Primate Conservation 2022 (36): 191-202

Dietary Composition, Food Choice and Food Plants of Capped Langur, *Trachypithecus pileatus* (Blyth, 1843) in and around the Madhupur National Park, Bangladesh

Shawkat Imam Khan[1], Mohammad Firoj Jaman[2] and Mohammad Zashim Uddin[3]

[1]*Department of Natural History, Bangladesh National Museum, Shahbag, Dhaka, Bangladesh*
[2]*Department of Zoology, University of Dhaka, Dhaka, Bangladesh*
[3]*Department of Botany, University of Dhaka, Dhaka, Bangladesh*

Abstract: A study of the dietary composition, food choice and the food plant species used by *Trachypithecus pileatus* (Blyth, 1843) was carried out in the deciduous *sal* (*Shorea robusta* Roxb. *ex*. Gaertn.) forest and its adjacent area of human habitation from April 2016 to March 2017 in Madhupur, Bangladesh. The instantaneous scan sampling method was used to collect data on feeding ecology. Capped langurs preferred leaves (55.4%), followed by fruits (25%), flowers (7.6%), seeds (5.4%), flower buds (4.35%), bamboo shoots (1.1%) and tree bark (1.1%). Leaves were most predominant in August (19.1%) and the least in March (1.5%). In Summer, the diet constituted mostly leaves, flowers and fruits but in the Winter and Monsoon seeds were consumed. Seventy-seven species of food plants in 38 families were identified, most of them (54.5%) in natural forest but with 45.4% in areas of human habitation. The five most preferred food plant species were *Dillenia pentagyna* (5.3%), *Litsea monopetala* (4.8%), *Haldina cordifolia* (4.2%), *Bursera serrata* (3.95%) and *Albizia lebbeck* (3.8%). In the Summer, most of (72.7%) of the species providing food were in the forest, whereas in Winter the majority (55.5%) were in the area of human habitation. Most (72.7%) of the recorded food plants were trees, followed by shrubs (6.5%), climbers (19.5%) and parasitic plants (1.3%). Food plant species belonging to Moraceae (10.4%) were the most preferred items. They used the forest floor to the upper canopy for foraging and feeding. Shortage of food plants in the natural forest forced them to invade areas of human habitation. The implications of this research are that increasing the availability of preferred food plants in the natural forest could result in capped langurs eschewing areas of human habitation.

Keywords: Capped langur, food plants, dietary preference, Madhupur National Park

Introduction

Capped langurs, *Trachypithecus pileatus*, occur in Bangladesh, Bhutan, Northeast India, northwestern Myanmar and southern China (Roonwal and Mohnot 1977; Zhang *et al.* 1981; Khan and Ahsan 1986; Ahsan 1994; Srivastava 1999; Das *et al*. 2020). They are mostly folivorous (Choudhury 1989; Stanford 1991a) but consume a variety of food items including fruits and flowers (Solanki *et al.* 2008a). Studies have demonstrated their folivory in the Pakhui Wildlife Sanctuary, India (Solanki *et al.* 2008a), Northeast India (Gupta 1996) and in Madhupur National Park, Bangladesh (Stanford 1991a).

Their diet is influenced by a number of environmental factors, including the condition of their habitat, and the availability, quality, dispersion, and abundance of resources available to them (Ganguli *et al.* 1964; Majumder *et al.* 1967; Tejwani 1994). The phenological stages of a plant influence the food choice of primates (Freeland and Janzen 1974; Milton 1980; Solanki *et al.* 2008a) and they may alter their feeding strategy in relation to the availability of specific resources (Chapman 1988). Seasonal resource abundance affects the dietary composition (Remis 1997; Tutin *et al.* 1997). Food selection is also affected by physiological status, reproduction and lactation, and by sex (Altmann

1980; Clutton-Brock *et al.* 1989; Garber 1987). Even tree size influences selection (Stevenson *et al*. 1994; Yiming *et al*. 2002).

The diet of the capped langur has been studied in Bangladesh (Islam and Husain 1982; Stanford 1991a; Kabir 2002) and India (Solanki *et al*. 2008a; 2008b; Choudhury 2012), with the focus being on food items, and the plant species and habits in the diet in undisturbed forests. Here we examine the dietary flexibility of capped langurs in the Madhupur National Park as well as in human-dominated areas adjacent to the park, where the groups raid crops at times of food scarcity. We recorded the times and the reasons behind their movement from the park to areas of human habitation and the dietary composition during lean periods and recorded the important food plants in and around the deciduous forest as a contribution to long-term conservation measures for the species.

Methods

Study area

The study was carried out in Madhupur National Park (8,436 ha; 24°41.323'N, 90°8.275'E) (Fig. 1), 50 km south of the Garo Hills in the state of Meghalaya, India, and about 151 km north of Dhaka, the capital of Bangladesh (Khan and Ahsan 2015). The altitude of the park is about 20 m above sea level (Monirujjaman and Khan 2018). The climate there is tropical. During the study period the temperatures ranged from 7°C to 38°C and the yearly total precipitation was 2899.1 mm. The highest monthly precipitation recorded was 555.1 mm in June. The highest average relative humidity was 87% in July and September and the lowest average relative humidity was 71% in March.

The Madhupur forest is on a slightly elevated tract of land, approximately 1–2 m in height over the surrounding plains. There are numerous depressions with gentle slopes intercepting flat ridges that run north to south forming the irregular masses of highlands with gentle slopes. These highlands are intercepted by numerous depressions—long and narrow ditches where paddy is cultivated. In the rainy season the low-lying depressions accumulate water and become marshy. They dry up in the Summer and Winter seasons but they expand into broad shallow swampy areas in the rainy season covered with aquatic plants, grasses and reeds. The forest is partly dense, with slim-trunked trees and there are also areas of scrub and bush. Vegetation in the area

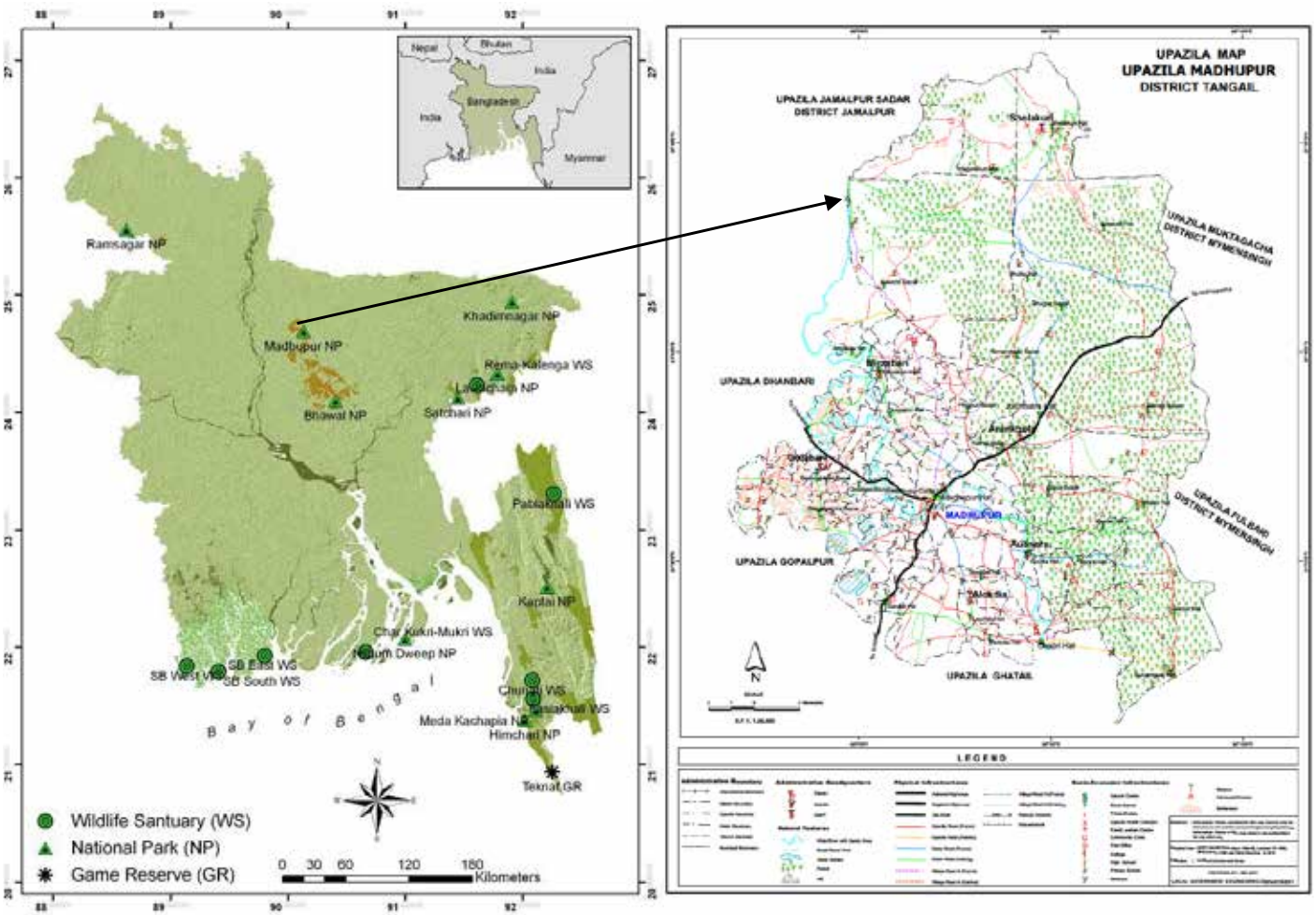

Figure 1. The study area in north central Bangladesh, District of Tangail, administrative region (*upazila*) of Madhupur (map source: Reza 2014; http://wikimapia.org/).

Table 1. Group size, age-sex structure and GPS location of the study groups.

Group	Group size	Recorded date and time	Recorded area	GPS	Group composition						
					AM	AF	SAM	SAF	JM	JF	In
Gr-1	7	03/04/2016 06:00 hr	Joloi	24°40'44.39"N 90° 7'37.87"E	1	1	2	3	0	0	0
Gr-2	4	24/04/2016 06:30 hr	Telki	24°40'22.61"N 90° 7'9.58"E	1	1	1	1	0	0	0
Gr-3	11	15/05/2016 06:00 hr	Joloi	24°40'44.48"N 90° 7'41.81"E	1	3	2	3	0	1	1
Gr-4	5	19/05/2016 11:30 hr	Joloi	24°40'32.23"N 90° 7'32.27"E	1	4	0	0	0	0	0
Gr-5	10	25/05/2016 11:20 hr	Joloi	24°40'26.61"N 90° 7'25.05"E	1	4	1	0	0	0	4
Gr-6	11	26/05/2016 10:30 hr	Human habitation (Harinatala village)	24°41'41.25"N 90° 8'49.87"E	1	5	1	0	2	2	0
Gr-7	12	05/06/2016 06:00 hr	Joloi	24°40'48.10"N 90° 7'40.46"E	2	4	1	1	0	0	4
Gr-8	3	21/07/2016 12:30 hr	Joloi (Garo village)	24°40'32.71"N 90° 7'49.81"E	1	1	1	0	0	0	0
Gr-9	6	23/07/2016 14:00 hr	Lohoria	24°41'33.91"N 90° 7'28.89"E	1	2	1	1	0	0	1
Gr-10	5	23/07/2016 14:15 hr	Lohoria	24°41'32.77"N 90° 7'19.86"E	1	2	1	0	0	0	1
Gr-11	9	24/07/2016 09:00 hr	Lohoria	24°41'38.85"N 90° 6'54.36"E	1	3	1	1	0	2	1
Gr-12	10	24/07/2016 10:00 hr	Dokhola	24°41'55.20"N 90° 4'46.61"E	1	2	1	1	1	2	2
Gr-13	6	13/08/2016 17:45 hr	Joloi	24°40'37.86"N 90° 7'38.36"E	2	2	0	1	0	0	1
Gr-14	9	01/09/2016 10:30 hr	Human habitation (Razabari beat)	24°40'27.19"N 90° 8'42.60"E	1	4	0	1	1	2	0
Gr-15	14	30/09/2016 07:45 hr	Joloi	24°40'41.14"N 90° 7'35.56"E	1	7	1	2	1	2	0
Gr-16	6	12/11/2016 11:15 hr	Human habitation (Kathalia village)	24°40'44.40"N 90° 8'38.77"E	1	3	0	0	2	0	0
Gr-17	14	27/01/2017 12:00 hr	Rasulpur	24°41'17.57"N 90° 8'20.37"E	1	5	1	1	3	2	1
Gr-18	12	31/03/2017 10:30 hr	Human habitation (Harinatala village)	24°41'42.79"N 90° 9'2.77"E	1	5	1	0	1	3	1
Total =					**20**	**58**	**16**	**16**	**11**	**16**	**17**
%					**13**	**37.7**	**10.4**	**10.4**	**7.1**	**10.4**	**11**

AM – Adult male, AF – Adult female, SAM – Sub-adult male

SAF – Sub-adult female, JM – Juvenile male, JF – Juvenile female, In – Infant

is dominated by *Sal* (*Shorea robusta*) associated with other deciduous trees (Khan 2010).

Data collection

Data on diet presented here are the percentage of time spent eating particular food items as the unit of measurement. We used instantaneous scan sampling (Altmann 1974) with a 10-minute interval to collect data on feeding ecology during April 2016 to March 2017 in natural forest and areas of human habitation near the national park. Fortnightly, two consecutive following days were spent sampling 18 groups (Table 1). Each scan took 30-75 seconds to obtain data for all group members. Observations began at sunrise and ended in the evening when the capped langurs entered their sleeping trees. We accompanied the langurs on 104 days, totalling 1,144 hours and providing 4,168 feeding scans. November through February is the cool Winter season, March to June the hot Summer, and July to October the Monsoon season.

We recorded the food plant species and plant parts eaten by the langurs. Food items were classified into (1) leaves, (2) flower buds, (3) flowers, (4) fruits, (7) seeds, (8) shoots and (9) bark. Drinking water and occasional food items such as ingestion of soil from termite trails were also recorded.

The local names of the food plant species were obtained from a local field guide. Both known and unknown food plants were photographed, and representative samples (leaves, flowers and fruits) were collected for herbarium specimens and subsequent identification (Siddiqui *et al.* 2007; Ahmed *et al.* 2008a, 2008b, 2009a, 2009b, 2009c, 2009d). Plant specimens were sent to the Dhaka University Salar Khan Herbarium.

The heights at which the langurs were feeding was recorded through visual estimation and categorized as upper canopy (above 20 m), middle canopy (10–20 m) and lower canopy (up to 10 m), following Solanki *et al.* (2008a) and Martin and Bateson (2007).

Data analysis

The percentage of feeding time on different food items was calculated as described by Gupta and Kumar (1994). Food diversity and food preferences were calculated on the basis of feeding time on a plant species and the part of the particular plant consumed as per the procedures indicated by Sussman (1987) and Bartlett (1999). The Shannon-Wiener Diversity Index was used to examine seasonal variation in dietary diversity. The T-test was used for monthly variation and the Chi-squared Test was used to examine seasonal variation in the food plant species. Statistical significance for all analyses was set at $P < 0.05$.

Results

Food and food preferences

The capped langurs ate leaves (tender, young, and mature), fruits (unripe and ripe), flower buds, flowers, seeds, bamboo shoots, bark, and soil from termite trails. Seventy-seven plant species provided food for the capped langurs. Leaves were much preferred (55.43%, n = 51 species) followed by fruit (25%, n = 23 species), flowers (7.61%, n = 7 species), seeds (5.43%, n = 5 species), flower buds (4.35%, n = 4 species), and shoots and bark, which were equally selected (1.09%, n = 1 species each). Of the total food plants (77 species), 45 species were in the forest in the park, 39 species were in the area of human habitation and seven species were in both areas. Capped langurs consumed leaves, fruits, flowers, flower buds, and seeds in the forest and in the area of human habitation, but bamboo shoots and bark were eaten only in the latter. The langurs ate the leaves of 51

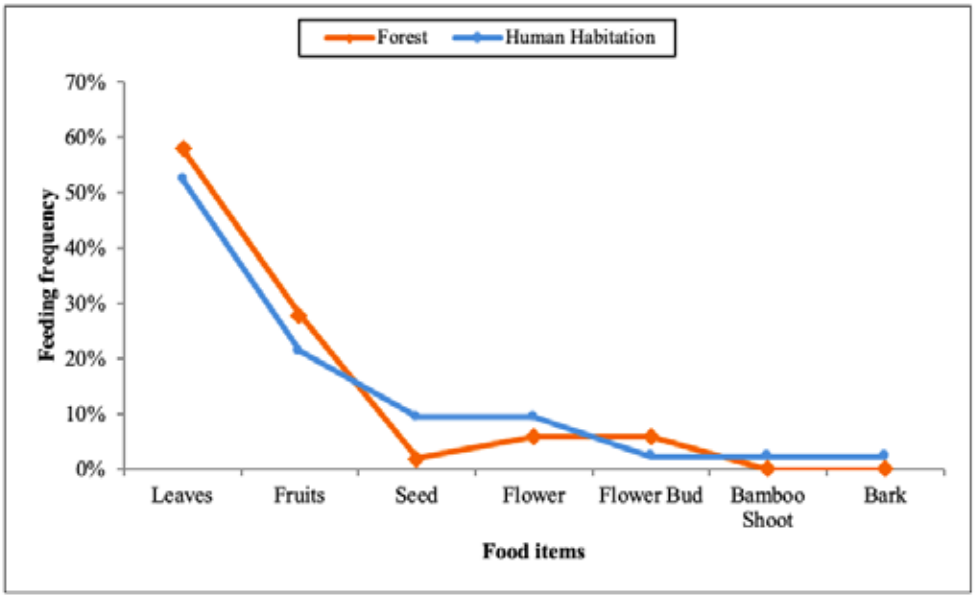

Figure 2. Percentages of food items in the diet of the capped langur.

species (69.05%, n = 29 species and 62.86%, n = 22 species in the forest and the area of human habitation, respectively) (Fig. 2).

The capped langurs drank accumulated rainwater from tree trunks in the forest or other available water sources such as ditches and cratches (large clay bowls used for cattle feed) in the area of human habitation. They ate young leaves, flowers and fruits in the early morning, but mature leaves, seeds and shoots more at mid-day.

Monthly variation of food items

Food preference varied across the year (Fig. 3). Leaves were highly preferred in August (19.12%, n = 13 species) and least in March (1.47%, n = 1). Fruit preference was highest in April and June (22.22%, n = 6) and lowest in February and July (4.17%, n = 1). Due to lack of available fruits, none were consumed during September and October. Flowers were eaten in April and August (28.57%, n = 2), flower buds in January, April, June and November. They were seen to eat bamboo shoots just once, in November, and bark in August. Adult-males were observed ingesting soil covering termite trails in May. The consumption of different food items in different months varied significantly ($H = 30.21$, $df = 11$, $n = 60$, $p < 0.05$).

Seasonal dietary diversity

Leaves, flowers and fruits were predominant in the Summer, and seeds in the overlapping Winter and Monsoon seasons (Fig. 4), but the consumption of different food items was not significantly different between seasons ($\chi^2 = 0.5471$, $df = 12$, $p > 0.05$). Flower buds were eaten in the Winter and Summer, bamboo shoots just once in Winter, and likewise tree bark in the Monsoon season.

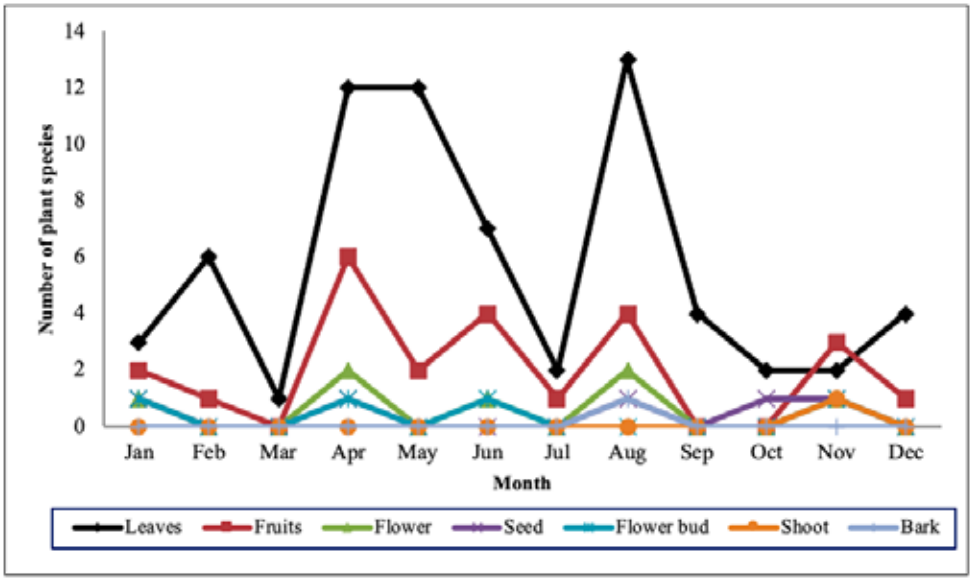

Figure 3. Monthly variation of different food items consumed by the capped langur.

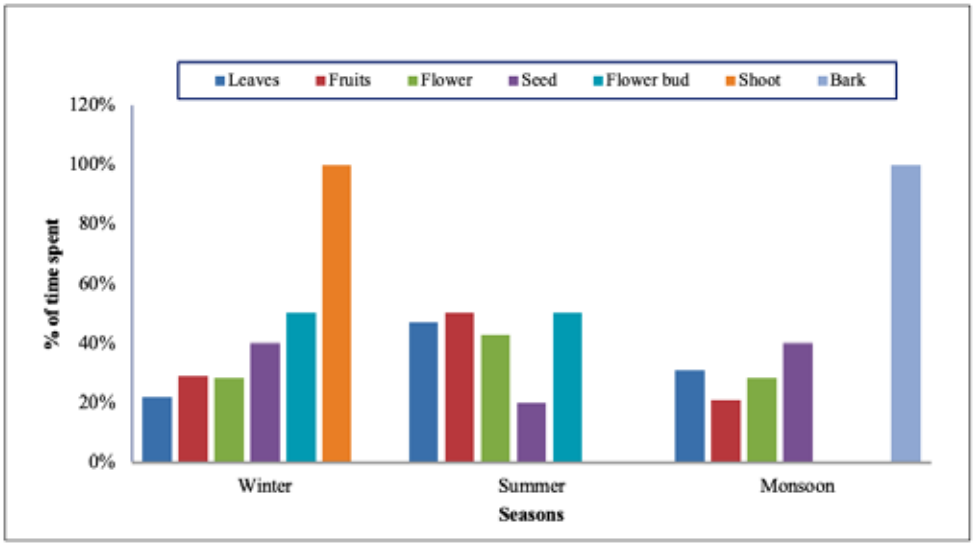

Figure 4. Seasonal variation of different food items consumed by the capped langur.

Table 2. Food plant species in the diet of the capped langur in Madhupur National Park. Species with an '*' have not been reported in earlier studies (Islam and Husain 1982; Stanford 1991a) (Family names are arranged alphabetically).

	Scientific Name	Local name	Family	Habit	Part eaten[1]	Month	% of feeding records	Rank
1	**Thunbergia fragrans* Roxb.	–	Acanthaceae	Climber	YL	Apr	0.85	34
2	**Thunbergia grandiflora* Roxb.	Nillata	Acanthaceae	Climber	YL, ML, FB, Fl	Jun	0.58	50
3	*Mangifera indica* L.	Aam	Anacardiaceae	Tree	UFr, RFr	Jun	0.42	63
4	**Annona reticulata* L.	Nonaata	Annonaceae	Tree	RFr	Mar	0.53	55
5	*Miliusa velutina* (Dunal) Hook. f. & Thom.	Gandigajari	Annonaceae	Tree	YL	May	3.7	8
6	**Uvaria hamiltonii* Hook. f. & Thom.	Banarkala	Annonaceae	Shrub	YL, RFr	Apr, Aug	0.97	25
7	*Wrightia coccinea*.	Dudh-koraiya	Apocynaceae	Tree	YL	May	0.68	44
8	**Rhaphidorpha peepla* (Roxb.)	–	Araceae	Climber	YL	Apr, May	0.88	32
9	**Areca catechu* L.	Supari	Arecaceae	Tree	UFr	Aug	0.25	67
10	*Mikania cordata* (Burm. f.) Robinson	Assamlata	Asteraceae	Climber	YL, ML	Apr, May	1.47	14
11	**Oroxylum indicum* (L.) Kurz	Nasona	Bignoniaceae	Tree	YL	May	1.22	23
12	**Bombax ceiba* L.	Tula	Bombacaceae	Tree	YL	Sep	0.81	36
13	**Bursera serrata* Wall. Ex Colebr.	Chitrika	Burseraceae	Tree	YL, RFr	Apr	3.95	4
14	*Bauhinia malabarica* Roxb.	Karmai	Caesalpiniaceae	Tree	YL	May, Jun	0.63	49
15	**Tamarindus indica* L.	Tetul	Caesalpiniaceae	Tree	RFr	Jan	0.54	54
16	*Capparis zeylanica* L.	Asarilata	Capparaceae	Climber	YL	Apr	0.57	51
17	**Carica papaya* L.	Pepe	Caricaceae	Shrub	YL	Dec	0.52	56
18	*Terminalia bellirica* (Gaertn.) Roxb.	Bohera	Combretaceae	Tree	UFr	Apr	0.94	28
19	**Merremia umbellata* (L.) Hallier f.	Sadakalmi	Convolvulaceae	Climber	YL	Feb	0.69	43
20	**Coccinea grandis* (L.) Voigt	Telakucha	Cucurbitaceae	Climber	TL, YL, FB, Fl	Nov	0.95	27
21	*Dillenia pentagyna* Roxb.	Ajuli	Dilleniaceae	Tree	RFr	May, Jun	5.34	1
22	**Dioscorea bulbifera* L.	Pagla alu	Dioscoreaceae	Climber	UFr	Nov	0.66	46
23	**Dioscorea pentaphylla* L.	Jhum alu	Dioscoreaceae	Climber	YL	Jun	0.43	62
24	**Dioscorea* sp. 1	Gas alu	Dioscoreaceae	Climber	YL, UFr	Aug	0.72	41
25	**Dioscorea* sp. 2	Gas alu	Dioscoreaceae	Climber	YL	May	0.75	39
26	**Dioscorea* sp. 3	–	Dioscoreaceae	Climber	ML	Aug	0.53	55
27	*Shorea robusta* Roxb. ex Gaertn.	Gajari/Sal	Dipterocar-paceae	Tree	YL	May	1.25	21
28	**Elaeocarpus robustus* Roxb.	Jalpai	Elaeocarpaceae	Tree	TL	Feb	0.44	61
29	**Aporosa dioica* (Roxb.) Muell.-Arg.	Patakharulla	Euphorbiaceae	Tree	RFr	May, Jun	0.39	65
30	**Bridelia tomentosa* Blume	Khoi	Euphorbiaceae	Tree	UFr	Dec	0.21	68
31	**Gelonium multiflorum* A. Juss.	–	Euphorbiaceae	Tree	YL	Feb	0.77	38
32	**Manihot esculenta* Crantz.	Kasava/ Simul Alu	Euphorbiaceae	Shrub	YL	May	0.49	58
33	*Dalbergia lanceolaria* L. f.	–	Fabaceae	Tree	YL, Fl	Apr	0.65	47
34	*Dalbergia* sp.	–	Fabaceae	Tree	YL	Dec	0.67	45
35	**Erythrina ovalifolia* Roxb.	Kantamandar	Fabaceae	Tree	YL	Aug	0.47	59
36	*Mucuna* sp.	–	Fabaceae	Tree	YL	Sep	0.45	60
37	*Spatholobus* sp.	–	Fabaceae	Climber	YL	Sep	0.51	57
38	**Litsia glutinosa* (Lour.) Robinson	Kukurchita	Lauraceae	Tree	TL, YL, Br	Aug	0.79	37
39	*Litsea monopetala* (Roxb.) Pers.	Kharajora	Lauraceae	Tree	YL, UFr	Apr	4.83	2
40	**Loranthus falcatus* L.f**.**	Pargacha	Loranthaceae	Parasitic	YL, ML	Jan, Jun	0.70	42

Table 2. *Cont'd*.

	Scientific Name	Local name	Family	Habit	Part eaten[1]	Month	% of feeding records	Rank
41	**Aphanamixis polystachya* (Wall.) R N. Parker.	Pitraj	Meliaceae	Tree	TL, ML	Nov	1.34	18
42	**Chickrassia tabularis* (A. Juss.) Wight & Arn.	Chickrass	Meliaceae	Tree	UFr	Aug	1.33	19
43	**Melia sempervirens* (L.) Sw.	Goranim	Meliaceae	Tree	YL	Aug	1.29	20
44	**Toona ciliata* M. Roem.	Pia	Meliaceae	Tree	YL	Jan	0.65	47
45	*Acacia auriculiformis* A.Cunn. ex Benth. & Hook	Akashmoni	Mimosaceae	Tree	MS	Nov	0.89	31
46	*Acacia pennata* (L.) Willd.	Kuchi lot	Mimosaceae	Climber	YL	Feb	0.93	29
47	*Albizia lebbeck* (L.) Benth. & Hook.	Kalo-koroi	Mimosaceae	Tree	TL, MS	Aug	3.78	5
48	*Albizia procera* (Roxb.) Benth.	Koroi	Mimosaceae	Tree	MS	Nov	3.73	6
49	*Albizia* sp.	–	Mimosaceae	Tree	YL	Aug	1.44	15
50	**Leucaena leucocephala* (Lamk.) de Wit.	Ipil-Ipil	Mimosaceae	Tree	IS	Jan, Oct	3.71	7
51	*Samanea saman* (Jacq.) Merr.	Rendikoroi	Mimosaceae	Tree	YL	Aug	3.67	10
52	*Artocarpus lacucha* Buch.-Ham.	Dewa	Moraceae	Tree	YL, RFr	Apr	0.92	30
53	*Ficus benghalensis* L.	Krishna-bot	Moraceae	Tree	UFr, RFr	Dec, Jun	2.55	12
54	**Ficus hispida* L. f.	Kak dumur	Moraceae	Tree	UFr, RFr	Apr	0.93	29
55	**Ficus racemosa* L.	Jagga dumur	Moraceae	Tree	UFr, RFr	Apr	0.84	35
56	**Ficus retusa* L.	Jir Bat	Moraceae	Tree	UFr, RFr	Jun	0.93	29
57	**Ficus rumphii* Blume	Hijulia	Moraceae	Tree	UFr, RFr	Apr	0.96	26
58	**Morus alba* L.	Tunt	Moraceae	Tree	YL	Feb	0.64	48
59	*Streblus asper* Lour.	Shaowra	Moraceae	Tree	YL	Apr	1.43	16
60	**Musa paradisiaca* L.	Aittakola	Musaceae	shrub	UFr	Nov	0.84	35
61	**Syzygium samarangense* (Blume) Merr. & Perry	Jamrul	Myrtaceae	Tree	FB, Fl	Jan	1.23	22
62	**Bambusa tulda* Roxb.	Talla bans	Poaceae	Tree	Sh	Nov	0.38	66
63	**Ziziphus mauritiana* Lamk.	Baroi	Rhamnaceae	Tree	UFr	Nov	2.83	11
64	**Anthocephalus chinensis* (Lamk.) A. Rich.ex Walp.	Kadam	Rubiaceae	Tree	YL, Fl	Aug	3.68	9
65	*Haldina cordifolia* (Roxb.) Ridsdale	Kaika	Rubiaceae	Tree	TL, YL	Apr, Aug	4.16	3
66	*Randia* sp.	Mankata	Rubiaceae	Tree	UFr	Jul, Aug	0.45	60
67	**Citrus aurantifolia* (Christm. & Panzer) Swingle	Lebu	Rutaceae	Shrub	UFr	Jan	3.68	9
68	*Citrus grandis* (L.) Osbeck	Jambura	Rutaceae	Tree	TL	Feb	1.37	17
69	**Erioglossum edule* Blume	Baraharina	Sapindaceae	Tree	RFr	Jun	0.58	50
70	**Schleichera oleosa* (Lour.) Oken.	Joyna	Sapindaceae	Tree	YL	May	1.22	23
71	**Pterospermum acerifolium* (L.) Willd.	Kanak champa	Sterculiaceae	Tree	FB, Fl, MS	Apr	0.73	40
72	**Trema orientalis* (L.) Blume	Jiban	Ulmaceae	Tree	YL	Jan, Aug	0.86	33
73	**Gmelina arborea* Roxb.	Gamari	Verbenaceae	Tree	TL	Aug	1.51	13
74	**Tectona grandis* L. f.	Segun	Verbenaceae	Tree	TL, Fl	Aug	0.68	44
75	**Vitex* sp. 1	–	Verbenaceae	Tree	YL	May	0.53	55
76	**Vitex* sp. 2	–	Verbenaceae	Tree	YL	Oct	0.53	55
77	*Vitis* sp.	–	Vitaceae	Climber	YL	Jun	0.58	50

[1]Note: IS – Immature seeds; MS – Mature seeds; UFr – Unripe fruit; RFr – Ripe fruit; TL – Tender leaves; YL – Young leaves; ML – Mature leaves; FB – Flower buds; Fl – Flowers; Sh – Shoots; Br – Bark.

Food availability in different months and seasons influences the diet of capped langurs. They increased their consumption of new leaves in the Summer. Trees were a source of food throughout the year, but climbers just in eight months, shrubs in six months and parasitic plants in two months. The dietary diversity was highest in Summer at Madhupur National Park due to the increased availability of diverse food items.

Food plant species diversity

A total of 77 plant species belonging to 38 families were included in the diet, of which 72.73% (n = 56 species) were trees, 6.49% (n = 5) were shrubs, 19.48% (n = 15) were climbers and 1.30% (n = 1), the parasitic *Loranthus falcatus* of the Loranthaceae family (Table 2). Based on the total feeding records (4,168 feeding scans) it was revealed that, *Dillenia pentagyna* (5.34%), *Litsea monopetala* (4.83%), *Haldina cordifolia* (4.16%), *Bursera serrata* (3.95%) and *Albizia lebbeck* (3.78%) were the top five preferred food plant species. The capped langurs consumed leaves from 51 species, followed by fruits (23 species), flowers (7 species), seeds (5 species) and others (Table 2). The selection of different food plants in two different habitats (forest and human habitation) was significantly different ($\chi^2 = 0.34$, df = 6, $p < 0.05$). The forest is the main provider. Trees, shrubs and climbers provided food in every season. The leaves of *Loranthus* were eaten only in January (Winter) and June (Summer). Sixty-five food plants supported the diet for just one month and the remainder for two months in the year.

Preferred food plant families

The preferred food plant family was Moraceae (10.39%, n = 8 species), the second was Mimosaceae (9.09%, n = 7), and third were Dioscoreaceae, Euphorbiaceae and Fabaceae (6.49%, n = 5 each) (Fig. 5).

Monthly variation of food plant species

The number of food plant species in different months ranged from 2 to 22 (mean 11.08 ± 6.78, n = 12). May was the month with the most diverse diet (28.57%, n = 77) with 22 species, and March the least diverse (2.60%, n = 77) (Fig. 6). The number of food plant species did not vary significantly (t = 0.001704, p = 0.998671) between different months.

Seasonal variation of food plant species

The number of food plant species varied significantly ($\chi^2 = 3.97$, df = 1, $p < 0.01$) in the two habitats (forest and the area of human habitation) in the different seasons. In the forest habitat the highest number of food plant species was recorded in Summer (73.08%, n = 38) but in the area of human habitation it was highest in Winter (55.55%, n = 20). New leaves flushed in Summer. The Shannon-Wiener Index (H) ranged from 1.06–1.11, the lowest in Winter and the highest in Summer.

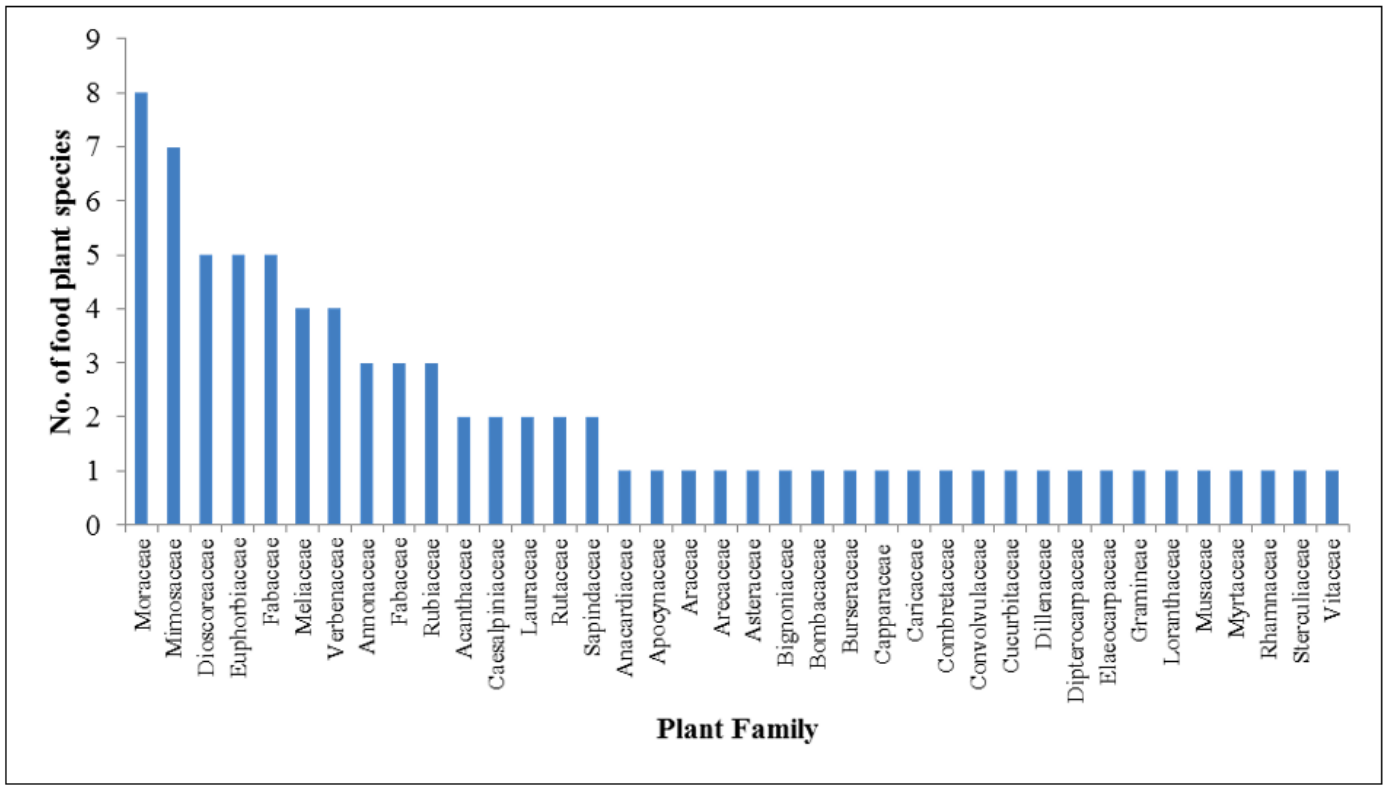

Figure 5. Food plant families preferred by the capped langur.

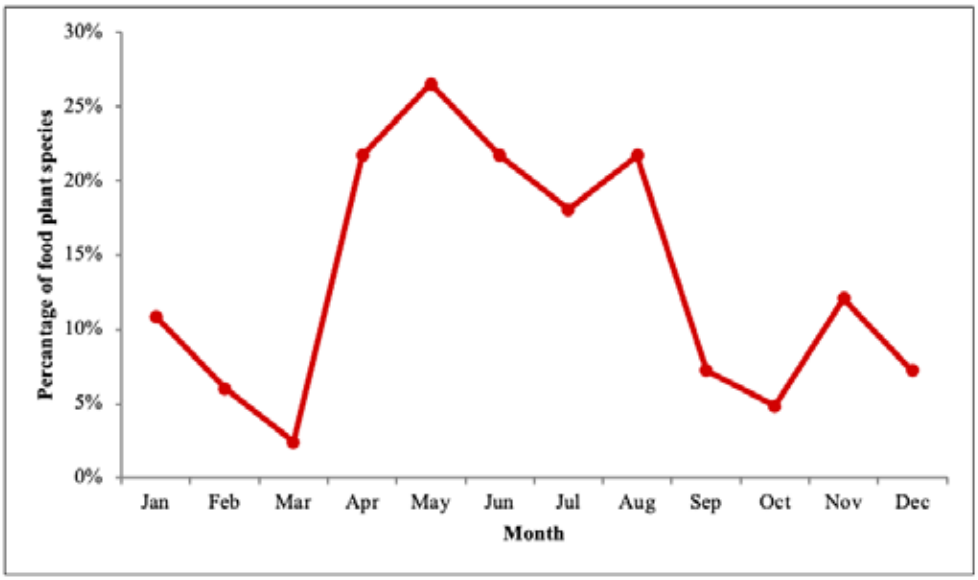

Figure 6. Monthly variation of plant species in the diet of the capped langur.

Preferred feeding height

The capped langurs showed no particular preference. They used the forest floor to the upper canopy (range 0–24.4 m, mean 10.12 ± 6.4, n = 77) for feeding. When feeding, they were most often in the middle canopy (Fig. 7). On occasion they would go to the forest floor to pick up fallen fruits of the tree *Citrus aurantifolia*, for example, and to drink water.

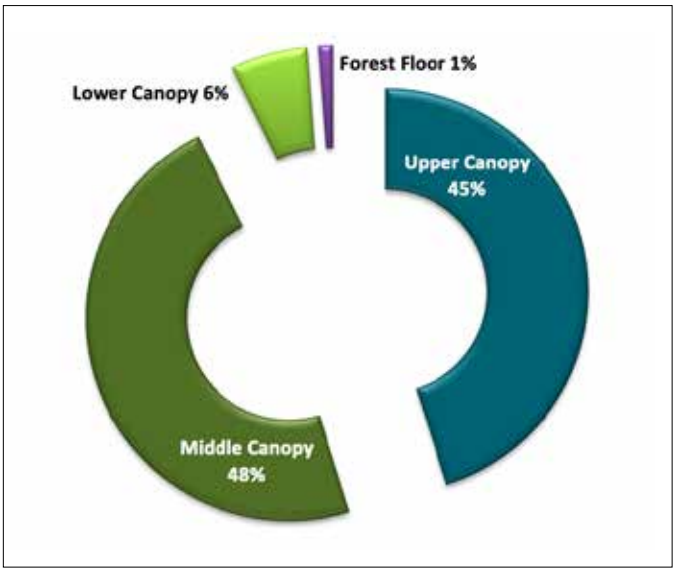

Figure 7. Canopy preferences by the capped langur for feeding.

Discussion

Leaves were the dominant food item in terms of time spent feeding, followed by fruits and flowers, in line with the studies of Islam and Husain (1982), Stanford (1991b) and Hasan (2017). Leaves are also dominant in the diets of *Trachypithecus phayrei* in Bangladesh, but not the Hanuman langur, *Semnopithecus entellus*, in Keshabpur where fruits and seeds were found to comprise more than half of their diet and leaves only 42% (Khatun *et al*. 2011) (Table 3). Young leaves were highly preferred by the capped langurs,

Table 3. Proportion of time spent in feeding and percentage of different food consumed by *Trachypithecus pileatus*, *Trachypithecus phayrei* and *Semnopithecus entellus* in Bangladesh. NP = National Park; WS = Wildlife Sanctuary.

Species	Leaves	Flowers	Fruits & seeds	Shoots	Buds	Bark	Study area	Source
T. pileatus	61.81	6.36	29.1	0.91	0.91	0.91	Madhupur NP	This study
T. pileatus	68	3.6	26.5	2	–	–	Madhupur NP	Islam & Husain (1982)
T. pileatus	66.8	7.0	33.7	–	–	–	Madhupur NP	Stanford (1991a)
T. pileatus	40.5	18	37.5	–	–	–	Rema Kalenga WS	Kabir (2002)
T. phayrei	51	16	14	19	–	–	Lawachara NP	Aziz & Feeroz (2009)
T. phayrei	46.6	17.5	34.3	–	–	–	Rema Kalenga WS	Kabir (2002)
S. entellus	42.3	2.4	53.2	–	–	–	Keshabpur	Khatun *et al*. (2011)

similar to the Phayre's langurs studied by Kabir (2002) in the semi-evergreen forest of the Rema Kalenga Wildlife Sanctaury, Bangladesh. This preference is due to the high protein content and low fiber of flush and young leaves (Milton 1979; Waterman 1984). Young leaves accounted for 59.7% of 4,168 total feeding records throughout the course of this study. This differs from the findings (11% of total feeding records) of Stanford (1991a) 30 years ago at the same study site as the groups were restricted to the national park area.

Primates regulate their diets in response to seasonal food fluctuations (Bennett 1983; Davies 1984). In the deciduous forest where the capped langurs live, leaves are shed in the Winter and the langurs turn to other foods. The season when food-type diversity was lowest was the Summer with the flush of their favored new leaves (Stanford 1990, 1991a; Solanki *et al.* 2008a). Hasan (2017) found the same for his capped langurs in semi-evergreen forest (Satchari National Park), Bangladesh. Leaves as such comprise the predominant food in Summer, in line with the findings of Solanki *et al.* (2008a) at Pakhui Wildlife Sanctuary, India.

The number of plant species that we recorded in the diet (77) was higher than in earlier studies in the same area (Islam and Husain 1982, Stanford 1991a). This may be because groups in our study foraged in natural habitats in association with human habitation. Almost forty years ago, Islam and Husain (1982) recorded 26 food plants, and thirty years ago Stanford (1991b) recorded 35. The groups were confined to natural forest. The number of food plant species recorded for capped langurs was also lower in other areas: 52 food plant species in Satchari National Park (Hasan 2017) and 70 in the Rema Kalenga Wildlife Sanctuary (Kabir 2002) in Bangladesh, and 52 in the Pakhui Wildlife Sanctuary, India (Solanki *et al*. 2008a). Ahsan and Khan (2006) recorded 43 species and Khatun *et al.* (2011) counted 91 for *Semnopithecus entellus* at Keshabpur in Bangladesh. Aziz and Feeroz (2009) documented 29 food plant species for *Trachypithecus phayrei* at Lawachara National Park and Kabir (2002) recorded 80 food plant species in the Rema Kalenga Wildlife Sanctuary. Capped langurs obtained leaves from 51 plant species in the study area, whereas Stanford (1991a) reported 22 species as sources of leaves in the Madhupur National Park. The preference of food trees was not only influenced by the number and density of trees (Solanki *et al.* 2008b; Hasan 2017) but also the different floristic compositions of their habitats (Mohnot 1971; Hladik 1977; Gupta and Kumar 1994; Solanki *et al*. 2008a).

The Moraceae provided the most food plant species for the capped langurs in our study, as was found in the study of Hasan (2017) in the Satchari National Park, Bangladesh.

The capped langurs focused on young leaves, flowers and fruits in the early morning and mature leaves at mid-day, as was found by Hasan (2017) at the Satchari National Park. The plausible reason to consume varieties of food parts might be to fulfill their energy demand after overnight fasting as indicated by Raemaekers (1978). Seeds and shoots were eaten around mid-day.

The capped langur fed largely in the middle canopy, as was found by Kabir (2002) and Hasan (2017). This might be to protect themselves from direct sunlight and rain.

Conclusions

Dietary composition of the capped langurs in Madhupur National Park is influenced by the temporal abundance of food items. They are predominantly folivores but tend to diversify their diet during lean periods in Winter. Seasonal scarcity of foods forced them to invade human habitation around the national park. Eating foods from a large variety of food plants adapts them well to deciduous forest. A detailed phenological study may provide a better understanding of the dietary changes and habitat suitability of this langur in this fragmented forest.

Acknowledgments

The research was supported by the Nagao Natural Environment Foundation (NEF) grant for field work and Idea Wild for equipment. We are much indebted to the Department of Zoology, University of Dhaka, for permitting us to conduct this research. This study would not have been possible without the permission and cooperation of the Bangladesh Forest Department. The authors are most grateful to local field assistants for their support during data collection.

Literature Cited

Ahmed, Z. U., Z. N. T. Begum, M. A. Hassan, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.). 2008a. *Encyclopedia of Flora and Fauna of Bangladesh, Volume 6. Angiosperms: Dicotyledons (Acanthaceae – Asteraceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahmed, Z. U., M. A. Hassan, Z. N. T. Begum, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.). 2008b. *Encyclopedia of Flora and Fauna of Bangladesh, Volume 12. Angiosperms: Monocotyledons (Orchidaceae – Zingiberaceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahmed, Z. U., M. A. Hassan, Z. N. T. Begum, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.). 2009a. *Encyclopedia of Flora and Fauna of Bangladesh*, *Volume 7. Angiosperms: Dicotyledons (Balsaminaceae – Euphorbiaceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahmed, Z. U., M. A. Hassan, Z. N. T. Begum, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.). 2009b. *Encyclopedia of Flora and Fauna of Bangladesh*, *Volume 8. Angiosperms: Dicotyledons (Fabaceae – Lythraceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahmed, Z. U., M. A. Hassan, Z. N. T. Begum, M. Khondker, S. M. H. Kabir, M. Ahmad and A. T. A. Ahmed (eds.). 2009c. *Encyclopedia of Flora and Fauna of Bangladesh, Volume 9. Angiosperms: Dicotyledons (Magnoliaceae – Punicaceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahmed, Z. U., M. A. Hassan, Z. N. T. Begum, M. Khondker, S. M. H. Kabir, M. Ahmad and A. T. A. Ahmed (eds.). 2009d. *Encyclopedia of Flora and Fauna of Bangladesh, Volume 10. Angiosperms: Dicotyledons (Ranunculaceae – Zygophyllaceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

Ahsan, M. F. 1994. Feeding ecology of the primates of Bangladesh. In: *Current Primatology, Volume 1: Ecology and Evolution*, B. Thierry, J. R. Anderson, J. J. Roeder and N. Herrenschmidt (eds.), pp.79–86. Université Louis Pasteur, Strasbourg, France.

Ahsan, M. F. and M. A. R. Khan. 2006. Eco-ethology of the common langur *Semnopithecus entellus* (Dufresne) in Bangladesh. *Univ. J. Zool, Rajshahi Univ*. 25: 3–10.

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

Altmann, J. 1980. *Baboon Mothers and Infants.* Harvard University Press. Cambridge, MT.

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(5): 257–262.

Bartlett, T. Q. 1999. Feeding and Ranging Behaviour of the White-headed Gibbon (*Hylobates lar*) in Khai Yai National Park, Thailand. Ph.D. Dissertation, Washington University, St Louis, MO.

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

Chapman, C. A. 1988. Patch use and patch depletion by the spider and howler monkeys of Santa Rosa National Park. *Behaviour* 105: 99–116.

Choudhury, A. 1989. Ecology of the capped langur (*Presbytis pileatus*) in Assam, India. *Folia Primatol*. 52: 88–92.

Choudhury, A. 2012. Capped langur *Trachypithecus pileatus*. In: *Mammals of South Asia*, Vol. 1., A. J. T. Johnsingh and N. Manjrekar (eds.), pp.296–314. Universities Press, Hyderabad.

Clutton-Brock, T. H., S. D. Albon and F. E. Guiness. 1989. Fitness costs of gestation and lactation in wild mammals. *Nature* 337: 260–262.

Das, J., D. Chetry, A. Choudhury and W. Bleisch. 2020. *Trachypithecus pileatus* (errata version published in 2021). The IUCN Red List of Threatened Species 2020: e.T22041A196580469. Accessed: 26 May 2021.

Davies, A. G. 1984. An Ecological Study of the Red Leaf-Monkey (*Presbytis rubicunda*) in the Dipterocarp Forest of Northern Borneo. PhD Thesis, University of Cambridge, England.

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

Ganguli, B. N., R. N. Kaul and K. T. N. Nambiar. 1964. Preliminary studies on few top feed species. *Ann. Ari. Zone*. 3: 31–37.

Garber, P. A. 1987. Foraging strategies among living primates. *Ann. Rev. Anthropol.* 16: 339–364.

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

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

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

Hladik, C. M. 1977. A comparative study of the feeding strategies of two sympatric species of leaf monkeys: *Presbytis senex* and *Presbytis entellus*. 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. Husain. 1982. A preliminary study of the capped langur. *Folia Primatol*. 39: 145–159.

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.

Khan, M. A. R. and M. F. Ahsan. 1986. The status of the primates in Bangladesh and a description of their forest habitats. *Primate Conserv*. (7): 102–108.

Khan, S. I. 2010. Frugivorous Birds and Seed Dispersal in Madhupur National Park and Chittagong University Campus, Bangladesh. MPhil thesis, Department of Zoology, University of Chittagong, Chittagong, Bangladesh.

Khan, S. I. and M. F. Ahsan. 2015. Frugivorous birds and fruit plants in a deciduous forest in Bangladesh: a case study in the Madhupur National Park. *Bangladesh J. Zool.* 43(2): 173–187.

Khatun, M. U. H., M. F. Ahsan and E. Røskaft. 2011. Feeding behaviour and ecology of the common langurs (*Semnopithecus entellus*) of Keshabpur in Bangladesh. *Proc. Intl. Conf. Biodiv. – Present State, Problems and Prospects of its Conservation*., pp.21–33. University of Chittagong, Bangladesh, January 8–10, 2011.

Majumdar, B. N., S. A. Momin and D. N. Kehar. 1967. Studies on tree leaves as cattle fodder. 2. Chemical composition as affected by locality. *Indian J. Vet. Sci.* 37: 224–231.

Martin, P. and P. Bateson. 2007. *Measuring Behaviour: An Introductory Guide.* Cambridge University Press, Cambridge, UK.

Milton, K. 1979. Factors influencing leaf choice by howler monkeys: a test of some hypotheses of food selection by generalist herbivores. *Am. Nat.* 114: 362–378.

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

Mohnot, S. M. 1971. Some aspects of social changes and infant-killing in hanuman langur, *Presbytis entellus* (Primates: Cercopithecidae) in western India. *Mammalia* 35: 175–198.

Monirujjaman and M. M. H. Khan. 2018. Wildlife diversity of Madhupur National Park, Bangladesh. *Jahangirnagar Univ. J. Biol. Sci*. 7(1): 1–13.

Raemaekers, J. 1978. Changes through the day in the food choice of wild gibbons. *Folia Primatol*. 30(3): 194–205.

Remis, M. J. 1997. Western lowland gorillas as seasonal frugivores: use of variable resources. *Am. J. Primatol*. 43(2): 87–109.

Reza, A. H. M. A. 2014. Status, Distribution and Conservation of the Amphibians of Bangladesh. In: *Conservation Biology of Amphibians of Asia: Status of Conservation and Decline of Amphibian: Eastern Hemisphere*, H. Heatwole and I. Das (eds.), pp.209–230. Natural History Publications (Borneo), Kota Kina-balu, Malaysia.

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

Siddiqui, K. U., M. A. Islam, Z. U. Ahmed, Z. N. T. Begum, M. A. Hassan, M. Khondker, M. M. Rahman, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.) 2007. *Encyclopedia of Flora and Fauna of Bangladesh, Volume 11. Angiosperms: Monocotyledons (Agavaceae – Najadaceae)*. Asiatic Society of Bangladesh, Dhaka, Bangladesh.

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

Solanki, G. S., A. Kumar and B. K. Sharma. 2008b. Winter food selection and diet consumption of capped langur (*Trachypithecus pileatus*) in Arunachal Pradesh, India. *Trop. Ecol.* 49(2): 157–166.

Srivastava, A. 1999. *Primates of Northeast India*. Megadiversity Press, Bikaner (Rajasthan), India.

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

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

Stanford, C. B. 1991b. *The Capped Langur in Bangladesh: Behavioral Ecology and Reproductive Tactics*. Karger, Basel.

Stevenson, P. R., M. J. Quinones and J. A. Ahumada. 1994. Ecological strategies of woolly monkeys (*Lagothrix lagotricha*) at Tinigua National Park, Colombia. *Am. J. Primatol.* 32: 123–140.

Sussman, R. W. 1987. Species-specific dietary patterns in primates and human dietary adaptations. In: *The Evolution of Human Behaviour: Primate Models*, W. G. Kinzey (ed.), pp.151–179. SUNY Press, New York.

Tejwani, K. G. 1994. *Agro Forestry in India*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Tutin, C. E. G., R. M. Ham, L. J. T. White and M. J. S. Harrison. 1997. The primate community of the Lope Reserve, Gabon: diets, responses to fruit scarcity and effects on biomass. *Am. J. Primatol*. 42: 1–24.

Waterman, P. G. 1984. Food acquisition and processing as a function of plant chemistry. In: *Food Acquisition and Processing in Primates*, D. J. Chivers, B. A. Wood and A. Bilsborough (eds.), pp.177–211. Plenum Press, New York.

Yiming, L., C. B. Stanford and Y. Yuhui. 2002. Winter feeding tree choice in Sichuan snub-nosed monkey (*Rhinopithecus roxellanae*) in Shennongjia Nature Reserve, China. *Int. J. Primatol*. 23: 657–675.

Zhang, Y. Z., S. Wang and G, Q. Quan. 1981. On the geographical distribution of primates in China. *J. Hum. Evol.* 10: 215–226.

Authors' addresses:
Shawkat Imam Khan, Department of Natural History, Bangladesh National Museum, Shahbag, Dhaka 1000, Bangladesh; **Mohammad Firoj Jaman**, Department of Zoology, University of Dhaka, Dhaka 1000, Bangladesh; and **Mohammad Zashim Uddin**, Department of Botany, University of Dhaka, Dhaka 1000, Bangladesh.

Corresponding author: Shawkat Imam Khan
E-mail: <shawkat194@gmail.com>

Received for publication: 15 February 2021
Revised: 16 December 2021