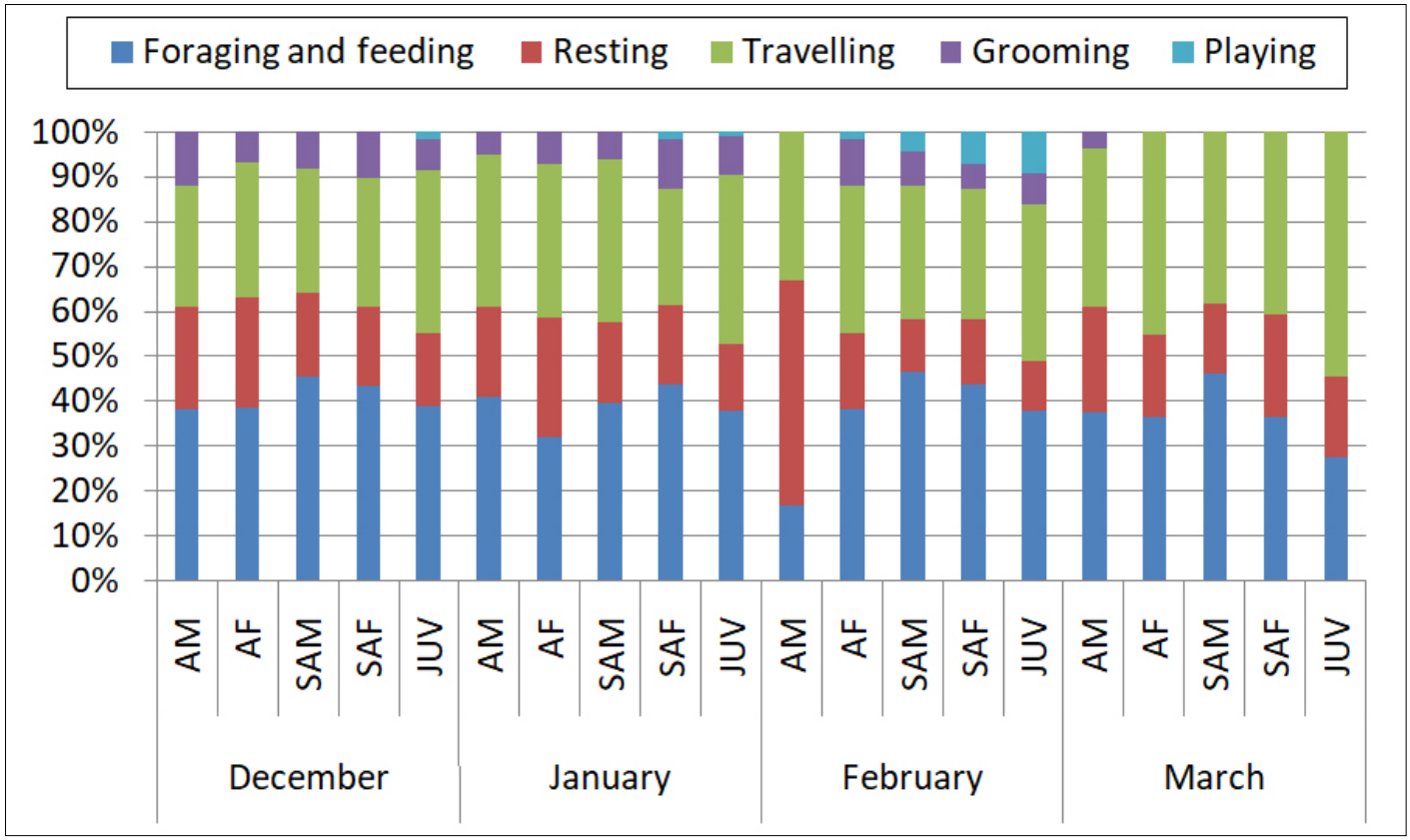

Figure 8. Monthly diurnal activities according to age-sex classes: Phayre's langur in Satchari National Park.

Dietary flexibility of Phayre's langur

Half (50%) of the feeding time of the Phayre's langurs was spent consuming leaves of different trees. They spent 18.6% of their feeding time on fruits, 16.2% on flowers, 8.8% on buds and 6.4% on bamboo shoots. Comparing the group members, the juvenile consumed more young leaves, the sub-adult males consumed more fruits, especially ripe fruits, and bamboo shoots, the adult male consumed more

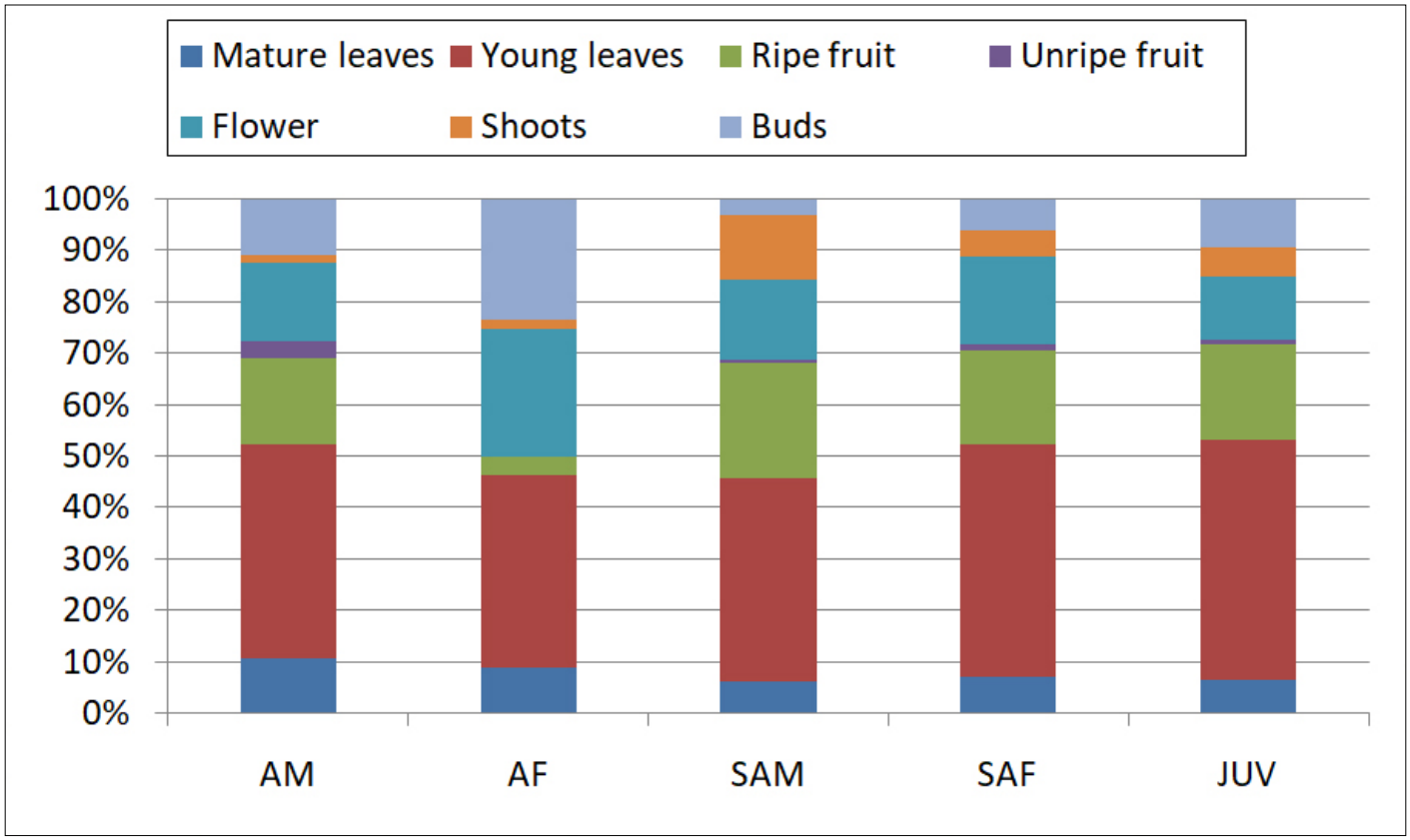

Figure 9. Percentage of time spent in feeding on different food items according to age-sex classes: Phayre's langur in Satchari National Park.

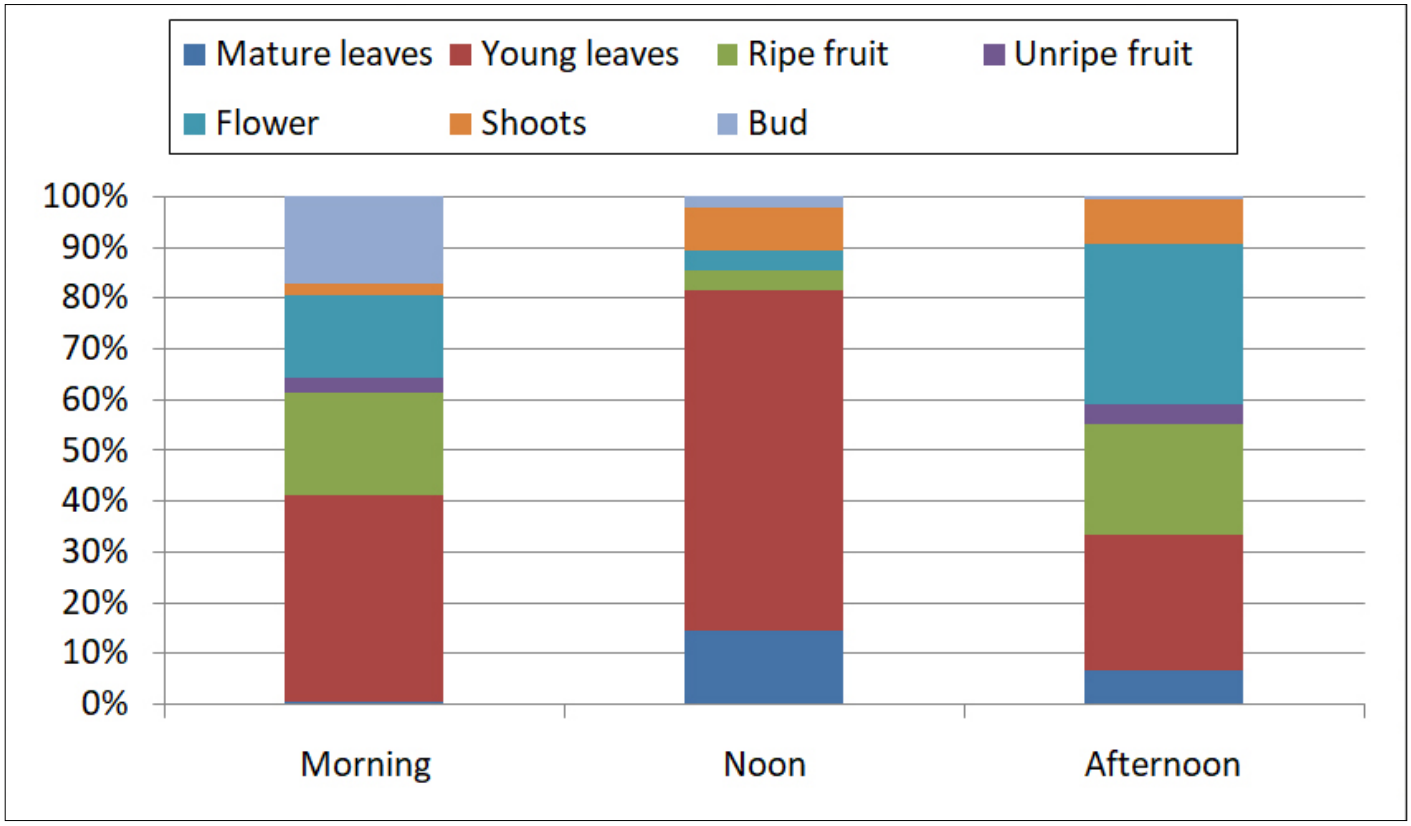

Figure 10. Time spent feeding (%) on different food items at different times of the day: Phayre's langur in Satchari National Park.

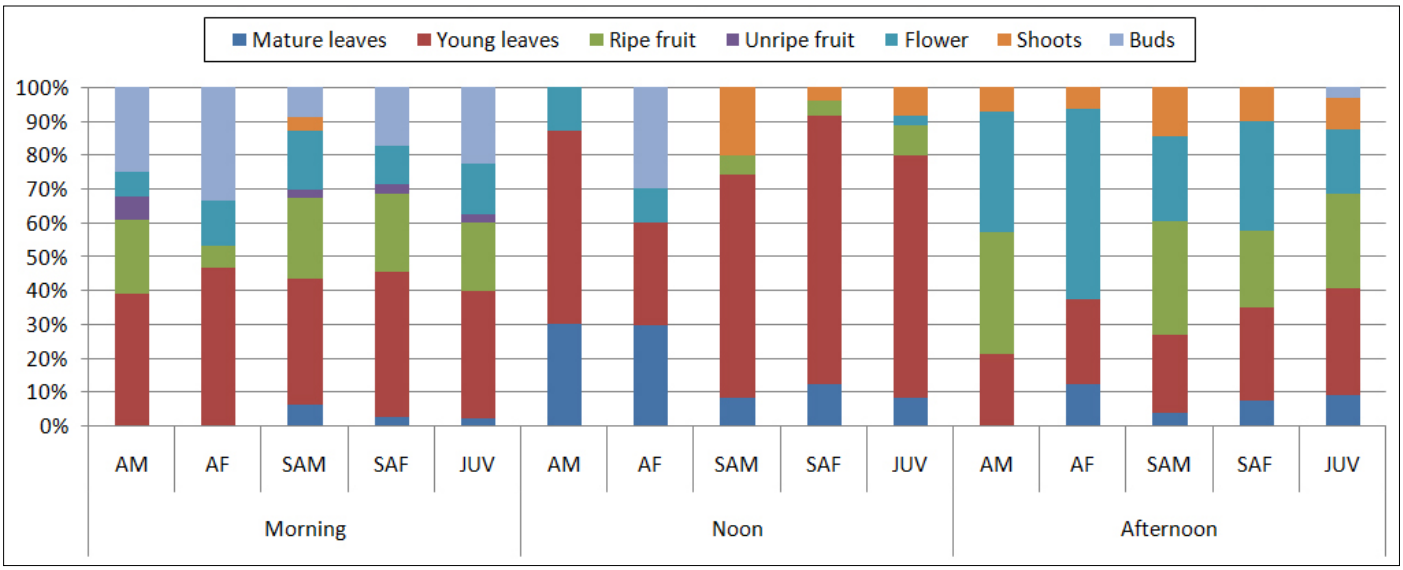

Figure 11. Time spent feeding (%) on different food items according to age-sex classes at different times of the day: Phayre's langur in Satchari National Park.

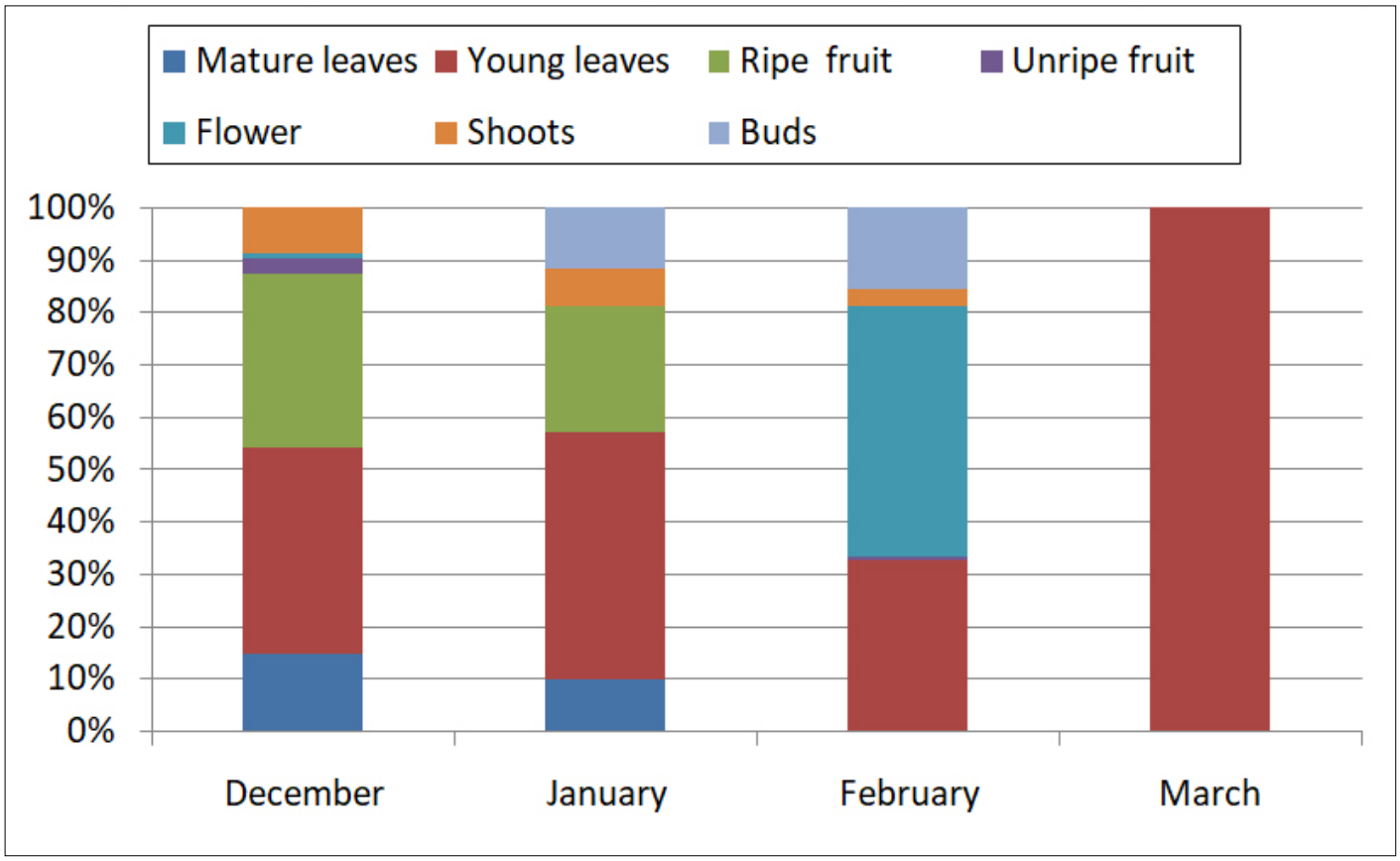

Figure 12. Time spent feeding (%) on different food items in each month: Phayre's langur in Satchari National Park.

mature leaves and unripe fruits, and the adult female consumed more flowers and buds (Fig. 9).

Dietary composition was distinctly diversified during the day (Fig. 10). Leaves, mature and young, were predominant at noon, whereas fruits, ripe and unripe, were predominant in the morning and afternoon. Flowers were eaten mostly in the afternoon, buds in the morning, and bamboo shoots both at noon and in the afternoon (Fig. 10).

Consumption of different food items during the day varied according to age-sex classes (Fig. 11). All individuals preferred to consume young leaves throughout the day but adult individuals (both male and female) avoided

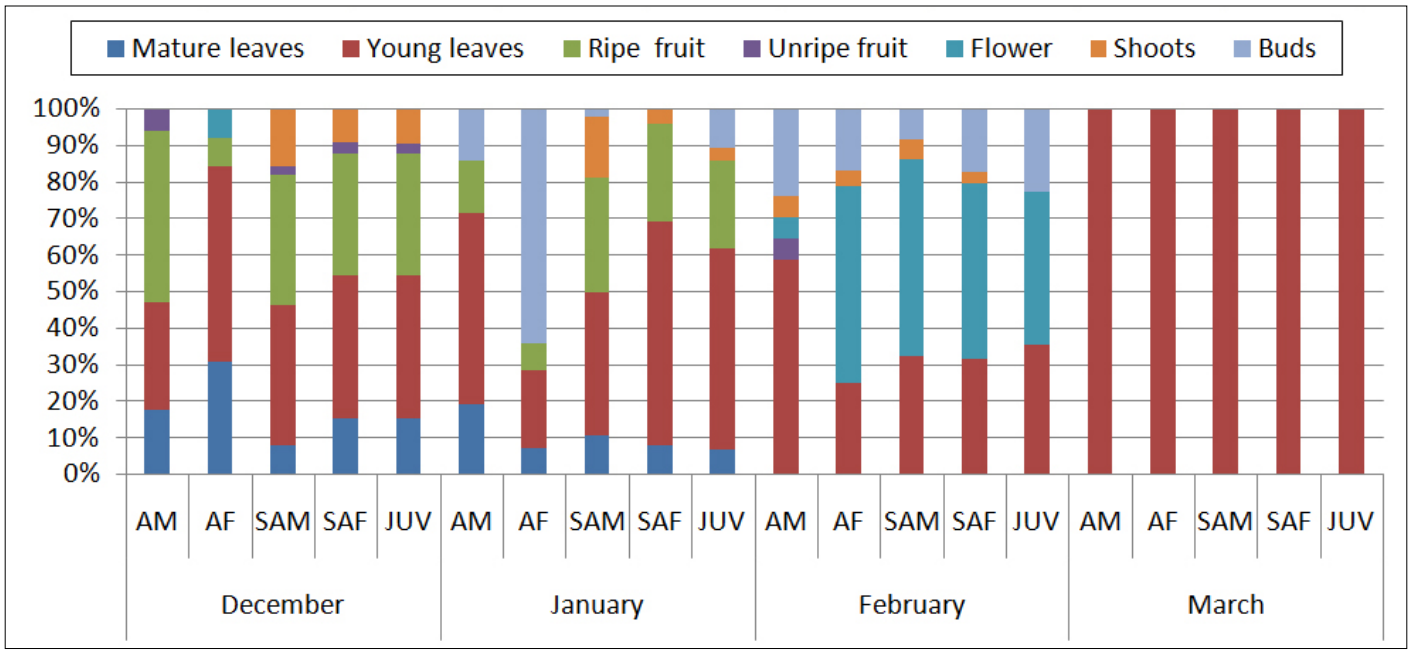

Figure 13. Monthly variation in time spent feeding (%) on different food items by each of the group members: Phayre's langur at Satchari National Park.

mature leaves in the morning. All individuals spent much of their time eating ripe fruits in the morning and afternoon except the adult female, which ate fruits only in the morning. Almost negligible amounts of unripe fruits (1.12%) were consumed in the morning by all individuals, except for the adult female, which was not seen to eat unripe fruits at all. All group members ate flowers mostly in the afternoon. Buds were eaten in the morning (Fig. 11).

The composition of the diet varied monthly (Fig. 12). They ate young leaves in all months, but mature leaves in December and January. Ripe fruits were consumed in December and January while the fruits of *Ficus hispida* were available. Flowers of *Erythrina variegata* (Fabaceae), and *Bombax ceiba* (Malvaceae) were consumed in February. Buds *Artocarpus lakoocha* (Moraceae) were consumed in January and February.

Preference for different food items varied according to age-sex class in different months (Fig. 13). In comparison to other individuals, while the adult female consumed more mature leaves in December, the adult male ate more mature leaves in January. Consumption of young leaves was highest for juveniles in December, and the adult male in January and February. All group members depended on young leaves in March, when they were readily available. The adult male was the principal consumer of ripe fruits in December, the sub-adult males in January. Flowers were eaten by the entire group in February; the adult female consumed the most and, besides, a small amount in December. All, except for the adult female, took small amounts of unripe fruits in December but the adult female ate some in February. Bamboo shoots were eaten in all months except March, the sub-adult males consumed the most in December and January and the adult female likewise in February. Buds were eaten only in January and February.

Plant use for different activities

The Phayre's langurs used 22 species of 12 families during the day (Table 1). They selected 17 species of plants for feeding and foraging and 10 spp. for traveling, 6 spp. for resting, 8 spp. for grooming and just one for play. Moraceae (6 species) was the most dominant plant family followed by Fabaceae (4 species) and Malvaceae (3 species).

Discussion

Foraging and feeding were predominant (41%) in this study contrasting with the findings of Koenig *et al*. (2004) at Phu Khieo Wildlife Sanctuary, Thailand, where the langurs were inactive much of the time (43.7%). The time spent in feeding was considerably more than was found in the studies conducted by Gupta and Kumar (1994) but foraging and feeding was higher (29.2%) at Phu Khieo Wildlife Sanctuary (Koenig *et al.* 2004). Feeding is recorded as a major diurnal activity in other colobines including the capped langur (*Trachypithecus pileatus*) at Tripura in Northeast India (Gupta 1996), Cantor's dusky leaf monkeys (*Trachypithecus obscurus*) at the Penang Botanical Garden in Malaysia (Zain and Ch'ng 2011), and the Angolan black-and white colobus *Colobus angolensis* at the Kakamega Forest in Kenya (Fashing *et al*. 2007).

Our findings contradict a number of studies which have reported resting rather than feeding as predominant for many colobines: *T. pileatus* at Madhupur National Park (Islam and Hussain 1982; Stanford 1991; Kabir and Islam 1995; Mandal

Table 1. Plant species used by Phayre's langurs in different activities. Note: F = Foraging and feeding; R = Resting; T = Traveling; G = Grooming; P = Playing.

Sl.	Common name: Bangladesh	Scientific name	Family	F	R	T	G	P
1	Bamboo	*Bambusa vulgaris*	Poaceae	√		√		
2	Black Berry	*Cleistocalyx operculatus*	Myrtaceae	√		√		
3	Pithraj tree	*Aphanamixis polystachya*	Meliaceae			√		
4	Chapalish	*Artocarpus chaplasha*	Moraceae		√	√	√	
5	Hairy Fig	*Ficus hispida*	Moraceae	√		√	√	
6	Indian Fig	*Ficus racemosa*	Moraceae	√	√		√	√
7	Monkey Jack	*Artocarpus lacucha*	Moraceae	√	√		√	
8	Serut	*Streblus asper*	Moraceae	√				
9	Sandpaper	*Trophis aspera*	Moraceae		√		√	
10	Mango	*Mangifira indica*	Anacardiaceae		√		√	
11	Indian Olive	*Elaeocarpus floribundus*	Elaeocarpaceae	√		√		
12	Teak	*Tectona grandis*	Lamiaceae	√			√	
13	Hairy-leafed Molave	*Vitex pubescens*	Lamiaceae	√		√		
14	Phalsha	*Grewia nervosa*	Malvaceae	√	√	√		
15	Agarwood	*Aquilaria agallocha*	Malvaceae			√		
16	Cotton	*Bombax cieba*	Malvaceae	√		√	√	
17	Black board tree	*Alstonia scholaris*	Apocynaceae	√				
18	Silk tree	*Albizia chinensis*	Fabaceae	√				
19	White siris	*Albizia procera*	Fabaceae	√				
20	Indian coral tree	*Erythrina variegata*	Fabaceae	√				
21	Gum-Arabic tree	*Vachellia nilotica*	Fabaceae	√				
22	Helicopter Flower	*Hiptage benghalensis*	Malpighiaceae	√				

and Kabir 2014; Khan 2020), Satchari National Park (Hasan 2017), Rema Kelanga Wildlife Reserve (Kabir 2006) and West Bhanugacha (Kabir and Islam 1995) in Bangladesh; the white-headed langur *Trachypithecus leucocephalus* (see Li and Rogers 2004), François' langur *T. francoisi* (see Zhou *et al.* 2007), Guereza *Colobus guereza* (see Fashing 2001), *T. obscurus* (see Leen *et al*. 2019) and the white-thighed colobus *C. vellerosus* (see Teichroeb *et al.* 2003) in different sites in Asia and Africa. The plausible reason for the highest feeding time in the present study might be the need to

maintain high energy intake, in line with the Cantor's Dusky Leaf Monkey in Penang Botanical Garden in Malaysia (Zain and Ch'ng 2011). Differences can also occur because of the difference in observation technique. Koenig *et al.* (2004), for example, used an interval of 30-minutes when scan sampling, which made it less likely to capture traveling. Gupta and Kumar (1994) used 5-minute scans at 15-minute intervals and Leen *et al.* (2019) used 5-minute scans at 10-minute intervals which captured more traveling. Another possibility is differences in behavioral definitions. Gupta and Kumar (1994) recorded all moving activities as traveling but Leen *et al.* (2019) observed foraging, feeding and locomotion/traveling separately. Levels of disturbance in different habitats may affect the activity budget (Leen *et al.* 2019). The extent to which the langurs are habituated can also affect observations. Unhabituated or weakly habituated animals are more likely to be observed when they are feeding or traveling and less likely when they rest or groom. Duration of the study may influence the findings, as the present study covered only four months of the year. Activity budget and diet variation may differ in a year-long study.

Bimodal feeding peaks (morning and afternoon) were observed for this species and other primates (Clutton-Brock 1974; Aldrich-Blake 1980; Green 1981; Ahsan 1994; Beckwith 1995; Gupta 1996; Feeroz 1999; Kabir 2006; Aziz and Feeroz 2009; Mandal and Kabir 2014; Khan 2020).

Traveling took up more than 30% of the day in our study compared to only 14.4% in the study by Gupta and Kumar (1994) in Northeast India, and 17.1% in the study of Koenig *et al*. (2004), at Phu Khieo Wildlife Sanctuary, Thailand. Resting time in this study was almost similar to that found by Gupta and Kumar (1994). Due to the shortage of food resources in Satchari National Park, the langurs had to travel farther, in general, but especially in March when the dry season is at its height and productivity is low. Less productive forest habitat may influence Phayre's langur to travel more (1030–1152 m/day, 1089±298) in Phu Khieo Wildlife Sanctuary in Thailand (Koenig *et al*. 2004). Play constituted a small component of activities in this study, but Gupta and Kumar (1994) recorded 29.5% of the time being spent in playing and grooming in Northeast India. Differences could be attributed to general shortage of food resources compared to northeastern India, where the forest cover is more substantial (Gupta and Kumar 1994).

Time spent on different activities varied according to age-sex classes, months, and time of day. The adult male spent most of his time resting during the morning, staying in the upper canopy or some other elevated position from where it could be vigilant. Males of other colobine species watch over their group while the group forages (Green 1981; Stanford 1990). This is consistent with the observation that other individuals spent most of their time in feeding and foraging during this time. The adult female spent more time resting in the late morning after her first feeding bout. At noon, both the adult male and the adult female traveled more to locate areas with high food abundance where the group would remain until sunset. During the afternoon, group members spent most of their time foraging and feeding in preparation for the night (Khan 2020; Akhter 2021).

The sub-adult male consumed considerably more compared to the others, presumably needing more energy for their rapid growth and development (Khan 2020). The adult female rested more often compared to others as females need more time in caring for infants and juveniles (Khan 2020).

The group members spent similar amounts of time in grooming (allo- and autogrooming), comparable to the 6.6% recorded by Koenig *et al.* (2004) for the Phayre's leaf monkeys at Phu Khieo Wildlife Sanctuary in Thailand. François' langurs (*Trachypithecus francoisi*) and Dusky leaf monkeys (*T. obscura halonifer*) spent little time on social activity (allogrooming and playing) in the Fusui Nature Reserve, China (Zhou *et al*. 2007), and (grooming, allomothering, playing) and in the Penang Botanical Garden, Malaysia (Zain and Ch'ng 2011), respectively. The entire group auto-groomed when resting but allogrooming was seen only between the adult female and the juveniles. In our study, playing among the adult female, sub-adult female and juveniles was minimal as is found in other primate species (Zain and Ch'ng 2011; Akhter 2021).

Leaves were the principal food item for Phayre's langurs in the park, in line with earlier studies at different sites in Bangladesh (Ahsan 1994; Aziz and Feeroz 2009; Kabir 2002), Northeast India (Gupta and Kumar 1994) and the Phu Khieo Wildlife Sanctuary, Thailand (Koenig *et al.* 2004). Young leaves were much preferred, consistent with other studies (Gupta and Kumar 1994, Suarez 2013; Decemson *et al*. 2018) and colobines in general (Curtin 1976; Kool 1993; Zhou *et al*. 2006; Solanki *et al*. 2008; Leen *et al*. 2019; Khan 2020). The range of food items recorded in the diet of Phayre's langurs at Satchari was similar to that found in Tripura, India (young and mature leaves, ripe and unripe fruits, seeds, petioles, flowers and gums) (Gupta and Kumar 1994) and Thailand (leaves, fruits, animal matter, flowers, soil and bark) (Koenig *et al*. 2004). Young leaves, fruits and flowers constituted 86.3% of the langurs diet in Satchari National Park, essentially the same as found by Decemson *et al.* (2018) (nearly 80%) at Dampa Tiger Reserve in Mizoram, Northeast India. Mature leaves provided a small percentage (7.2%) of their diet in Satchari National Park as is typical of leaf monkeys of the genus *Trachypithecus*: <10% mature leaves in Indonesia for *T. auratus* at Pangandaran Nature Reserve in West Java of Indonesia (Kool 1993), 14% in Nonggang Nature Reserve in China for *T. francoisi* (Zhou *et al*. 2006), 6% in Pakhui Wildlife Sanctuary in Arunachal Pradesh of India for *T. pileatus* (Solanki *et al*. 2008) and 22% in Malaysia for *T. obscurus* (Curtin 1976).

Besides leaves, the Satchari Phayre's langurs completed their diet with fruits, bamboo shoots, flowers and buds, as seen for other colobines (Hladik 1977; Newton 1992; Gupta and Kumar 1994). Almost one-fifth of their diet was made up of fruits. Fruits and seeds provided 14% of the Phayre's langur's diet in Lawachara National Park (Aziz and Feeroz

2009). Fruits of *Ficus* spp. were recorded during the present study as they were in Northeast India (Gupta and Kumar 1994) and Thailand (Suarez 2013). Figs are an important food source for other primates in the tropical world (Ripley 1970; Terborgh 1983; Kinnaird and O'Brien 2005; Neha *et al.* 2020). Besides figs, the langurs at the Phu Khieo Wildlife Sanctuary ate the fruits of *Psydrax umbellata* (Rubiacae), *Artocarpus lakoocha* (Moraceae), *Alphonsea elliptica* (Annonaceae) and *Suregada multiflora* (Euphorbiaceae) (Suarez 2013). Young pods and seeds of two legumes (*Albizia procera* and *A. lebbek*: Fabaceae), and unripe and partly ripe fruits of two *Ficus* species accounted for 5.2% of the Phayre's langur diet in Northeast India (Gupta and Kumar 1994). Fruits of *Diospyros peregrina* (Ebeneaceae), *Artocarpus chaplasha*, *Dipterocarpus* spp., *Ficus glomerata*, *Mangifera* spp. (Anacardiacae), *Spatholobus* spp. (Fabaceae), *Syzygium* spp., *Terminalia bellirica*, *T. catappa*, and *T. chibula* (Combretaceae) were recorded throughout Bangladesh (Ahsan and Khan 1984), many of which were also recorded in the present study. Buds and petioles of *Artocarpus lakoocha* and shoots of *Bambusa vulgaris* (Poaceae) were important food items in Satchari National Park. Flowers and buds provided 16% and bamboo shoots provided 19% of their diet (Aziz and Feeroz 2009) in Lawachara National Park, whereas petioles, gums, and flowers comprised 20.6% in Northeast India (Gupta and Kumar 1994). Ahsan and Khan (1984) recorded buds of *Bambusa*, *Diospyros peregrina, Dipterocarpus*, *Syzygium*, *Derris* (Fabaceae), *Loranthus* (Loranthaceae), *Spatholobus* and *Bauhinea* (Fabaceae), *Terminalia bellirica*, *T. catappa*, *T. chibula* as food items of Phayre's langur in Bangladesh. Flowers of *Bombax ceiba* (Malvaceae) and *Erythrina variegata* were important in the diet in Satchari National Park. Phayre's langur consumed flowers of *Cerasus trichostoma* (Rosaceae), *Wightia speciosissima* (Paulowniaceae), *Schefflera minutistellata* (Araliaceae) and *Michelia floribunda* (Magnoliaceae) in Mt. Gaoligon, Yunnan, China (Ma *et al.* 2017) and *Afzelia xylocarpa* (Fabaceae), *Millettia leucantha* (Fabaceae), *Ulmus lanceifolia* (Ulmaceae) and *Pterocarpus macrocarpus* (Fabaceae) in Phu Khieo Wildlife Sanctuary in Thailand (Suarez 2013). Flowers of *Derris*, *Loranthus*, *Spatholobus* and *Bauhinia, Dillenea indica* and *Dillenea pentagyna* (Dillieniaceae), *Lagerstoemia* and flowers of *Vanda roxburghii* (Orchidaceae) and petioles of *Lannea coromandelica* (Anacardiaceae) were recorded in Bangladesh (Ahsan and Khan 1984). Monthly variation of diet composition also reveals that the food choice depended on the availability of various food parts in their habitat, as was found by Lee and Hauser (1998). Primates adjust their diets in response to seasonal shortage in their preferred foods (Hladik 1977; Bennett 1983; Newton 1992; Gupta and Kumar 1994; Sayers and Norconk 2008; Zhou *et al.* 2009; Xiang *et al.* 2012).

Larger numbers of species in the diet have been found in other sites of Bangladesh than were recorded in the present study (17 species) — 80 species in the Rema Kalenga Wildlife Sanctuary (Kabir 2002); and 29 species in Lawachara National Park (Aziz and Feeroz 2009). This is because our study covered just four months. Eighteen food species were recorded in Northeast India, in a study of eight months (Gupta and Kumar 1994) and eight species were recorded in Mizoram, India, in a study of just three months' during summer (March–May 2014) (Decemson *et al.* 2018). The food plants in Satchari National Park belonged to ten families—Fabaceae and Moraceae were predominant with four species in each. In Lawachara National Park, 14 families were selected (Aziz and Feeroz, 2009) and the Leguminosae and Moraceae also figured significantly (32% of their food plants). Other studies have shown that members of the Moraceae are important in the diets of colobines (Akonda 1979; Kool 1989; Fashing 2001; Hasan 2017).

Most of the food plant species in Satchari were selected for leaves (seven species), as found by Ahsan and Khan (1984) (12 spp. throughout the country) and in northeastern India (18 spp., Gupta and Kumar 1994). The langurs ate the flowers of two species only one species for its fruits, one species for buds, and another for bamboo shoots. Ahsan and Khan (1984) identified 11 species providing buds, 10 species providing fruits, eight species providing flowers and one from which the langurs ate petioles. In Lawachara National Park, the langurs ate leaves and shoots were of the Poaceae, and flowers, pods, leaves and seeds from the Leguminosae (Aziz and Feeroz 2009). Eight plants species was selected in the summer season at Dampa Tiger Reserve in Mizoram of India, and the langurs spent ≥90% their feeding time on *Musa ornata* (Musaceae), *Melacana baccifera* and *Dendrocalamus longispathus* (both Poaceae) (Decemson *et al.* 2018). As such, food selection is not necessarily related to the abundance of tree species, and scarce plants are sometimes selected more frequently than would be expected if the choice were random (Dunham 2017).

Almost 60% of food items were consumed from only three species, *Ficus hispida, Albizia chinensis* and *Vachellia nilotica* (Fabaceae), which were highly dependable food sources for the Phayre's langurs in Satchari National Park. Six species accounted for more than 75% of total feeding time in Northeast India (Gupta and Kumar 1994). A strong preference for just a few food plant species has been reported for other Asian colobines (Oates *et al.* 1980).

Artocarpus chaplasha and *Mangifera indica* provide extensive and moderate shade (Feeroz *et al*. 1994) for the langurs resting in Lawachara National Park. There, other trees and bamboos where they rested included *Artocarpus chaplasha*, *Gmelina arborea* (Lamiacaeae), *Albizia chinensis*, *Melocanna baccifera*, *M. bambusoides*, *Bambusa tulda* (Poaceae), and *Acacia mangium* (Fabaceae) (Aziz and Feeroz 2009). In Satchari, they rested in *Artocarpus chaplasha*, *Artocarpus lakoocha*, *Ficus racemosa*, *Trophis aspera* (Moraceae), *Mangifera indica* and *Grewia nervosa* (Malvaceae), suggesting that the species used shade or cover are similar in the two parks.

In Satchari National Park, the langurs show a preference for areas dominated by *Artocarpus chama* and *A.*

lakoocha, *Terminalia grandis*, *T. bellirica, Lagerstroemia speciosa, Aglaia spectabilis* (Meliaceae), *Gmelina arborea*, *Ficus racemosa*, and *Bambusa* (Al-Razi and Naher 2021). In Assam, this was the case for forests dominated by *Ficus* spp., *A. chama* and bamboo, in Mizoram, *Terminalia myriocarpa*, *F. benghalensis*, *Bischofia javanica* (Phyllanthaceae), *Gmelina arborea*, *Michelia champaca* (Magnoliacae) (Bose 2003) and in northeastern India bamboo (Roonwal and Mohnot 1977; Wolfheim 1983; Choudhury 1987; 1994; 1996; Raman *et al*. 1995; Bose and Bhattacharjee 2002).

In Northeast India, the time spent by these langurs on different activities varies between months (Gupta and Kumar 1994). The southwestern monsoons influence fruiting phenology in the entire region (Neha *et al.* 2020), and foraging behavior of primates is strongly influenced by this annual cycle, with increased travel time being observed in times of low food abundance (Neha *et al.* 2020). From December to February, the Satchari langurs consumed a variety of foods but in March the group ate only leaves. Their increased travel time in March is consistent with the lower productivity of the forest at the time (Khan 2020). From December to March, the time spent traveling was inversely related to the time spent resting and grooming. The dispersion, seasonal abundance and energy content of the different food items undoubtedly influence the activity budgets of these primates as do habitat types, floral composition, and the level of human disturbance (Newton 1992; Koenig *et al*. 1997; Zhou *et al.* 2007; Leen *et al.* 2019). Long-term studies are needed to better understand the relationships between the activity budgets and diet of these langurs with habitat and food availability, both seasonal and between years, fundamental for their conservation management in the increasingly fragmented forests where they occur.

Acknowledgements

This study was funded by Jagannath University Research Fund (2017-2018). We thank the Forest Department of Bangladesh, for giving us permission to conduct research in Satchari National Park. We are grateful to the Divisional Forest Officers of Moulvibazar district of Bangladesh, local forest officials,forest guards and local people who provided useful information, including the local names of the plants.

Literature Cited

Adimallaiah, D., K. Thiyagesan and A. K. Gupta. 2014. Population status of Phayre's langur, *Trachypithecus phayrei* in Sepahijala Wildlife Sanctuary, Tripura, Northeast India. *Primate Conserv*. (28): 159–163.

Ahmed, T. and H. Naher. 2021. Population status of Northern pig-tailed macaque (*Macaca leonina*) in Satchari National Park, Bangladesh. *Asian Primates J.* 9(1): 32–40.

Ahmed, A. T. A., S. M. H. Kabir, M. Ahmed, Z. U. Ahmed, Z. N. T. Begum, M. A. Hassan and M. Khondker (eds.). 2009. *Encyclopedia of Flora and Fauna of Bangladesh. Volume 27. Mammals*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahsan, M. F. 1994. Behavioural Ecology of the Hoolock Gibbon (*Hylobates hoolock*) in Bangladesh. PhD thesis, Department of Anatomy, University of Cambridge, Cambridge, UK.

Ahsan, M. F. and M. A. R. Khan. 1984. Food and feeding habit of non-human primates of Bangladesh. *Chittagong Univ. Stud., Part II.* 8(2): 101–112.

Akhter, T. 2021. Activity Budget of Western Hoolock Gibbon (*Hoolock hoolock*) at Lawachara National Park in Bangladesh. MSc thesis. Jagannath University, Dhaka, Bangladesh.

Akonda, A. W. 1979. Feeding ecology of capped langur (*Trachypithecus pileatus*) in India. *Int. J. Primatol.* 29(1): 173–182.

Aldrich-Blake, F. P. G. 1980. Long-tailed macaques. In: *Malayan Forest Primates: Ten Years' Study in Tropical Rain Forest*, D. J. Chivers (ed.), pp.79–101. Academic Press, London.

Al-Razi, H. and H. Naher. 2021. Population status of Phayre's langur, *Trachypithecus phayrei* in Satchari National Park, Bangladesh. *Asian Primates J.* 9(1): 10–19.

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227–267.

Arefin, M. K., M. M. Rahman, M. Z. Uddin and M. A. Hassan. 2011. Angiosperm flora of Satchari National Park, Habiganj, Bangladesh. *Bangladesh J. Plant Taxon.* 18(2): 117–140.

Aziz, M. A. and M. M. Feeroz. 2009. Utilization of forest flora by Phayre's leaf monkey *Trachypithecus phayrei* (Primates: Cercopithecidae) in semi-evergreen forests of Bangladesh. *J. Threat. Taxa* 1: 257–262.

Beckwith, R. S. 1995. The Ecology and Behaviour of the Javan Black Langur, in Lower Montane Rain Forest, West Java. PhD thesis, University of Cambridge, Cambridge, UK.

Bennett, E. L. 1983. The Banded Langur: Ecology of a Colobine in a West Malaysian Rain Forest. Ph.D thesis, Univ. of Cambridge, Cambridge, UK.

Bhattacharya, T. and D. Chakraborty. 1990. Sex identification of the Phayre's leaf monkey, with the help of facial marks. *Primates* 31: 617–620.

Bose, J. 2003. *'Search for a Spectacle': A Conservation Survey of Phayre's Leaf Monkey (*Trachypithecus phayrei*) in Assam and Mizoram*. Wildlife Trust of India, Noida, India.

Bose, J. and P. C. Bhattacharjee. 2002. Behavioural profile of a troop of Phayre's leaf monkey (*Trachypithecus phayrei*) in a fragmented and disturbed habitat, Northeast India. *XIX Congress of the Int. Primatol. Soc.*, Beijing, China. Abstract.

Chalmers, N. R. 1968. Group composition, ecology and activities of free-living Mangabeys in Uganda. *Folia Primatol*. 8: 247–262.

Chapman, C. A. and L. J. Chapman. 1999. Implications of small-scale variation in ecological conditions for the diet and density of red colobus monkeys. *Primates* 40: 215–231.

Chaves, O. M. and J. C. Bicca-Marques. 2013. Dietary flexibility of the brown howler monkey throughout its geographic distribution. *Am. J. Primatol*. 75: 16–29.

Chetry, D. and T. Ahmed. 2021. *Trachypithecus phayrei*. *The IUCN Red List of Threatened Species* 2021: e.T175862145A175862149. Accessed 10 November 2021.

Choudhury, A. 1987. Notes on the distribution and conservation of Phayre's leaf monkey and hoolock gibbon in India. *Tigerpaper* 14(2): 2–6.

Choudhury, A. 1994. Phayre's leaf monkey (*Trachypithecus phayrei*) in North-east India. *Tigerpaper* 21(3): 1–4.

Choudhury, A. 1996. Primates in Assam – status and conservation. *Tigerpaper* 23: 14–17.

Choudhury, A. 2001. Primates of NE India: an overview of their distribution and conservation status. *ENVIS Bull Wild. Prot. Areas.* 1: 92–101.

Clutton-Brock, T. H. 1974. Activity patterns of red colobus (*Colobus badius tephrosceles*). *Folia Primatol.* 21: 161–187.

Cristóbal-Azkarate, J. and V. Arroyo-Rodríguez. 2007. Diet and activity patterns of howler monkeys (*Alouatta palliata*) in Los Tuxtlas, Mexico: effects of habitat fragmentation and implications for conservation. *Am. J. Primatol*. 69: 1–17.

Curtin, S. H. 1976. Niche Differentiation and Social Organization in Sympatric Malaysian Colobines. PhD thesis, University of California, Berkeley, CA.

Decemson, Ht., A. Parida and G. S. Solanki. 2018. Feeding Behavior of Phayre's leaf monkey (*Trachypithecus phayrei*) and capped langur (*Trachypithecus pileatus*) in Dampa Tiger Reserve, Mizoram. *Sci. Tech. J.* 6(1): 31–38.

Dunham, N. T. 2017. Feeding ecology and dietary flexibility of *Colobus angolensis* in relation to habitat disturbance. *Int. J. Primatol.* 38: 553–571.

Fashing, P. J. 2001. Feeding ecology of guerezas in the Kakamega Forest, Kenya: the importance of Moraceae fruit in their diet. *Int. J. Primatol*. 22(4): 579–609.

Fashing, P. J., E. S. Dierenfeld and C. B. Mowry. 2007. Influence of plant and soil chemistry on food selection, ranging patterns and biomass of *Colobus guereza* in Kakamega forest, Kenya. *Int. J. Primatol*. 28: 673–703.

Feeroz, M. M. 1999. Ecology and Behaviour of the Pig-tailed Macaque (*Macaca nemestrina leonina*) in Bangladesh. PhD thesis, University of Cambridge, Cambridge, UK.

Feeroz, M. M., M. A. Islam and M. M. Kabir. 1994. Food and feeding behavior of hoolock gibbon (*Hylobates hoolock*), capped langur (*Presbytes pileata*) and pig-tailed macaque (*Macaca nemestrina*) of Lawachhara. *Bangladesh J. Zool.* 22(2): 123–132.

Freeland, W. J. and D. H. Janzen. 1974. Strategies of herbivory in mammals; the role of plant secondary compounds. *Am. Nat.* 108: 269–289.

Gittins, S. P. and A. W. Akonda. 1982. What survives in Bangladesh? *Oryx* 16(3): 275–282.

Green, K. M. 1981. Preliminary observations on the ecology and behavior of the capped langur, *Presbytis pileatus* in the Madhupur Forest of Bangladesh. *Int. J. Primatol.* 2(2): 131–151.

Gupta, A. K. 1996. Conservation Ecology of Primates and Human Impact in Northeast India. PhD thesis, University of Cambridge, Cambridge, UK.

Gupta, A. K. 2001. Status of primates in Tripura. *ENVIS Bull. Wild. Protec. Areas* 1: 127–135.

Gupta, A. K. and A. Kumar. 1994. Feeding ecology and conservation of the Phayre's leaf monkey (*Presbytis phayrei*) in Northeast India. *Biol. Conserv.* 69: 301–306.

Harris, T. R., C. A. Chapman and S. L. Monfort. 2010. Small folivorous primate groups exhibit behavioral and physiological effects of food scarcity. *Behav. Ecol.* 21: 46–56.

Hasan, M. A. U. 2017. Feeding Behavior, Ecology and Conservation of Capped Langur (*Trachypithecus pileatus*) at Satchari National Park in Sylhet, Bangladesh. MSc thesis, Jagannath University, Dhaka, Bangladesh.

Hladik, C. M. 1977. A comparative study of two sympatric species of leaf monkeys: *Presbytis entellus* and *Presbytis senex*. In: *Primate Ecology: Studies of feeding and Ranging Behaviour in Lemurs, Monkeys and Apes*, T. H. Clutton-Brock (ed.), pp.323–353. Academic Press, London.

Islam, M. A. and K. Z. Hussain. 1982. A preliminary study on the ecology of the capped langur. *Folia Primatol.* 39: 145–159.

IUCN Bangladesh. 2015. *Red List of Bangladesh. Volume 2: Mammals.* IUCN International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh.

IUCN. 2021. The IUCN Red List of Threatened Species. International Union for Conservation of Nature (IUCN), Gland, Switzerland and Cambridge, UK. <www.iucnredlist.org>.

Jaman, M. F. and M. A. Huffman. 2008. Enclosure environment affects the activity budgets of captive Japanese macaques (*Macaca fuscata*). *Am. J. Primatol*. 70: 1133–1144.

Jolly, A. 1985. *Evolution of Primate Behaviour*. Second edition. MacMillan, New York.

Kabir, M. M. 2002. Behavioural Ecology of Two Sympatric Langur Species in the Semi-evergreen Forest of Bangladesh. PhD thesis, Department of Anatomy, University of Cambridge, Cambridge, UK.

Kabir, M. M. 2006. Activity pattern of capped langur in the Rema-Kalenga Wildlife Sanctuary of Bangladesh. *Bangladesh J. Life Sci.* 18(2): 59–69.

Kabir, M. M. and M. A. Islam. 1995. An ecological study of the capped langur (*Presbytis pileatus*) in the semi-evergreen and moist deciduous forests of Bangladesh. *J. Nat. Studies* 2: 41–60.

Khan, M. A. R. and M. F. Ahsan. 1981. The group structure, composition and age-sex relationship of primates of Bangladesh. *Proceedings of the Third National Zool. Conf*. 1981: 287–302.

Khan, M. A. R. and M. F. Ahsan. 1986. The status of primates in Bangladesh and a description of their habitat. *Primate Conserv.* (7):102–109.

Khan, S. I. 2020. Behavioral Patterns and Conservation of Capped Langur (*Trachypithecus pileatus*) of Madhupur National Park, Tangail, Bangladesh. PhD thesis, University of Dhaka, Dhaka, Bangladesh.

Kinnaird, M. F. and T. O'Brien. 2005. Fast foods of the forest: the influence of figs on primates and hornbills across Wallace's Line. In: *Tropical Fruits and Frugivores: The Search for Strong Interactors*, J. L. Dew and J. P. Boubli (eds.), pp.155–184. Springer, The Netherlands.

Koenig, A., C. Borris, S. Suarez, K. Kreetiyutanont and J. Prabnasuk. 2004. Socio-ecology of Phayre's leaf monkey (*Trachypithecus phayrei*) at Phu Khieo Wildlife Sanctuary. *J. Wildl. Thailand* 12(1): 150–163.

Koenig, A, C. Borries, M. K, Chalise and P. Winkler. 1997. Ecology, nutrition, and timing of reproductive events in an Asian primate, the Hanuman langur (*Presbytis entellus*). *J. Zool. Lond.* 243: 215–235.

Kool, K. M. 1989. Behavioural Ecology of Silvered Leaf Monkeys*, Trachypithecus auratus sondaicus*, in the Pangandaram Nature Reserve, West Java, Indonesia. PhD thesis, University of New South Wales, Sydney, Australia.

Kool, K. M. 1993. The diet and feeding behavior of the silver leaf monkey (*Trachypithecus auratus sondaicus*) in Indonesia. *Int. J. Primatol.* 14(5): 667–700.

Kumar, A. and G. S. Solanki. 2004. Ethno-sociological impact on capped langur (*Trachypithecus pileatus*) and suggestions for conservation: a case study of Reserve Forest in Assam, India. *J. Nat. Conserv*. 16(1): 107–113.

Lambert, J. E. 2007. Primate nutritional ecology: feeding biology and diet at ecological and evolutionary scales. In: *Primates in Perspective,* C. Campbell, A. Fuentes, K. C. MacKinnon, M. Panger and S. K. Bearder (eds.), pp.482–495. Oxford University Press, Oxford.

Lee, P. C. and M. D. Hauser. 1998. Long-term consequences of changes in territory quality of feeding and reproductive strategy of vervet monkeys. *J. Anim. Ecol.* 67: 347–358.

Leen, Y. J., N. Ruppert and N. F. N. Rosely. 2019. Activities, habitat use and diet of wild dusky langurs, *Trachypithecus obscurus* in different habitat types in Penang, Malaysia. *J. of Sustain. Sci. Manage.* 14(4): 71–85.

Leighton, M. and D. R. Leighton. 1983. Vertebrate responses to fruiting seasonality within a Bornean Rain Forest. In: *Tropical Rain Forest: Ecology and Management.* Volume 2, S. *T. C. Whitmore and A. C. Chadwick* (eds.), pp.181–196. Blackwell Scientific Publications, Oxford, UK.

Li, Z. and E. Rogers. 2004. Habitat quality and activity budgets of white-headed langurs in Fusui, China. *Int. J. Primatol*. 25: 41–54.

Ma, C., P.-F. Fan, Z-Y. Zhang, J-H. Li, X-C. Shi and W. Xiao. 2017. Diet and feeding behavior of a group of 42 Phayre's langurs in a seasonal habitat in Mt. Gaoligong, Yunnan, China. *Am. J. Primatol.* 79(10): 1–9.

Mandal, B. K. and M. M. Kabir. 2014. Activity patterns of capped langur (*Trachypithecus pileatus*) in a moist deciduous forest of Bangladesh. *Jagannath Uni. J. Sci*. 3(1): 65–77.

Marsh, C. W. and R. A. Mittermeier (eds.) 1987. *Primate Conservation in the Tropical Rain Forest.* Alan R. Liss, New York.

Milton, K. 1980. *The Foraging Strategy of Howler Monkeys.* Columbia Press, New York.

Minhas, R. A., K. B. Ahmed, M. S. Awan and N. L. Dar. 2010. Habitat utilization and feeding biology of Himalayan grey langur *(Semnopithecus entellus ajax)* in Machiara National Park, Azad Kashmir, Pakistan. *Zool. Res.* 31: 1–13.

Molur, S., D. Brandon-Jones, W. Dittus, A. Eudey, A. Kumar, M. Singh, M. M. Feeroz, M. Chalise, P. Priya and S. Walker. 2003. *Status of South Asian Primates: Conservation Assessment and Management Plan Report.* Workshop Report. Zoo Outreach Organization /CBSG-South Asia, Coimbatore, India.

Mukul, S.A. 2007. Bridging Livelihoods and Forest Conservation in Protected Areas: Exploring the Role and Scope of Non-Timber Forest Products. BSc dissertation, Department of Forestry, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology, Sylhet, Bangladesh.

Mukul, S. A., M. B. Uddin and M. R. Tito. 2006. Study on the status and various uses of invasive alien plant species in and around Satchari National Park, Sylhet, Bangladesh. *Tigerpaper* 33: 28–31.

Neha, S. A., M. U. H. Khatun and M. A. U. Hasan 2020. Feeding behavior of the western hoolock gibbon (*Hoolock hoolock*) in Bangladesh: response to temporal variation of food sources. *Primate Conserv.* (34): 1–10.

Newton, P. 1992. Feeding and ranging patterns of forest Hanuman langurs (*Presbytis entellus*). *Int. J. Primatol.* 13: 245–285.

Nigam, P., B. Nilofer, A. Srivastava and P. C. Tyagi. 2014. *National Study Book of Phayre's Leaf Monkey (*Trachypithecus phayrei*)*. Wildlife Institute of India, Dehradun and Central Zoo Authority, New Delhi.

Oates, J. F., P. G. Waterman and G. M. Choo. 1980. Food selection by the South Indian leaf-monkey, *Presbytis johnii*, in relation to leaf chemistry. *Oecol. (Berlin)* 45: 45–56.

Riley, E. P. 2007. Flexibility in diet and activity patterns of *Macaca tonkeana* in response to anthropogenic habitat alteration. *Int. J. Primatol*. 28: 107–133.

Raman, T. R. S., C. Mishra and A. J. T. Johnsingh. 1995. Survey of primates in Mizoram, Northeast India. *Primate Conserv.* (16): 59–62.

Rave, D. P. and G. A. Baldassare. 1989. Activity budget of Green-winged Teal wintering in coastal wetlands of Louisiana. *J. Wildl. Manage*. 53: 753–759.

Ripley, S. 1970. Leaves and leaf-monkeys: the social organization of foraging in grey langurs. In: *Old World Monkeys: Evolution, Systematics and Behavior,* J. R. Napier and P. H. Napier (eds.), pp.481–509. Academic Press, London.

Rizvi, S. N. H. 1970. *East Pakistan district gazetteers for Sylhet*. Government of East Pakistan Survices and General Administration Department, Dhaka.

Roonwal, M. L. and S. M. Mohnot. 1977. *Primates of South Asia: Ecology, Sociobiology, and Behavior*. Harvard University Press, Cambridge, MA.

Molur, S., C. P. Groves and C. Roos. 2013. Phayre's langur *Trachypithecus phayrei*. In: *Handbook of the Mammals of the World*. *Volume 3. Primates*. R. A. Mittermeier, A. B. Rylands and D. E. Wilson (eds.), pp.747–748. Lynx Edicions, Barcelona.

Roos, C., R. Boonratana, J. Supriatna, J. R. Fellowes, C. P. Groves, S. D. Nash, A. B. Rylands and R. A. Mittermeier. 2014. An updated taxonomy and conservation status review of Asian primates. *Asian Primates J.* 4(1): 2–38.

Ruppert, N., A. Holzner, K. W. See, A.Gisbrecht and A. Beck. 2018. Activity budgets and habitat use of wild southern pig-tailed macaques (*Macaca nemestrina*) in oil palm plantation and forest. *Int. J. Primatol.* 39(2): 237–251.

Sayers, K. and M. A. Norconk. 2008. Himalayan *Semnopithecus entellus* at Langtang National Park, Nepal: diet, activity patterns, and resources. *Int. J. Primatol.* 29: 509–530.

Sharma, R. 2006. *Management Plan for Satchari National Park*. Nishorgo Support Project, Forest Department, Government of the People's Republic of Bangladesh.

Solanki, G. S., A. Kumar and B. K. Sharma. 2008. Feeding ecology of *Trachypithecus pileatus* in India. *Int. J. Primatol.* 29: 173–182.

Stanford, C. B. 1990. Ecology of the capped langur and Phayre's leaf monkey in Bangladesh. *Primate Conserv.* (9):125–128.

Stanford, C. B. 1991. Diet of the capped langur (*Presbytis pileatus*) in a moist deciduous forest in Bangladesh. *Int. J. Primatol.* 12(3):199–216.

Suarez, S. A. 2013. Diet of Phayre's leaf monkey in the Phu Khieo Wildlife Sanctuary, Thailand. *Asian Primates J.* 3(1): 2–12.

Teichroeb, J. A., T. L. Saj, J. D. Paterson and P. Sicotte. 2003. Effect of group size on activity budgets of *Colobus vellerosus* in Ghana. *Int. J. Primatol.* 24(3): 743–758.

Terborgh, J. 1983. *Five New World Primates: A Study in Comparative Ecology*. Princeton University Press, Princeton, NJ.

Wolfheim, J. H. 1983. *Primates of the World*. University of Washington Press, Seattle, WA.

Xiang, Z. F., W. B. Liang, S. G. Nie and M. Li. 2012. Diet and feeding behavior of *Rhinopithecus brelichi* at Yangaoping, Guizhou. *Am. J. Primatol.* 74: 551–560.

Zain, B. M. M. and C. E. Ch'ng. 2011. The activity patterns of Cantor's dusky leaf monkeys (*Trachypithecus obscurus halonifer*). *Int. J. Zool. Res.* 7(1): 59–67.

Zhou, Q., C. Huang, Y. Li and X. Cai. 2007. Ranging behavior of the François langur (*Trachypithecus francoisi*) in the Fusui Nature Reserve, China. *Primates* 48: 320–323.

Zhou, Q., F. Wei and M. Li. 2006. Diet and food choice of *Trachypithecus francoisi* in the Nonggang Nature Reserve, China. *Int. J. Primatol.* 27(5): 1441–1460.

Zhou, Q., Z. Huang, F. Wei and X. Huang. 2009. Factors influencing international and intersite variability in the diet of *Trachypithecus francoisi*. *Int. J. Primatol.* 30: 583–599.

Authors' addresses:
Habibon Naher, **Md. Sabbir Hasan**, **Tonmoy Mondal**, Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh; **Shawkat Imam Khan**, Department of Natural History, Bangladesh National Museum, Dhaka 1000, Bangladesh; and **Sabir Bin Muzaffar**, Department of Biology, United Arab Emirates University, Al-Ain, United Arab Emirates.

Corresponding author: Habibon Naher
E-mail: <likhi.habibon@gmail.com>

Received for publication: 9 July 2021
Revised: 21 November 2021