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Research Article

SUBSTRATE UTILIZATION BY BENGAL SACRED LANGUR *SEMNOPITHECUS ENTELLUS* (DUFRESNE, 1797) IN JESSORE, BANGLADESH: EFFECT OF RESOURCE TYPE ON FEEDING IN URBAN AND RURAL GROUPS

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ABSTRACT

Substrate utilization by Bengal sacred langur (*Semnopithecus entellus*) was studied from September, 2012 to August, 2013 in Jessore, Bangladesh. The study was based on direct observation from dawn to dusk and data was collected using focal animal sampling. The results showed that Bengal sacred langur is not totally arboreal or ground dwellers but they use different layers of trees, wall/roof of houses and other substrates, depending on suitability and presence of substrates. The langur spent 32.6% of their total time on ground followed by 21.8%, 15.7%, 15.4% and 14.4% for canopy, roof/wall, lower canopy and mid canopy, respectively. Regardless of group, the time spent on behavioral activities of Bengal sacred langur was significantly varied across the different substrates. Langurs of the urban group spent more time on ground and roof/wall than the rural group, on the other hand the rural group utilized different layers of trees. Regardless of group, Bengal sacred langur of all age-sex classes spent more or less similar time on different substrates in their habitat except canopy, in where sub-adult insisted on more time than adults. Langurs of the rural and the urban group spent 130 and 150 min/day, respectively on feeding from different food sources. The urban group spent more time on ground and roof/wall for feeding whereas the rural group insisted on basically arboreal feeding. These are probably due to the differences of food sources between two habitats. Time spent feeding significantly differed across the food sources in both the rural and the urban groups of Bengal sacred langurs.

Keywords: Substrate, Bengal sacred langur, Urban and rural groups, Resources.

INTRODUCTION

The Bengal sacred langur (*Semnopithecus entellus*), previously known as Hanuman langur, is the most widespread primate species of South Asia (Roos *et al*., 2014). In Bangladesh, Bengal sacred langurs distributed only in south-western part including Jessore, Jhenaidah, Chuadanga, Meherpur and Kushtia districts (Khan, 1982). Although, this species is ecologically very adaptable to a variety of habitats ranging over 2200-4000m above sea level, inhabiting arid deserts like savannah to tropical rain forests and tropical habitats to temperate habitats (Minhas *et al*., 2010). They are also found in coniferous forests, alpine, broadleaf forests, moist deciduous forests, sub-tropical pine forests, mountains foot hills, scrublands and mixed grasslands (Roberts, 1997; Nowak, 1999; Hilton and Taylor, 2000; Ahmed *et al*., 2009; Minhas *et al*., 2010). They can adapt well to modified human habitations and are found in villages, towns, areas with housing or agriculture and some langur

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population accustomed to living close to the human settlements with persistence of commensal relationship (Tritsch, 2001). They can live in densely populated cities numbering up to a million populations (Waite *et al*., 2007) and they are the most commensal of all primates of Indian subcontinent and seem to thrive in human dominated landscapes (Chhangani and Mohnot, 2004). The extraordinary adaptability of this species make it difficult to assess what their natural habitat actually is (Bishop *et al*., 1981).

Substrate use within their habitat in different primate species varies in relation to their different activities (Sarker *et al*., 2005), as they use ground during foraging and interacting with other group members, while use trees for roosting. A number of factors such as the body size, composition of the foraging group and population density may influence the substrate selection of primates (Dunbar, 1988). Substrate utilization by different age-sex classes have been found to utilize their substrate differently in their environments (Marriott, 1988; Jaman and Huffman, 2013) and the degree of differences in body mass between adults and sub-adult strongly influenced their substrate selection. Sub-adult, due to their lighter body weight, are well adapted to terminal branches (canopy) of trees which may help them satisfy their energy requirements and allow them to reach satiety whereas heavy weighed adults cannot do this (Hanya, 2003; Jaman and Huffman, 2011).

Primates change their feeding ecology in response to the wide variety of habitats (Agetsuma and Nakagawa, 1998). Habitat differences which may influence feeding strategy of a species which depends on two principal factors: 1) differences in food sources and food quality between two habitats, 2) relative temperature between two habitats, for example, gelada baboons (*Theropithecus gelada*) spent long time feeding in cooler habitat than wormer (Agetsuma and Nakagawa, 1998). Types of food sources particularly affect feeding behavior, distribution and behavioral activities (Basabose, 2005).

To improve our knowledge of how habitat and their resources affect feeding behavior of langurs in Bangladesh, we felt langur population into two categories (urban and rural) based on the habitat they are used to. The effect of resource on feeding behavior is important to understand how this species copes under human induced environmental pressures. Such studies should be beneficial for conservation and management plan as feeding is the crucial part for survival of any species. Thus, the current study was conducted to reveal substrate utilization patterns during behavioral activities of the rural and the urban groups of Bengal sacred langur. More specifically, we make three predictions: 1) substrate has impact on behavioral activities i.e. certain behavior is performed in specific substrate and substrate utilization is greatly influenced by location of the habitat, 2) sub-adult utilize terminal branches of trees whereas adult insist on ground and middle layer, 3) resource type effects on feeding behavior between two groups of Bengal sacred langur in two different habitat settings.

MATERIALS AND METHODS

Study area and Study Subject

This study was conducted in Keshabpur (22° 54' 29.71", 89° 13' 9.18" E) and Manirampur (23° 1' 0" N, 89° 14' 0" E) upazilas (sub-district) under the Jessore district on the southwestern part of Bangladesh (Figure 1). These two study sites cover 703.25 sq km (271.52 sq mile) with human density of 953 individuals per square kilometers (Census 2011). Annual average maximum temperature in these areas was 37.1 ^{0}C in (June) while the minimum was 11.2 ^{0}C in (January) with annual rainfall of 1537 mm.

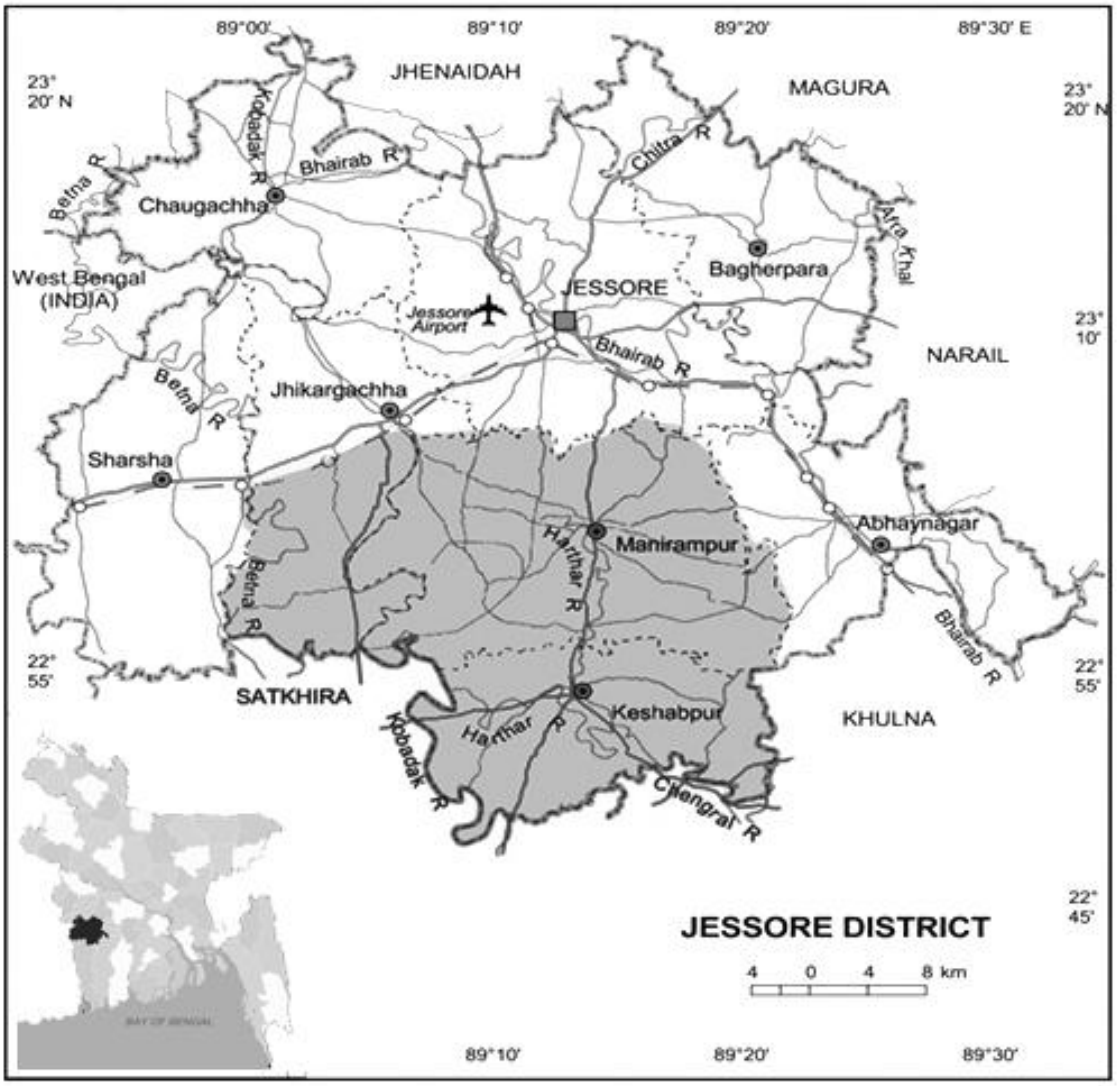

Figure 1. Study area - Bangladesh (bottom left) and Jessore district (top).

These two areas are open plain land and not under any protected area. The vegetation in the area is predominated by human plantations of economically important plant species. There are patches of natural vegetation dominated by herbs and shrubs, mostly in fallow lands. The urban area dominated by infrastructures where density of human population is higher and most covered by non-vegetated areas whereas scenery of rural area is vice versa.

Age-sex categories used in this study were determined according to age estimates as follows: adult male (> 5 years old), adult female (> 2.9 years old), sub-adult male (2-5 years old), sub-adult female (2-2.9 years old), juveniles (9 months-2 years old) and infant (<8 months old) (Gron, 2008). Adults are capable of reproduction (i.e. hormone production, descended testacies, sexual activity, menstrual signs in females and mating behaviour), whereas sub-adults are still not able to reproduce, although they might already display mating behaviours during the breeding period (Lynch *et al*., 2002).

Observations and sampling protocol

On the basis of habitat we classified the Bengal sacred langur population into two groups; the urban group: lives center of the Keshabpur (sub-district) receives provisioned foods, human handouts besides available natural foods, and the rural group: lives away from the town, subsists on natural vegetation as well as crops/seasonal

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food and food stolen from houses and traditional outdoors. They damage human resources to acquire their foods and appear high level of conflict with human.

We collected data from September 2012 to August 2013 in the form of 10 minutes continuous focal animal samples according to Altman (1974). Before collecting data, identification of individual langur and assessment of environmental condition were conducted. Three days were spent per month and each month we sampled 150 focal around half in one group (75 focal × 12 months = 900 focal samples) in total (900 × 2 groups = 1800 focal = 300 hours + additional one hour). We sampled all focal subjects equally across the four time blocks in a day: early morning (6.00-9.00), late morning (9.01-12.00), noon (12.01-15.00) and afternoon (15.01-18.00) and this protocol were maintained across the study period. Study period was divided into three seasons; rainy (July-October), winter (November-February) and summer (March-June).

Positional behavior was studied during substrate utilization by Bengal sacred langurs. Positional behavior is defined as the representation of behavioral activities in an advantageous place or location by an animal in order to access resources easily (Ripley, 1979). Five positions were categorized from ground to top of the tree: ground, wall/roof, lower canopy (3-5 m height from the ground), mid canopy (5-10 m) and canopy (> 10 m) layer of the tree.

Data on feeding behavior were collected using focal sampling techniques in which the activities of visible animals were recorded throughout the day from dawn to dusk. Feeding is defined as the intake of solid food or water into the mouth followed by chewing and/or swallowing. When focal subjects ate any food, these food types were recorded. Food items were classified as 1) provisioned food, 2) year round available natural food and 3) cultivated crops/seasonal foods. Food items and their frequencies consumed by the langurs were also recorded. One day prior to the commencement of data collection, the trees on which the focal group roosted over night were noted. This strategy facilitated to start observation next day before the group would leave its sleeping trees very early in the morning.

Data analysis

We organized the data set according to the group and data was equally distributed among all focal subjects across time period of a day, months and seasons. It failed to test normality (i.e., Kolmogorov-Smirnov, $P < 0.05$) and thus all tests were nonparametric. We used Pearson chi-square test to examine substrate variation for performing their whole activities. We also used same test to assess age-sex differences of time spent in different substrates. We performed Mann-Whitney U test to examine the group differences of substrate utilization during behavioral display by Bengal sacred langur including feeding. We employed Friedman test to examine variation of feeding time between two gropus of langurs on different food types. We performed Wilcoxon Signed Ranks test to find the differences of time spent feeding between two food sources within group. Same test was done to compare time spent feeding in each food sources between two groups of Bengal sacred langur. We present exact *P* value for each analysis in the results and level of significance was $\alpha = 0.05$. All data were analyzed using MS-Excel and SPSS (version 17).

RESULTS

Overall habitat utilization during behavioral activities

During our study period Bengal sacred langur used different substrate of their habitats. Of the total 301hours recording time of activity budgets they spent 32.6% of their total time on ground followed by 21.8%, 15.7%, 15.4% and 14.4% for canopy, roof/wall, lower canopy and mid canopy respectively (Figure 2). For performing their daily activities efficiently they frequently moved one layer to another. Regardless of group we found significant difference of utilization of different substrate during all behavioral activities except resting (Chi square test: feeding, $\chi^2 = 62.3$, df = 4, $p < 0.0125$; grooming, $\chi^2 = 21.4$, d.f. = 4, $p < 0.0125$; interaction, $\chi^2 = 170.3$, d.f. = 4,

$p < 0.0125$; moving, $\chi^2 = 31.4$, d.f. = 4, $p < 0.0125$; playing and object manipulating, $\chi^2 = 44.9$, d.f. = 4, $p < 0.0125$; resting, $\chi^2 = 8.2$, d.f. = 4, $p > 0.05$ and vigilance, $\chi^2 = 23.3$, d.f. = 4, $p < 0.0125$, Figure 3). This finding strongly supports first part of prediction 1 that Bengal sacred langur use specific substrate for performing their behavioral activities.

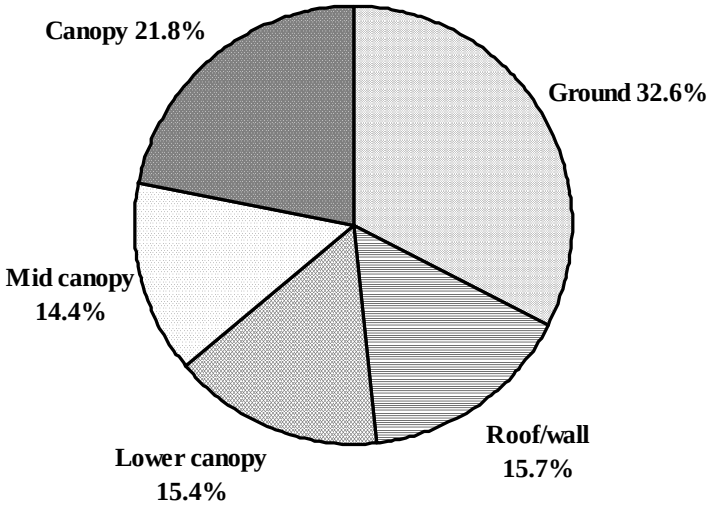

Figure 2. Overall time spent in different substrates.

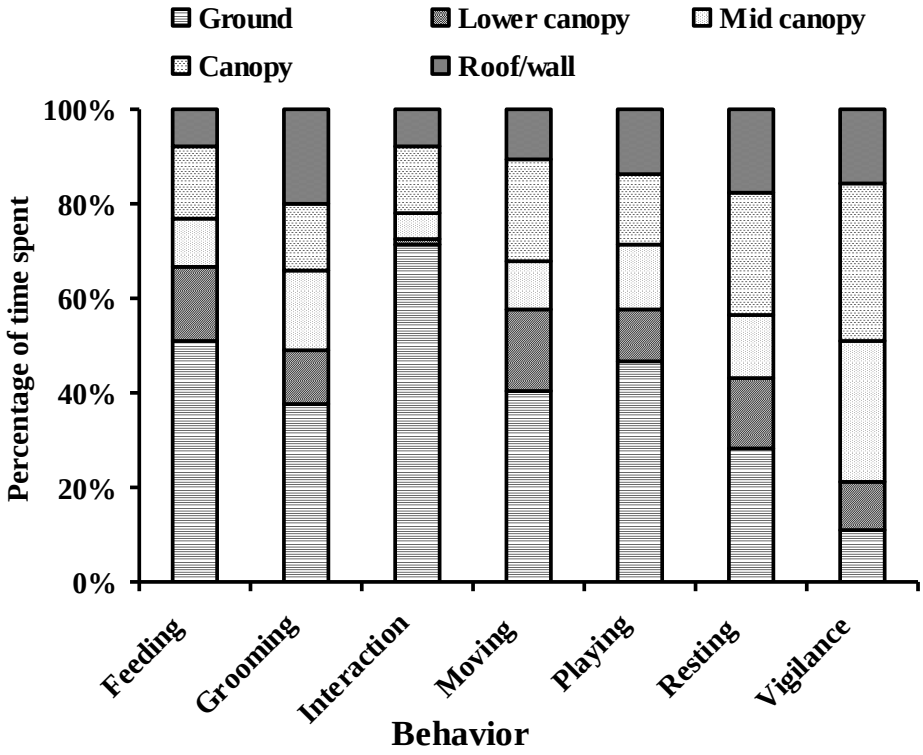

Figure 3. Substrate utilization during behavioral activities.

Age-sex differences in utilization of different substrates

Regardless of group and season, Bengal sacred langur of all age-sex classes used different substrates in their habitats. We found significant differences in utilization of canopy level across the age-sex classes and no significant differences in other substrates (Chi square test: canopy, χ^2 = 8.4, d.f. = 3, p = 0.03; ground, χ^2 = 1.9, d.f. = 3, p > 0.05; lower canopy, χ^2 = 2.9, d.f. = 3, p > 0.05; mid canopy, χ^2 = 3.7, d.f. = 3, p > 0.05 and roof/wall, χ^2 = 1.04, d.f. = 3, p > 0.05, Table 1). This result suggests that age-sex class has no effect of utilization of substrate in their habitat except canopy which partially supports prediction 2 that is sub-adult spent more time on canopy whereas adults use rest of the substrate.

Table 1. Age-sex differences of time spent in different substrate.

Layer	Age-sex	% of time spent	Chi	d.f.	p
Ground	Adult-female	27.4	1.9	3	> 0.05
	Adult-male	25.4			
	Sub-adult-female	27.8			
	Sub-adult-male	19.4			
Lower canopy	Adult-female	30.1	2.9	3	> 0.05
	Adult-male	27.7			
	Sub-adult-female	23.1			
	Sub-adult-male	19.1			
Mid canopy	Adult-female	31.4	3.7	3	> 0.05
	Adult-male	22.9			
	Sub-adult-female	27.4			
	Sub-adult-male	18.3			
Canopy	Adult-female	16.5	8.4	3	= 0.03
	Adult-male	17.5			
	Sub-adult-female	31.3			
	Sub-adult-male	34.7			
Roof/wall	Adult-female	27.3	1.04	3	> 0.05
	Adult-male	22.8			
	Sub-adult-female	27.8			
	Sub-adult-male	22.1			

Substrate utilization during behavior including feeding in two different groups

Regardless of behavior we examined average time spent/day on different substrates and compared between two groups of Bengal sacred langur. We found significant differences of time spent/day between two groups in some layers but did not find in other layers (Mann-Whitney test: ground, U = 1073480, p < 0.0125, n_1 = 1163, n_2 = 1961; lower canopy, U = 149938.5, p = 0.02, n_1 = 575, n_2 = 566; mid canopy, U = 100334.5, p > 0.05, n_1 = 498, n_2 = 407; canopy, U = 283693, p > 0.05, n_1 = 811, n_2 = 706 and roof/wall, U = 93403, p < 0.0125, n_1 = 350, n_2 = 597, Figure 4) which supports the second part of prediction 1, i.e., position utilization was influenced by habitat types. Furthermore, we examined average time spent feeding/day in different substrate during feeding between two groups of Bengal sacred langur and we found significant differences in utilization of ground, canopy and roof/wall and other layers showed no differences (Mann-Whitney test: ground, U = 97673, p < 0.0125, n_1 = 366, n_2 = 655; lower canopy, U = 11700.5, p > 0.05, n_1 = 161, n_2 = 150; mid canopy, U = 5934, p > 0.05, n_1 = 120,

n_2 = 102; canopy, U = 10648, p = 0.01, n_1 = 183, n_2 = 125 and roof/wall, U = 1501, p = 0.02, n_1 = 44, n_2 = 89, Figure 5). This result suggests that use of substrate during feeding also affected by habitat types.

Differences of resource utilization between two groups

Bengal sacred langur of the rural and the urban groups spent 130 and 150 min/day, respectively in feeding on different food types. We found time spent feeding significantly differed across the food types in both the rural and the urban groups (Friedman test: rural, χ^2 = 20.18, d.f. = 2, p < 0.0125; urban, χ^2 = 14.0, d.f. = 2, p < 0.0125, Figure 6). Pair wise comparison based on ranked test showed that langur of both group spent more time on common food than provisioned food and crops/seasonal food (*P* values were the same for each comparison, *P < 0.05*). We also found significant differences of time spent feeding on provisioned food and crops/seasonal food between two groups (Wilcoxon Singed Ranked test: provisioned food, Z = -1.9, p = 0.03; crops/seasonal food, Z = -2.19, p = 0.02, Figure 4). There was no significance on common food between two groups. This results show that utilization of resource greatly influenced by habitat which support prediction 3.

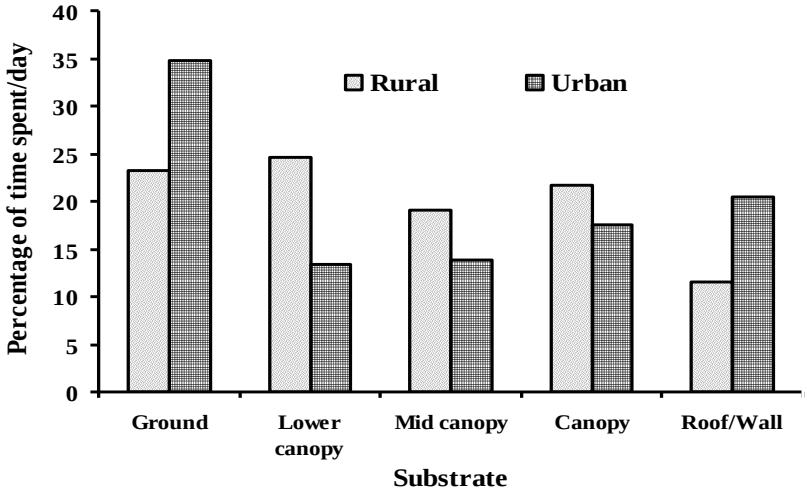

Figure 4. Variation of substrate utilization during behavioral activities between two groups.

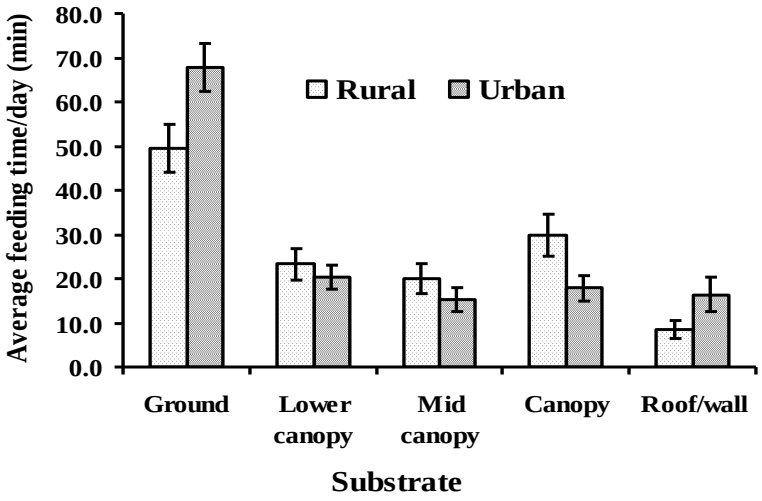

Figure 5. Substrate use during feeding in two different groups of langurs.

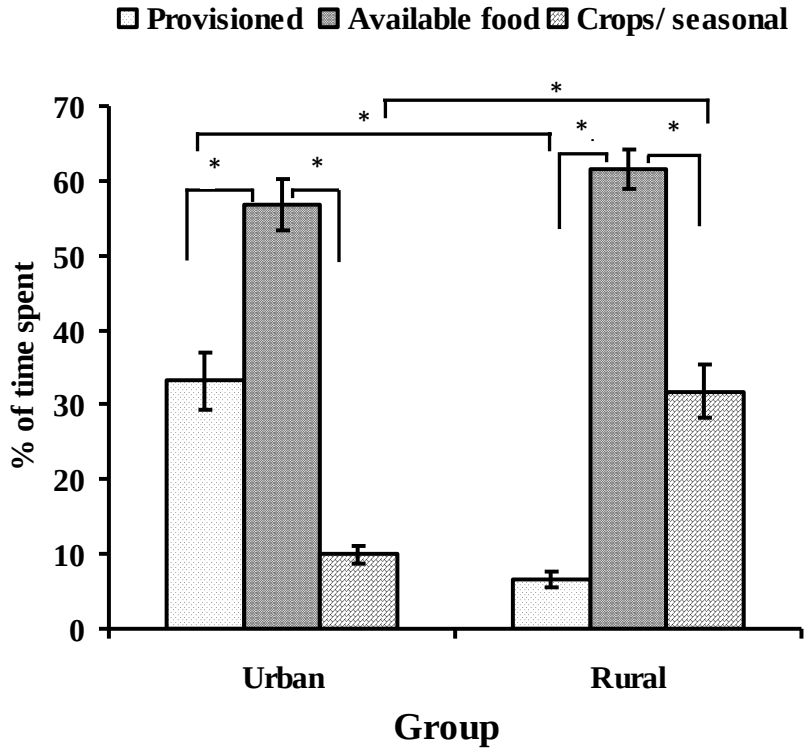

Figure 6. Variation of resource utilization between two groups of langurs. Statistical significant in pair-wise comparison, **P < 0.05*

DISCUSSION

The contemplation for substrate utilization and study of habitat is essential for the conservation of a species and understanding of animal's ecological adaptation to its environment. The Bengal sacred langur is arboreal and diurnal forest dwelling species and can be adapted to variety of habitats (Minhas *et al*., 2010). Keshabpur is not a forested area, langur population living here sharing with human and for food they basically depend on available food, seasonal crops cultivated by villagers and provisioned food supplied from Forest Department, Bangladesh.

Of the total 301 hours of observation, Bengal sacred langur spent maximum time on ground (32.6%) and minimum on lower canopy of tree (14.4%). This result suggests that langurs of this site are not totally arboreal or ground dwellers but they use different layers of trees, wall/roof of houses and other substrate, probably depending on the suitability and availability of substrates. Similar study was done by Sarker *et al.* (2005) on Rhesus macaques (*Macaca mulata*) in Gazipur, Bangladesh. They found that macaques spent 43.6% of their active time on ground, 28.9% on roof/wall, 24.3% on trees and 3.2% on other substrates (electric poll, straw stack etc.). Although substrate use varies in relation to the behavioral activities of langurs, they spent maximum time for interaction on ground because they have to share habitat with other ground dwelling animals and compete with them for resources. Similarly, for moving and playing they spent more time on ground. Vigilance, basically done by male langurs, is an activity by which animals guard against intruders in their territory and warn other group members in case of unusual situation. Probably place high above ground is suitable for performing this activity and that is why Bengal sacred langur spent more time on canopy for vigilance. However, they spent more or less similar amount of time on every stratum for resting.

In the present study, habitat differences effect was found on substrate utilization i.e. langurs of

the urban group spent more time on ground and roof/wall than the rural group, while the rural group utilized different layers of trees. Wheatley (1980) speculated that both *Macaca fasicularis* and *M. thibetana* are predominantly terrestrial on the riverbank and the species is essentially arboreal in the forests. Pig-tailed macaques (*M. leonina*) in the Malayan Peninsula spend most of their time on ground and climb trees to escape predators and for roosting (Caldecott, 1986). Specific variation of ground and arboreal feeding between two groups of langur was found. The urban group spent more time on ground and roof/wall for feeding whereas the rural group insists on basically arboreal feeding. These are due to the differences of food sources between two habitats. Provisioned foods were usually supplied on the ground twice a day to the urban group. Being adjacent to upazila (local administration office), local visitors willingly provide handouts that keep them spending more time on ground to get satiety. On the contrary, members of rural group that do not get provisioned food, expended more time on canopy, lower canopy and mid canopy layer of the trees. This could be due to their limited access to provisioned foods that let them spend more feeding time on natural foods at different layers in trees. Sub-adult langur, due to their lighter body weight, had easier access to natural foods located on the smaller terminal branches of trees and exploited all available food items located there. In this way, it might assume that sub-adult were able to fulfill their energy requirements easily and reach satiety. In contrast, access to provisioned foods, heavy body weight, and perhaps energetic constraints, adults fed less on natural plants than sub-adult and when they did, spent more time feeding on the ground or at mid canopy in the trees. Jaman and Huffman (2011) reported that Japanese macaques show same feeding strategy as Bengal sacred langur did. These differences in feeding patterns in terms of substrate utilization likely helped to reduce feeding competition between sub-adult and adults. Therefore, it can be reported that adult feeding more on the ground and sub-adult feeding more at relatively higher locations in the trees, so that pressure on specific resources decrease and food of all layer are well utilized. Apart from this, we observed they maintain social hierarchy during feeding i.e. adult got first when provisioning and raiding crops.

Bengal sacred langur of urban groups spent more time (around 150 min/day) on feeding than rural groups (130 min/day). When an animal feed low quality of food, they must increase their feeding time to obtain sufficient energy (Agetsuma, 1995). Nakagawa (1989) showed that Japanese macaques feed for longer time to obtain energy as food quality deteriorates. Therefore, in the present study, the time spent feeding reflects food quality between two habitats.

Human interference has important consequences for the biology of primates (Bishop *et al*., 1981). The frequency of contact between humans and langurs, the degree of commensality and the amount of time spend in particular habitats are also important for conducting management plan. The rapid destruction and alteration of habitat (by plantation of exotic monoculture species) that continues in an unplanned manner throughout the Bangladesh will undoubtedly result in the extinction of species (Muzaffar *et al*., 2007). On top of this is the effect of the increasing human population living in or around the territory of wild species. Particularly important is the impact of converting increasingly larger areas of natural vegetation for agriculture and infrastructure developments. Protection of habitat would require a large commitment from the government and it's Forest Department (Muzaffar *et al*., 2007).

CONLUSION

Improvement of habitat should involve carefully planned plantation of mixed native species providing food and habitat of Bengal sacred langur based on salient scientific findings. Additionally, villagers living around should be carefully incorporated into conservation plans to

prevent further degradation of these habitats by conversion to agricultural land and developmental activities.

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