Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Article

Dietary preference and feeding patterns of the urban Rhesus Macaque *Macaca mulatta* (Mammalia: Primates: Cercopithecidae) in Asola-Bhatti Wildlife Sanctuary in India

Ishita Ganguly & Netrapal Singh Chauhan

26 December 2018 | Vol. 10 | No. 15 | Pages: 12907–12915
10.11609/jott.4347.10.15.12907-12915

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 December 2018 | 10(15): 12907–12915

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

OPEN ACCESS

ARTICLE

Dietary preference and feeding patterns of the urban Rhesus Macaque *Macaca mulatta* (Mammalia: Primates: Cercopithecidae) in Asola-Bhatti Wildlife Sanctuary in India

Ishita Ganguly [1] & **Netrapal Singh Chauhan** [2]

[1,2] Amity Institute of Forestry and Wildlife, Amity University Campus, Sector 125, Gautam Buddha Nagar, Noida, Uttar Pradesh 201303, India
[1] ishitaganguly23@gmail.com (corresponding author), [2] nschauhan@amity.edu

Abstract: We studied the feeding patterns and discrete spatio-temporal food habitsof16 groups of the urban Rhesus Macaque *Macaca mulatta* following their relocation in Asola-Bhatti Wildlife Sanctuary near Delhi, India. We observed that the macaques fed on 31 plant species, with *Prosopis juliflora* and *P. cineraria* appearing in most scans. We classified the food consumed by the species into six main categories the species and recorded the average time spent on each of these throughout the year. The maximum time was spent on supplementary feeding provided by the forest department and the minimum on natural plant resources. There was a significant difference in the consumption of different food categories from morning to evening but there were no significant seasonal variations. This study showed that Rhesus Macaque adopted different foraging strategies based on the availability of resources in their new environment and that variety in food resources buffered seasonality in their diet. Information on their feeding patterns and food habits will help in developing management protocols for the primates in urban environments.

Keywords: Feeding ecology, Delhi NCR, management, opportunistic feeding, primates, relocation, urban landscape.

DOI: https://doi.org/10.11609/jott.4347.10.15.12907-12915

Editor: Mewa Singh, University of Mysore, Mysuru, India

Date of publication: 26 December 2018 (online & print)

Manuscript details: Ms # 4347 | Received 20 June 2018 | Final received 04 December 2018 | Finally accepted 19 December 2018

Citation: Ganguly, I & N.S. Chauhan (2018). Dietary preference and feeding patterns of the urban Rhesus Macaque *Macaca mulatta* (Mammalia: Primates: Cercopithecidae) in Asola-Bhatti Wildlife Sanctuary in India. *Journal of Threatened Taxa* 10(15): 12907–12915; https://doi.org/10.11609/jott.4347.10.15.12907-12915

Funding: This study was funded by World Wide Fund for Nature - Small Grant Programme (2016–2018), India.

Competing interests: The authors declare no competing interests.

Author Details: Ishita Ganguly, B.Sc (Hons.), MSc, MPhil in Zoology and presently pursuing doctoral degree in Wildlife Science from Amity Institute of Forestry and Wildlife, Amity University Noida, India. I have been working on ecology of Rhesus Macaque and human-macaque conflict in urban landscape since 2015. My project is funded by WWF Small grant programme (2016–2018). Currently, writing my thesis and also preparing for attending students conference (SSCS Cambridge, UK) 2019 in United Kingdom. Dr. N.P.S. Chauhan, MSc & PhD, Zoology from Delhi University, actively involved in teaching, training and research in Delhi University colleges, North-Eastern Hill University, Shillong, Wildlife Institute of India, Dehradun and now in Amity University, Noida and presently serving as Director of Amity Institute of Forestry and Wildlife. He is the main supervisor of many PhD students in Amity University.

Author Contribution: IG wrote the project, raised funding, completed field research, worked on data analysis, writing manuscript and communication. NSC contributed in planning of research, writing the manuscript and revising.

Acknowledgements: We thank Mr. A.K. Shukla, Chief Wildlife Warden,Delhi Forest and Wildlife Department, for issuing the permit to work in the field area and Mr. S.K. Muan Giete, Deputy Conservator of Forest, South Division, Delhi, for providing support for the smooth conduct of the field research. We also thank Prof. Dr. Praful Singh and Ms. Pradipika Verma, Amity Institute of GIS and Remote Sensing,for designing the maps though GIS software and data imaging and Dr. G.S. Rawat, Wildlife Institute of India, for identifying the plant species specimens.

INTRODUCTION

Rhesus Macaque *Macaca mulatta* is the most common non-human primate in the forested and urban areas of Asia (Hasan et al. 2013). It is found throughout India in its peninsular (Madhya Pradesh, West Bengal, and Assam), northern (Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Rajasthan, and Gujarat) (Seth et al. 2001), and northeastern (Assam, Meghalaya, and Arunachal Pradesh; (Molur et al. 2003) regions. Information on the feeding ecology of a species provides the detailed dietary specialization necessary for its survival and is an important part of its natural life history (Harcourt et al. 2002). Flexibility in diet patterns plays a pivotal role in the survival of non-human primate species in urban and peri-urban ecosystems through resource sharing and competition and has evolutionary implications in the long-term. Primates are known to adopt several foraging strategies (Fleagle & Gilbert 2006). Natural diet of forest Rhesus Macaques includes fruits, seeds, inflorescences, flowers, buds, leaves, young shoots, twigs, barks, roots, and pith and resin of gymnosperms, angiosperms, and fungi (Fooden 2000). Macaques are also known to consume animal food items that such as insects, spiders, worms, termites, grasshoppers, lizards, ants, beetles, molluscs, crayfish, shellfish, honeycombs, crabs, and bird eggs (Mandal 1964; Lindburg 1971; Malik 1983). In marine coastal areas, the species is mostly known to rely on seeds and fruits (Hanya et al. 2003) and also catch live fish as in the Sunderban (Majumder et al. 2012). In forested habitats,primates consume 25% to 40% of the total frugivore biomass (Chapman et al. 1995). Ingestion of fruits or young leaves with sugar and insects with protein content help to balance their diet (Janson & Chapman 1999). Feeding patterns are also associated with human-macaque conflict—crop raiding by macaques in villages near forest areas has increased the level of negative association of the species by farmers (Air 2015). The dependency of urban macaques on anthropogenic food resources and their behaviours associated with food utilisation from urban areas often increase the risk of undesirable interactions with human beings (Sha & Hanya 2013).

In urban landscapes, the nutrition required for primates becomes highly questionable. Urban macaques largely share human food resources (Gupta 2001) and depend on cultivated crops, plants, and even garbage (Lee et al. 1986). In some cases, macaques depend on humans for being fed (Strum 1994)—the feeding patterns of primates that live in tourist sites and temples are often influenced by provisioning of food by humans. Urban macaques have also acquired behavioural adaptations in food-acquisition techniques (Mangalam & Singh 2013). Urban habitats, in contrast to natural ones, have a more direct influence on primate behaviours associated with competitive resource utilizations and foraging techniques. Several anthropogenic barriers and disturbances interfere with the feeding ecology of primates in urban environments.

Although Rhesus Macaques were assessed as a Least Concern (LC) species by IUCN (2018), primates are threatened globally by human-wildlife negative interactions, habitat loss and fragmentation, and several other anthropogenic factors (Strum 1994, 2001; Mittermeier & Konstant 1996, 1997; Kemf & Wilson 1997; Cowlishaw & Dunbar 2000; Peterson 2003; Hill 2005). The Negative interactions between humans and macaques due to food provisioning and other anthropogenic drivers possess major challenges for the survival and persistence of the species. The need for translocation of Rhesus Macaques and the consequences were due to its proliferation in urban areas of India was suggested and studied earlier (Malik & Johnson 1991, 1994; Southwick et al. 1998). Translocation or relocation is a widely used conservation tool but it is known to induce stress, as evident in the higher level of stress hormones in females of the species during the translocation process (Aguilar-Cucurachi et al. 2010).

The reproductive capacity, inter-birth interval, and the size of social groups in primates are often determined by the amount of food they consume (Air 2015). Again, the availability of different food resources can reduce seasonal fluctuations in diet and provisioning of food regularly to urban primates may have adverse effects on their behaviour, social organization, and conservation (Sinha&Vijayakrishnan 2017). The aim of this study was to investigate the food habits and feeding patterns of urban macaques in and around (0–1 km) Asola-Bhatti Wildlife Sanctuary in Delhi. The characteristic features of this sanctuary such as the availability of food resources infringe villages and food provisioning by the public have played an influential roles in the feeding ecology of its Rhesus Macaques. Information of dietary patterns of urban macaques will enhance the knowledge of its natural history and survival and that will help in the management of the species in urban ecosystems.

MATERIALS AND METHODS

Study area

Asola-Bhatti Wildlife Sanctuary is situated in South Delhi District (28.41^0–28.49^0 N and 77.19^{0}N–77.27^0 E) and covers a total area of about 6,874ha and there is a high density of *Acacia pendula*,scrub forests, and trees with a short diameters (Kushwaha et al. 2014) (Fig. 1). The forest area is located at the foothills of the Aravalli range and is about 16km long and 4.3km wide, with elevation ranging from 235–288 m. The forest is surrounded by hilly areas with shrubs, stunted trees, and moderate density forest cover and is adjacent to the urban areas of Delhi-Haryana interstate border region, Sangam Vihar, Faridabad (Surajkund Road), Pali Village, Satberi, Deragaon, Fatepurberi, and Anangpur. This protected area has semi-arid vegetation with xerophytic plants and several large, deep pits. The largest water-filled pit is Neeli-Jheel, situated 3km from Gate No. 7, where urban monkeys are intermittently released after capture since 2007.

The dominant tree species in Asola-Bhatti Wildlife Sanctuary are *Prosopis juliflora,* a native species introduced to counter forest degradation (Burkart 1976; Pasiecznik et al. 2001), which and present at high (7.68%), moderate (16.03%), and low (47.90%) densities,and *Anogeissus pendula* and *Acacia nilotica*, present in forest plantation, scrub vegetation (12.04%), water bodies (0.16%), and human settlements (2.92%) (Kushwaha et al. 2014). There were no Rhesus Macaques in the area before translocation began and the present population is derived entirely from relocated animals alone. This area exhibits extreme fluctuation in annual temperature, with summer highs in May (43–47 ^{0}C) and winter lows in January (6^{0}C). June to September is the wet season with an average annual rainfall of about 617mm. This sanctuary is composed of

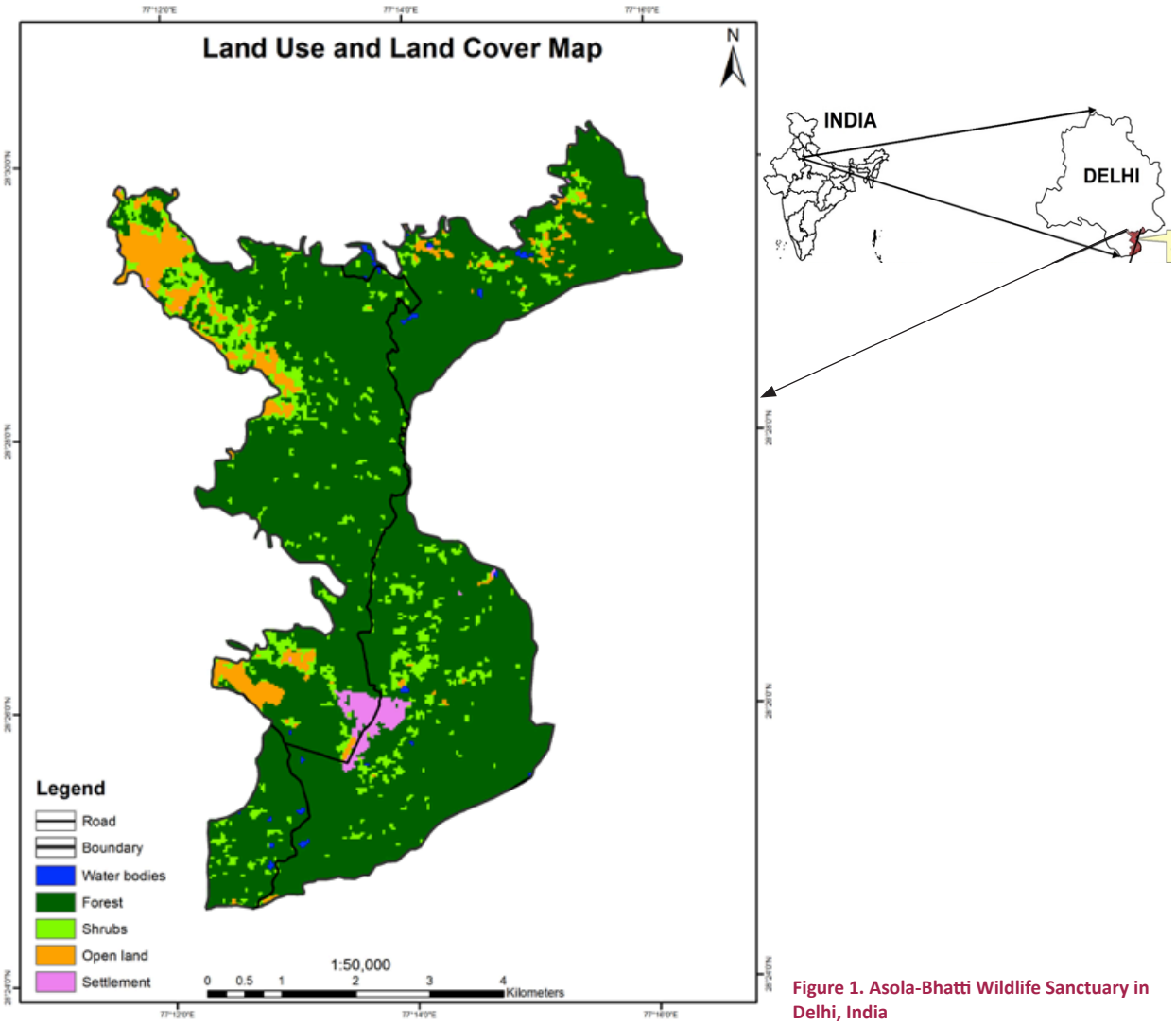

Figure 1. Asola-Bhatti Wildlife Sanctuary in Delhi, India

Asola Village in the north and Bhatti area in the south. It is a man-made sanctuary and the only protected area in Delhi. Most of the area of the sanctuary is degraded with the prevalence of xerophytic plants (Khanna & Sati 2003). Vegetation shows remarkable dominance of shrubs and stunted trees (Naithani et al. 2006).

Study groups

We sighted a total of 16 groups of translocated Rhesus Macaques in the area. Observations were made from a close distance of <10m and data on demography and food habits were collected from 06.00–18.00 hr daily from May 2016 to June 2017. Group size varied from 14 to 63 individuals per group (30.57±2.67) and a total of 492 (n) individuals were observed (Table 1).

Food categories

We classified the food consumed by the relocated Rhesus Macaques into categories based on variations in resource availability:

i) Natural plant species: The natural plants, trees, herbs, and shrubs available in the sanctuary.

ii) Supplementary foods: Food given by the forest department daily in this sanctuary for feeding the Rhesus Macaques only (seasonal vegetables and fruits; 2500kg/ day).

iii) Provisioned food: Banana and roadside food (bread and chick-pea) thrown by the public to the macaques daily; the macaques often travel to the boundary walls, cross it, and sit on the highway it to have these itemsthe the.

iv) Anthropogenic food: Garbage and human food resources (Indian bread, oily fries, and potato chips) snatched by the macaques daily from human settlements situated within 0.5km of the protected area.

v) Water: Water from channelsmade in the sanctuary exclusively for Rhesus Macaques (a total of 36 in number).

vi) Others: Insects, soil, lizards, and bird eggs.

Scan sampling technique

Instantaneous or scan sampling (Altmann 1974) was used to gather information on the feeding habits and food items of the macaques. Group scans were taken on all visible members of the group for 5min at every 10-minute interval. We recorded 13,740 scan samples and the type of food items eaten (young leaves,mature leaves, roots, stems, flowers, fruits, shoots, gum, bark, or animal prey). We collected the unidentified species for taxonomic identification (leaves, stem, and fruits) through herbarium in the Wildlife Institute of India, Dehradun.

Table 1. Group composition of the relocated Rhesus Macaques followed for studying feeding habitsin Asola-Bhatti Wildlife Sanctuary in Delhi

	AM	AF	SAM	SAF	JUV	INF	Total
1	3	4	7	8	5	2	33
2	2	3	8	7	6	4	37
3	2	3	2	3	3	1	14
4	3	4	5	9	5	4	33
5	2	3	7	9	3	1	32
6	3	4	6	8	4	2	33
7	4	6	7	9	4	2	36
8	3	5	5	7	5	3	28
9	7	11	14	13	11	7	63
10	5	7	6	9	3	1	32
11	2	3	7	11	2	3	34
12	3	5	5	8	2	3	26
13	3	4	4	5	4	5	25
14	2	5	4	6	2	2	21
15	3	4	3	5	2	3	20
16	2	3	6	7	4	3	25

AM - adult male, AF - adult female, SAM - sub-adult male, SAF - sub-adult female, JUV - juvenile, INF - infant (N=492).

Focal sampling technique

We focused on individuals (adult male/ adult female/ juvenile/ infant) and made 12 entries per hour of theiractivitiesins. We recorded the time spent by that focal individualson each food plant and the parts eaten along with thetime spent at different feeding sites. We recorded 13,874 focal samples and categorized the different plant parts eaten by the macaques.

We estimated the time spent feeding on different food items in a day as per theformula by Gupta &Kumar (1994):

$$T_{a =} N_a / N \times 100,$$

where T_a is the percentage of time spent on an activity a, N_a is the number of records with activity a, andN is the total number of records for the day.

Analysis: Analysis of variance (ANOVA) was used to compare the feeding time on food categories and the number of food plants eaten monthly and seasonally (Simpson et al. 1960). Independent sample t-test was used to analyse the difference in the average time spent on each category. Chi square test was performed to compare the association between groups. Microsoft Excel 2010 was used to summarize the data and Minitab version 17.0 software and web tool were used to calculate

descriptive statistics. Landsat data imageries 2016 and ArcGIS software were used to map the study area using coordinates collected during the data sampling though Garmin GPS 72H.

RESULTS

Food categories

Food plants, plant families, parts eaten, and the average percentage of time spent feeding on each plant species are given in Table 2. The macaques were mostly found to feed on Fabaceae (8.76±2.64), Moraceae (2.60±2.06), Rhamnaceae (0.34±0.02), and Mytraceae (0.06±0.03) families. Among the plant parts (nature food items) eaten, 34.65% of feeding time was spent on leaves, followed by 31% on bark and piths, 22.90% on flowers, and 11.01% on fruits. The macaques were mostly found in the lower canopy and bottom of trees in summer (39.13%), in the upper canopy in monsoon (31.26%), and in the middle to lower canopy in the winter (19%). The species was observed to spend 79% time on the ground and only 21% time on the trees.

We investigated the spatio-temporal feeding pattern of Rhesus Macaques in the sanctuary (Fig. 2). Daily percentage time spent on consuming different food categories (mentioned above) varied significantly with time intervals from 06:00–18:00 hr. Macaques adopted their feeding strategy to access all kind of resources available but with distinct time management practice. On average natural plant species eaten was calculated (mean±SE) 22.13±6.60, provisioned food 14.63±3.53, supplementary food by forest department 35.2±10.2, anthropogenic food resources 37.88±1.49, water 9.46±1.13 and others (insects, birds' eggs, lizards etc.) 6.02±0.60 and one-way ANOVA analysis showed significant difference in percent time spent on various food categories per day (F=4.09, df=5, P=0.01). The maximum time was spent on bananas (31%), followed by seasonal vegetables (27%), fruits (13.07%), bread (8.02%), garbage (7.8%), and icecreams (6%) and differed significantly (t=3.63, df=5, *P*=0.01).

Seasonality and Diet

Average percentage time spent on each food category was calculated for each month. The overall mean time spent on natural plant species was 13.29±2.32, in supplementary feeding provided by forest department 50.19±3.49, in anthropogenic food category 18.18±1.41, and in provisional food by public 18.34±4 throughout the year including summer, monsoon, and winter months (Table 3). We recorded the dietary pattern and found that the maximum average time was spent on supplementary food in all seasons followed by a maximum on provisioned food in winter (26%), in summer (18%), and a minimum during monsoon (11%). The macaques were observed spending maximum time consuming natural plant species (17.68%) during the rainy season, apart from supplementary food. ANOVA analysis showed that there was no statistically significant difference in the total dietary intake pattern throughout the year (F=0.05, df=11, *P*>0.05).

Age-sex feeding pattern in groups

We recorded the percentage of time spent by individuals in a group on each food type (Table 4). We calculated the average percentage time spent on all food categories by adult males (25.0±8.17), adult females

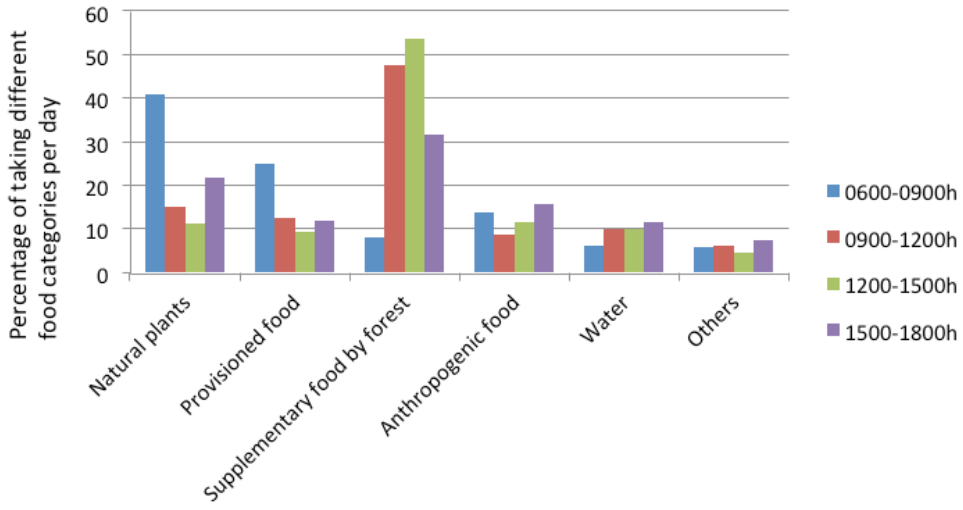

Figure 2. Percentage of time spent on different food categories by relocated Rhesus Macaques per day from 06:00–18:00 hr in the sanctuary

Table 2. Percentage of feeding time spent on each plant species by relocated Rhesus Macaques in Asola-Bhatti Wildlife Sanctuary in Delhi

	Family	Scientific name	Common name	Parts eaten	Percentage of time spent (%)
1.	Salvadoraceae	*Salvadora persica*	Meswak	Leaf, stem	0.18
2.	Fabaceae	*Pithecellobium dulce*	Jungle Jalebi	Leaf	7.08
		Prosopis juliflora	Kikar/Babul	Leaf, flower	16.34
		Prosopis cineraria	Khejri	Leaf	11.09
		Pongamia pinnata	Indian Beech	Leaf	0.14
		Acacia nilotica	Babul	Leaf, bark	9.16
3.	Myrtaceae	*Psidium guajava*	Guava	Fruit	0.09
		Syzygium cumini	Jamun	Leaf, fruit	0.03
4.	Moraceae	*Ficus benjamina*	Fig Tree	Leaf	6.7
		Ficus racemosa	Fig Tree	Fruit	0.04
		Ficus benghalensis	Banyan Fig	Leaf, bark	1.07
5.	Euphorbiaceae	*Sapium sebiferum*	Chineese Tallow Tree	Flower	0.89
6.	Carisseae	*Carissa opaca*	Wild Karonda	Fruit	1.08
7.	Malvaceae	*Hibiscus ovalifolius*	Roselle	Flower	0.47
8.	Amaranthaceae	*Alternanthera* sp.	Joyweed	Leaf	0.71
9.	Poaceae	*Dendrocalamus strictus*	Bamboo	Leaf	4.59
		Eleusine indica	Indian Goosegrass	Leaf	0.7
10.	Legumes	*Cassia fistula*	Amaltas	Leaf	0.81
11.	Zygophyllaceae	*Balanites aegyptiaca*	Desert Date (Hingot)	Leaf	0.59
12.	Rhamnaceae	*Zizyphus mauritiana*	Ber	Leaf	0.38
		Zizyphus oenoplia	Ber	Leaf	0.29
		Zizyphus sp.	Ber	Leaf	0.37
13.	Cleomaceae	*Cleome viscosa*	Asian Spider Flower	Leaf	0.11
14.	Capparaceae	*Capparis sepiaria*	Wild Caper Bush	Leaf	0.57
15.	Rutaceae	Citrus sp.	Nimbu	Leaf	1.39
16.	Apocynaceae	*Calotropis procera*	Rubber Bush	Leaf	3.81
17.	Meliaceae	*Azadirecta indica*	Neem	Leaf	7.56
18.	Moringaceae	*Moringa oleifera*	Drumstick Tree	Fruit	3.43
19.	Combretaceae	*Terminalia arjuna*	Arjun	Bark	7.01
20.	Solanaceae	*Datura innoxia*	Datura	Leaf, flower	7.15
21.	Verbenaceae	*Lantana camera*	Sage Tree	Leaf	3.68

Table 3. Food categories, average time spent based on seasonal variation, day length of consuming food categories, and average number of participants at a time during feeding activity

Food categories	Average time spent (%)				Day length (hours)	Average number of participants
	Summer	Monsoon	Winter	Mean±SE		
Plant species	12.45	17.68	9.75	13.29±2.32	5	9
Supplementary food	53	54.32	43.25	50.19±3.49	9	32
Anthropogenic food	16.55	17	21	18.18±1.41	2	11
Provisioned food	18	11	26	18.34±4.33	4	29

(22.01±7.13), sub-adult males (7.92±4.02), sub adult females (6.06±3.19), juveniles (0.65±0.20,) and infants (0). Adult males dominated the pattern and used up the maximum amount of food provided to them and spent the maximum time on it. Adult females were much protective and did not allow their infants to feed on artificial foods. Infants compensated their nutritional requirement through lactation only.

DISCUSSION

Non-human primates compete with human beings for resource utilisation and space, which can lead to negative interactions (Priston & Underdown 2009), especially in urban areas (Lee & Priston 2005). In India, Rhesus Macaques often co-exist with human populations and are highly dependent on them for food (Southwick et al. 1976). The high feeding dependency on anthropogenic food resources is, however, not correlated with natural resource scarcity. While natural resources such as fruits are highly variable over the year, anthropogenic food resources are potentially more stable and easily available. A study on Long-tailed Macaques *Macaca fascicularis* showed that the main drivers for exploitation of anthropogenic foods were natural food plant resource scarcity or an overt dependence on anthropogenic foods (Sha & Hanya 2013). Utilization of anthropogenic food resources lowered preferences of macaques on fruits and natural plants in another study (Hambali et al. 2014). The consequences of the dependency of macaques on human food resources can include food stealing, which may lead to negative interactions with humans. In our study, the relocated Rhesus Macaques were more inclined towards anthropogenic, supplementary, and provisioned food resources than natural plant resources in the forest. As this sanctuary is situated in a human-dominated landscape and human settlements are located close by (less than 50m away), Rhesus Macaques disperse from the sanctuary and consume food from nearby households, markets, and temple areas. The forest department of Delhi Government was also assigned to provide supplementary food to the rehabilitated macaques for the maintenance of a viable population in the newly introduced environment.

Our results showed that the macaques fed on natural plant species in the early morning between 06:00– 09:00 hr (40.8%), after which their tendency to consume natural resources declined before rising in the late afternoon (21.75%). Food provisioning by the public was recorded mostly in the early morning (25%) and continued throughout the day in the fringes of the sanctuary. Between 09:00hr and 11:00hr, macaques gathered at feeding stations within the sanctuary near the Bhatti Range Office, reaching a peak number between 12:00hr and 15:00hr (53.75%). The macaques were reportedly given 2,500kg food per day by the forest department and this feeding pattern had a large influence on their daily activity and movement. During supplementary feeding, the macaques did not consume natural plants within the forest area. The relocated Rhesus Macaques were highly inclined towards human food outside the sanctuary and often entered nearby houses or snatched bread and vegetables from open markets in the nearby Sanjay Colony (Bhatti Mines).

Our results showed that the macaques mostly preferred leaves and stems of *Prosopis juliflora* (16.34%) and *P. cineraria* (11.09%), which were reported to be beneficial for their health. The heartwood of these two plant species contains ample antioxidants such as flavonol and mesquitol (Sirmah et al. 2009). Though numerous species of medicinal plants and fruiting trees are available in the sanctuary, the macaques did not spend much time in natural foraging but mostly depended on artificial feeding. Our results showed a high consumption of supplementary food items throughout the year with no seasonal differences and low average time spent on natural food plants. The macaques showed dependency on anthropogenic and provisioned food over natural fruit. The former included bananas, seasonal fruits and vegetables, bread, chickpeas, fried snacks, and ice-creams; the macaques were even reported to steal cold water from refrigerators of houses in nearby localities at a 0.25–5 km distance (USA Today 2017).

Roadside food provisioning is a common practice across cities and villages in India. Southwick et al. (1976) documented the impact of artificial feeding on the ecology and behaviour of macaques. Our study provides information on feeding practices of Rhesus Macaques after translocation to an area containing various types of natural and anthropogenic food resources in a human-dominated landscape. An understanding of the basic natural history of primates is essential for their conservation (Caro 2007; Fashing 2007). The primary threat primates face today is habitat destruction (Wieczkowski 2004; Chapman et al. 2006). By reducing forest size and quality, habitat destruction leads to the reduction of food sources for forest-dwelling primates and, in some cases, threatens them with local extinction (Lee &Hauser 1998; Muoria et al. 2003). The increasing population of Rhesus Macaques living in proximity to human habitations has become a major issue in

India. Rapid urbanisation, deforestation, and habitat fragmentation altered the natural living spaces of animals and their natural behaviour in the wild. Most primate species were severely affected by threats in anthropogenic landscapes (Sinha & Vijayakrishnan 2017). The translocation of Rhesus Macaques from city areas to forest situated at close proximity with human settlementsmight not reduce the conservation threats for the taxa. The step, however, altered their feeding strategies as the species was observed to become more dependent on supplementary and anthropogenic food resources than on natural foraging. Though artificial feeding of fruits and vegetables might increase overall nutrition, their natural frugivorous behaviour seem to be lost. The macaques were seen to snatch and steal even those anthropogenic food resources that had no health benefits, as they were used to such behaviour in human habitats (Ganguly et al. 2018). The dietary habits of Rhesus Macaques were totally different in a human-dominated forest land. Previous studies showed that the species thrived in eight diverse habitats (temple, urban, village, village-cum-pond, pond, roadside, canal sides, and forest) having varying degrees of human interactions in India (Seth et al. 1986). The feeding practice seemed to increase the urban threats, diseases, and anthropogenic stress in the Rhesus Macaque population. In our study, the species was observed to spend maximum time on the ground instead of on the trees and their dependency on supplementary, provisioned, and anthropogenic food sources did not indicate conservation success. Understanding the feeding ecology in this sanctuary would help in planning the management of macaques in other urban areas.

REFERENCES

Aguilar-Cucurachi, M.A., P.A.D. Dias, A. Rangel-Negrín, R. Chavira, L. Boeck & D. Canales-Espinosa (2010). Preliminary evidence of accumulation of stress during translocation in mantled howlers. *American Journal of Primatology* 72(9): 805–10; https://doi.org/10.1002/ajp.20841

Air, A. (2015). Crop Raiding and Conflict: Study of Rhesus Macaque-human Conflict in Shivapuri-Nagarjun National Park, Kathmandu Nepal. Natural Resources Management, Norwegian University of Science and Technology, 32pp.

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behavior* 49(3/4): 227–267.

Begum, S. & M.M. Feeroz (2013). Distribution of Rhesus Macaques (Macaca mulatta) in Bangladesh: Interpopulation Variation in Group Size and Composition. *Primate Conservation* 26: 125–132.

Burkart, A. (1976). A monograph of the genus *Prosopis* (Leguminosae: Mimosoideae) (Part 1 and 2). Catalogue of the recognized species of *Prosopis. Journal of the Arnold Arboretum* 57: 219–249, 450–525.

Caro, T. (2007). Behavior and conservation: a bridge too far? *Trends in Ecology & Evolution* 22(8): 394–400.

Chapman, C.A., M.J. Lawes & H.A.C. Eeley (2006). What hope for African primate diversity? *African Journal of Ecology* 44: 116–133.

Chapman, C.A., R.W. Wrangham & L.J. Chapman (1995). Ecological constraints on group-size: an analysis of spider monkey and chimpanzee subgroups. *Behavioral Ecology and Sociobiology* 36(1): 59–70.

Cowlishaw, G. & R. I. Dunbar (2000). *Primate Conservation Biology*. University of Chicago Press, Chicago, 498pp; https://doi.org/10.1017/S1367943001221337

Fashing, P.J. (2007). Behavior, ecology and conservation of colobine monkeys: an introduction. *International Journal of Primatology* 28: 507–511.

Fleagle, J.G. & C.C. Gilbert (2006). The biogeography of primate evolution: the role of plate tectonics, climate and chance, pp. 375–418. In: Lehman, S.M. & J.G. Fleagle (eds.). *Primate Biogeography.* Springer, New York.

Fooden, J. (2000). *Systematic Review of the Rhesus Macaque, Macaca mulatta (Zimmermann 1780)*.Field Museum of Natural History, Chicago, USA, 180pp.

Ganguly, I., N.P.S. Chauhan & P. Verma (2018). Assessment of human-macaque conflict and possible mitigation strategies in and around Asola-Bhatti Wildlife Sanctuary. *Environment & Ecology* 36(3): 823–827.

Goldstein, S.J. & A.F. Richard (1989). Ecology of Rhesus Macaques (*Macaca mulatta*) in northwest Pakistan. *International Journal of Primatology* 10(6): 531–567.

Gupta, A.K. & A. Kumar (1994). Feeding ecology and conservation of the Phayre's Leaf Monkey *Presbytis phayrei* in northeast India. *Biological Conservation* 69(3): 301–306

Gupta, A.K. (2001). Status of primates in Tripura. *Envis Bulletin* 1(1): 127–135.

Hambali, K., A. Ismail, B.M. Md-Zain, A. Amir & F.A. Karim (2014). Diet of Long Tailed Macaques (*Macaca fascicularis*) at the Entrance of Kuala Selangor Nature Park (Anthropogenic Habitat): Food Selection that Leads to Human-Macaque Conflict. *Acta Biologica Malaysiana* 3(2): 58–68.

Hanya, G., N. Noma & N. Agetsuma (2003). Altitudinal and seasonal variations in the diet of Japanese Macaques in Yakushima. *Primates* 44: 51–59.

Harcourt, A.H., S.A. Coppeto & S.A. Parks (2002). Rarity, specialization and extinction in primates. *Journal of Biogeogr*aphy 29(4): 445–456; https://doi.org/10.1046/j.1365-2699.2002.00685.x

Hasan, K., M.A. Aziz, S.M.R. Alam, Y. Kawamoto, Y. Lisa, Jones-Engel, R.C. Kyes, S. Akhtar & C.M. Hill (2005). People, crops, and primates: a conflict of interests, pp. 41–59. In: Paterson, J.D.& J. Wallis (eds.). *Commensalism and Conflict: The Human–Primate Interface*. American Society of Primatologists, Norman.

IUCN (2018). The IUCN Red List of Threatened Species, Version 2018-1. http://www.iucnredlist.org. Downloaded on 05 July 2018.

Janson, C.H. & C.A. Chapman (1999). Resources and primate community structure, pp. 237–268. In: Fleagle, J.G., C. Janson & K.E. Reed (eds.). *Primate Communities*. Cambridge University Press, Cambridge.

Kemf, E. & A. Wilson (1997). *Great Apes in the Wild: Species Status Report*. World Wide Fund for Nature, Gland, 36pp.

Khanna, V. & J.P. Sati (2003). Some Selected Fauna of Asola-Bhatti Wildlife Sanctuary (Delhi), pp. 1–70. In: *Fauna of Conservation Area Vol 16*. Zoological Survey of India, Kolkata.

Kushwaha, S.P.S., S. Nandy & M. Gupta (2014). Growing stock & woody biomass assessment in Asola-Bhatti Wildlife Sanctuary, Delhi, India. *Environment Monitoring Assessment* 186(9): 5911–5920; https://doi.org/10.1007/s10661-014-3828-0

Lee P.C. & N.E.C. Priston (2005). Human attitudes to primates: Perceptions of pests, conflict and consequences for primate conservation, pp. 1–23. In: Paterson JD, Wallis J, editors. Commensalism and conflict: the human-primate interface. Norman, Oklahama, American Society of Primatology; http://doi.org/10.1002/047001539X.ch1

Lee, P.C. & M.D. Hauser (1998). Long-term consequence of changes

in territory quality on feeding and reproductive strategies of Vervet Monkeys. *Journal of Animal Ecology* 67: 347–358.

Lee, P.C., E.J. Brennan, J.G. Else & J. Altmann (1986). Ecology and behavior of vervet monkeys in a tourist lodge habitat, pp. 229–235. In: Else, J.G. & P.C. Lee (eds.). *Primate Ecology and Conservation*. Cambridge, Cambridge University Press.

Lindburg, D.G. (1971). The Rhesus Monkey in north Indian ecological and behavioral study, pp. 1–106. In: Rosenblum, L.A. (ed.). *Primate Behavior 2*. New York, Academic Press.

Majumder, J., R. Lodh & B.K. Agarwala (2012). Fish feeding adaptation by Rhesus Macaque *Macaca mulatta* (Cercopithecidae) in the Sundarban mangrove swamps, India. *Journal of Threatened Taxa* 4(4): 2539–2540; https://doi.org/10.11609/JoTT.o2884.2539-40

Malik, I. & R.L. Johnson (1991). Trapping and conservation: development of a translocation in India, pp. 63–64. In: Ehara, A., T. Kimura & M. Iwamoto (eds.). *Primatology Today*. Elsevier, Amsterdam.

Malik, I. & R.L. Johnson (1994). Commensal Rhesus in India: the need and cost of translocation. *Revue d'Ecologie (La Terre et la Vie)* 49: 233–243.

Malik, I. (1983). A study of selected behavioural traits of Rhesus Monkeys (*Macaca mulatta*) in free-ranging environments. PhD Thesis. University of Meerut.

Mandal, A.K. (1964). The behaviour of the Rhesus Monkeys (*Macaca mulatta* Zimmermann) in the Sundarbans. *Journal of the Bengal Natural History Society* 33: 153–165.

Mangalam, M. & M. Singh (2013). Flexibility in food extraction techniques in urban free-ranging Bonnet Macaques, *Macaca radiata*. *PLoS ONE* 12: e85497; https://doi.org/10.1371/ journal.pone.0085497

Mittermeier, R. & W. Konstant (1996/1997). Primate conservation: a retrospective and a look into the 21stCentury. *Primate Conservation* 17: 7–17.

Molur, S., D. Brandon-Jones, W. Dittus, A. Eudey, A. Kumar, M. Singh, M.M. Feeroz, M. Chalise, P. Priya & S. Walker (2003). Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report, 2003. Zoo Outreach Organisation / CBSG-South Asia, Coimbatore, India, viii+432pp

Muoria, P.K., G.M. Karere, N.N. Moinde & M.A. Suleman (2003). Primate census and habitat evaluation in the Tana delta region, Kenya.*African Journal of Ecology* 41(2): 157–163.

Naithani, H.B., S.S. Negi, M. Pal, S. Chandra & V.P. Khanduri (2006). *Vegetation Survey and Inventorisation of Species in the Ridge Forest of Delhi*. Department of Forest and Wildlife, Government of Delhi, Delhi.

Pasiecznik, N.M., P. Felker, P.J.C. Harris, L.N. Harsh, G. Cruz, J.C. Tewari, K. Cadoret & L.J. Maldonado (2001). The *Prosopis juliflora-Prosopis pallida* Complex. Coventry, HDRA, UK, 172pp.

Peterson, D. (2003). *Eating Apes*. University of California Press, Berkeley, 320pp.

Priston, N.E.C. & S.J. Underdown (2009). A simple method for calculating the likelihood of crop damage by primates: an epidemiological approach. *International Journal of Pest Management* 55(1): 51–56; https://doi.org/10.1080/09670870802450268

Seth, P.K. & N.K. Pokwal (2001). Behaviour and ecology of primates. *Journal of the Bombay Natural History Society* 14(3): 172–180.

Seth, P.K., P.K. Chopra & S. Seth (2001). Indian Rhesus Macaque: habitat, ecology and activity patterns of naturally occurring populations, pp. 68–80. In: Gupta, A.K. (ed.). *Non-human Primates of India, Vol 1(1)*. ENVIS Bulletin: Wildlife & Protected Areas. Wildlife Institute of India, Dehradun (India).

Seth, P.K. & S. Seth (1986). Ecology and behavior of rhesus monkeys in India, pp. 89–103. In: lse, J.G. & P.C. Lee (eds.). *Primate Ecology And Conservation*. Cambridge, Cambridge University Press.

Sha, J.C.M. & G. Hanya (2013). Temporal food resource correlates to the behavior and ecology of food-enhanced Long-Tailed Macaques (*Macaca fascicularis*). *Mammal Study* 38(3): 163–175; https://doi.org/10.3106/041.038.0305

Simpson, G.G., A. Roe & R.C. Lewontin (1960). *Quantitative Zoology*. Harcourt, Brace & Company, New York. *American Journal of Science* 258(2): 300–311.

Sinha, A. & S. Vijayakrishnan (2017). Primates in Urban Settings, pp. 1–8. In: Fuentes, A. (ed.). *The International Encyclopedia of Primatology.* John Wiley & Sons, Inc. Published 2017 by John Wiley & Sons, Inc.; https://doi.org/10.1002/9781119179313.wbprim0458

Sirmah, P., S. Dumarcay, E. Masson & P. Gerardin (2009). Unusual amount of (-) mesquitol from the heartwood of *Propopis juliflora*. *Natural Product Research* 23(2): 183–189.

Southwick, C.H., I. Malik & M.F. Siddiqi (1998). Translocations of Rhesus Monkeys in India: prospects and outcomes. *American Journal of Primatology* 45(2): 209–210.

Southwick, C.H., M.F. Siddiqi, M.Y. Farooqui & B.C. Pal (1976). The effects of artificial feeding on aggressive behaviour of Rhesus Monkeys in India. *Animal Behaviour* 24(1): 11–15.

Strum, S.C. (1994). Prospects for management of primate pests. *Revue d'Ecologie (La Terre et la Vie)* 49: 295–306.

Strum, S.C. (2001). *Almost Human*. University of Chicago Press, Chicago, 308pp.

USA Today (2017). Why India is going bananas over birth control for monkeys. https://www.usatoday.com/story/news/world/2017/05/11/monkeys-india

Wieczkowski, J. (2004). Ecological correlates of abundance in the Tana Mangabey (*Cercocebus galeritus*). *American Journal of Primatology* 63: 125–138.

Wilson, E.O. (2007). Rhesus Monkey (*Macaca mulatta*) feeding behaviour and diet of Rhesus Monkey in Shivalik forest in north India. *IUCN Red List of Threatened Species* 1(8): 1–11.

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

December 2018 | Vol. 10 | No. 15 | Pages: 12907–13046
Date of Publication: 26 December 2018 (Online & Print)
DOI: 10.11609/jott.2018.10.15.12907-13046

Partners

Member

Publisher & Host