

**Research Article**

**DIET, FEEDING HABIT AND BEHAVIORAL ACTIVITY OF RHESUS MACAQUE (*Macaca mulatta*) AT CHARMUGURIA OF MADARIPUR, BANGLADESH**

**Md. Mahedi Hasan<sup>\*</sup>, and Md Azizul Hakim**

*Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh*

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**ABSTRACT**

Diet, feeding habits, and behavioral activities of Rhesus macaque (*Macaca mulatta*) were studied at Charmuguria of Madaripur district from March 2021 to December 2021. Among the five troops, one troop with four age-sex individuals was selected for data collection. Scan sampling methods at 10-minute intervals were used for data collection. Rhesus macaque spent 72% of feeding time on natural foods and 28% on provisioned foods. During the study period, 11 types of provisioned foods were recorded as a diet of Rhesus macaque, of which 73% were unprocessed food, and 27% were processed food. Rhesus macaque depended on various types of provisioned foods like bananas, peanuts, bread, vegetables, guava, chips, and pet foods. A total of 24 plant species belonging to 20 families were identified, which provided food for the studied group. Among the recorded plant families, the Fabaceae family provided the highest portion of the macaque's diet during the study period. Among the natural food items, 34% were fruits, followed by 27% of leaves, 12% animal matter, grasses (7%), flowers (6%), seeds (4.5%), grains (3%), buds & shoot (2.5%), drinking water (2%), plant roots (1.5%) and soil (0.5%). The Rhesus macaques spent the highest time in resting (37.5%), followed by feeding (25.5%), moving (20.4%), grooming (8.5%), then playing (3.6%), while submission and aggression had 3% and 1.5 % respectively. These days, people are destroying macaque habitats and their feeding plants, so they can't move freely and don't get sufficient food. Therefore, the government should take practical steps to conserve Rhesus macaque.

**Keywords:** *Diet, Food Choice, Activities, Rhesus macaque*

**Introduction**

The diet and feeding behavior of primates have been studied for many years (Xiang *et al.*, 2012; Agetsuma, 1995; Hanya, 2004). Information on primates' diets is essential to understanding their dietary composition and food selection (Hanya, 2004; Agetsuma, 1995). It may vary among different primates' species. Many studies have depicted species-specific

<sup>\*</sup> **Correspondence:** *mahedi.1990@yahoo.com*

dietary features of macaques. For instance, the long-tailed macaque (*Macaca fascicularis*) is frugivorous (Riley, 2007), but Rhesus macaques (*Macaca mulatta*) and Japanese macaque (*Macaca fuscata*) are folivorous (Hanya, 2004). However, it is sometimes difficult to categorize a distinct dietary type as frugivorous or folivorous due to no indication of differences in dietary selections and food compositions (Hill, 1997). A proper diet is necessary for the existence of any individual or species because it supplies inevitable nutrients (Hanya, 2004a). All primates have similar needs to acquire essential vitamins, minerals, amino acids, glucose, certain fatty acids, and water, but their requirements are specific and varied among species (Smith, 1984). Significant disparity in primate's food and feeding habits are determined by activity, body size and energy requirements (Dames *et al.*, 1984). The feeding behavior of primates also changes seasonally in response to the availability of food resources and also preferred diet items (Terborgh, 2014). Different types of trees are abundant in our semi-evergreen and evergreen forests and in rural as well as urban sites of Bangladesh (Feeroz *et al.*, 1999). Trees are the main source from which primates and macaque get their essential foods (Hanya, 2004). Besides natural food, to some extent, macaques dependent on provisioned foods like bananas, biscuits, nuts, bread, chips, vegetables and cooked rice (Fooden, 1980). In Bangladesh, besides forest areas, macaques also live in some cultivated areas of the country, and they also rely on the cooked and left-over food of human beings along with the natural foods of those specific areas. Some work has been accomplished on macaques' diet and feeding behavior in several urban and rural sites in Bangladesh (Hasan *et al.*, 2016; Sultana, 2012; Naher *et al.*, 2016). However, extensive work on the feeding habit of Rhesus monkey has yet to be substantially accomplished at Charmuguria in Madaripur. On the other hand, behavioral activities of a species means the estimation of the proportion of time spent in different activities during a day or year (Kabir, 2002). Activity study is a way of quantifying the behavior of how animals allocate their time in different activities that are necessary for their existence, breeding, and environmental adaptations. It also may help in understanding the life history traits of animals (Rodway, 1998). Primates usually shift their daily activity in response to social and ecological factors to ensure their survival (Jaman and Huffman, 2008). Various studies have researched the fact that behavioral activity and feeding habits vary in response to diet, availability of food sources, individual requirements, and the structure of habitat (Peres, 1993; Passamani, 1998).

Primate populations are decreasing in many regions of the earth due to anthropogenic activity, competition for food and space, habitat destruction, biomedical research, bush meat hunting, and the pet trade (Wolfheim, 1983; Mittermeier, 1986). As the human population is rising significantly and the need for space, food, material, and land use is expanding terribly, people are drastically encroaching on and destroying the primate habitat for their needs (Naher *et al.*, 2016). Charmuguria is a union of Madaripur district, approximately 7 kilometers from Madaripur town. Charmuguria is a harbor site for a large number of free rhesus monkeys. However, in recent times, their populations have been decreasing day by day in this area (Hasan, 2013). The Rhesus monkey is already listed as a threatened species globally by IUCN, 2021 criteria. Due to human populations, rapid urbanization, and the extension of agricultural land and crop production, the existing habitat areas of macaques still face continuous threats of extinction. There are very few places in Bangladesh where you can see monkeys moving freely. That is why we are interested in

working on this creature. The aims of the study is to determine the macaque's dietary composition, diurnal variation, monthly variation on diet, and to find out the feeding time on natural and provisioned foods at Charmuguria. Fundamental knowledge of the behavioral activities of this species will be provided essential data to develop effective management strategies and conservation plans for the conservation of the Rhesus macaque.

## Materials and Methods

### Study area

A study was conducted in the Charmuguria union under Sadar Upazila of Madaripur district in Bangladesh. Madaripur district was established in 1854 and is also a part of the Dhaka division. The total area of Madaripur is about 1144.96 sq. km, geographically situated between 23°00' to 23°30' at north latitudes and between 89°56' to 90°21' at east longitudes. It is encompassed by Barisal and Gopalganj districts on the south, Faridpur and Munshiganj districts on the north, Faridpur district on the west, and Shariatpur district on the east. Charmuguria is the countryside of Madaripur district, approximately 7 kilometers east of Madaripur sadar. Many rhesus monkeys are available here and can move freely around Charmuguria without any fear of humans. The Kumar River is flowing to the west of Charmuguria.

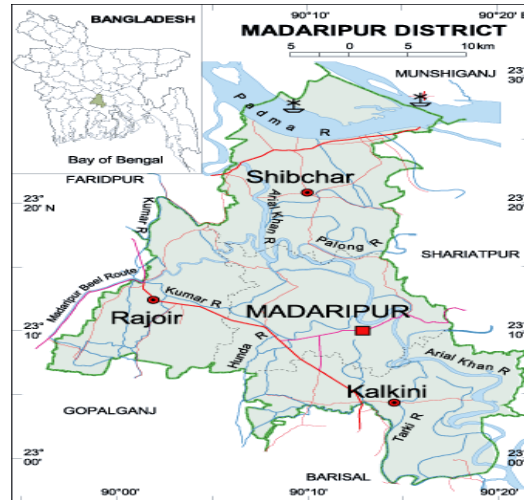
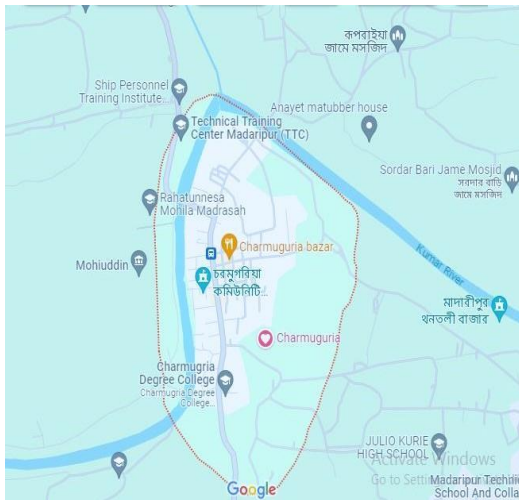


Fig. 1. Map of Madaripur district (Source: Internet). Fig. 2. Map of the study area.

### Data Collection

The data were collected from March to December 2021 by using the scan sampling method (Altmann, 1974) at 10 minute intervals, which was also followed by several researchers for observing the behavioral activities of primates (Chivers, 1974; Islam and Husain, 1982; Ahsan, 1994; Feeroz, 1991 and 1999; Gupta, 1996; Hasan, 2003; Sarker *et al.*, 2005; and Kabir, 2002 and 2006). Five troops (59, 54, 26, 20, and 17 individuals, respectively) were recorded during the study period, and among them, one troop at Charmuguria bazar with 54 individuals was followed for data collection. The age sex of the studied group was 11 adult males, 14 adult females, 7 adult

males, 6 sub-females, 7 juveniles, and 9 infants. Four age-sex classes of macaques—an adult male, a female, a juvenile, and an infant—were studied from dawn to dusk for 3–4 days each month, using the instantaneous scan sampling method. These focal individuals were observed for 10-minute intervals from a close distance of 10m. A total of 30 days of observation were carried out during the study period. A data sheet was prepared to record each activity, and a stopwatch was used to record the activity time. We made 3000 scans to record the following behavioral activities: resting, moving, feeding, grooming, aggression, submission, and playing or object manipulation. According to Guo *et al.* (2007), activities are resting, defined as when a monkey is stationary or sleeping; feeding; actively manipulating potential food items, masticating or swallowing foods; grooming, which means removing or scratching dirt and other objects from hair or skin for the hygienic benefits in the form of grooming itself or being groomed.; Playing behavior includes hanging on tree branches, false fighting with other individuals, picking up boughs, sticks, and other objects, and jumping on the back of the mother. Moving means the movement of an animal from one place to another. According to Jaman (2012), aggression" includes any aggressive physical contact, gesture, or vocalization typically shown toward a subordinate individual. "Submission" includes any submissive behavior, gesture, or vocalization (retreat, avoidance of eye contact, cry, grimace, crouching, etc.) in response to aggressive behaviors received from a more dominant individual. Kruskal-Wallis one-way ANOVA test was used to compare time spent by age-sex classes in each behavioral activity. Daily observations were divided into four time periods: morning (6:00 am–9 am), late morning (9:00 am–12:00 pm), noon (12:00 pm–3:00 pm), and afternoon (3.00 pm–6:00 pm)

Feeding activities were recorded when the macaques took foods through manipulating, masticating, and ingesting. Percentages of time spent on different food items were calculated following the equation:  $Tf: (nf \times 100) / N$ , where Tf = time spent on a particular food item as % of total feeding time, nf: number of feeding records on particular food items, and N =total number of feeding records (Gupta and Kumar, 1994). Primarily, food materials were identified as natural and provisioned foods. Natural foodstuffs were identified as (a) plant foods, i.e., leaves (mature and immature), fruits (both ripe and unripe), seeds, flowers, buds, barks, grasses (different types of herbs), and grains; (b) animal matters (vertebrates and invertebrates); (c) water; and (d) soil.

## Results and Discussion

Rhesus macaques at Charmuguria spent 25.5 % of their active time on feeding and foraging. Every day, they spent 17.5 % foraging and 82.5 % in feeding. During feeding time, they spent 2 % on drinking and 98% on taking food materials.

### *Diurnal variation in feeding time on natural and provisioned foods*

Among foods, they took 28% from provisioned foods offered by local people and governmental authorities, especially the forest department, and 72 % from natural foods. Rhesus macaque usually starts the day in the sleeping trees around 6.00 am to 7.00 am in the morning. They foraged on the natural food mainly in the mornings (6.00 am -10.00 am). The highest consumption of natural food (85.5%) was observed at 7.00 am (Fig. 3). They were observed to consume a supplementary diet from 11.11 am to 2.00 pm. The highest, 72.5%, was at 1.00 pm, as

provisioned foods were primarily given by the forest department at that time. In contrast, the percentage of natural food consumption was lowest at 27.5% at 1.00 pm.

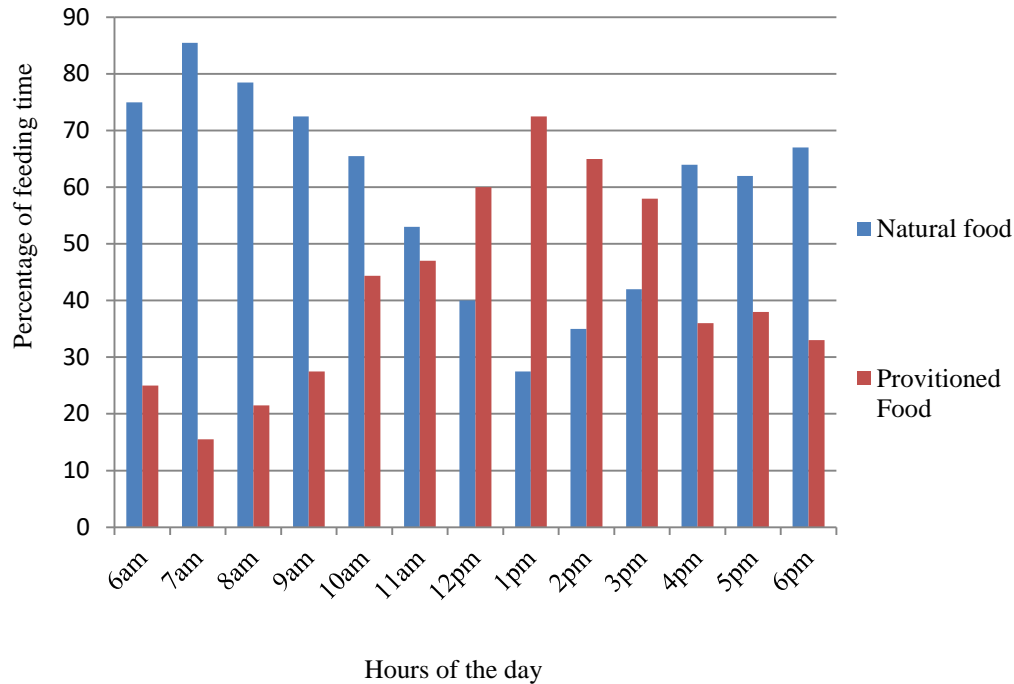


Fig. 3. Percentage of diurnal feeding time variation on natural and provisioned foods.

A study suggested by (Saj *et al.*, 1999) that time spent on feeding and resting is influenced by the regular supply of foods, which supply more energy to fulfill metabolic requirements in a few amount of food and in a shorter amount of time than wild plant foods. After taking provisioned foods, they rested for a while and then engaged in social grooming. (Lindburg, 1973) stated that Social grooming helps to maintain continuity and strengthen communal bonds between the individuals of a group

#### *Monthly variation in diet*

The percentage of feeding time on natural foods was always higher than the percentage of provisioned foods, except in July, November, and December (Fig. 4). The peak natural food consumption rate (72%) was recorded in March. The lowest rate (39%) was noted in November. On the other hand, the highest percentage of provisional food consumption was (61%) in November, and the lowest (28%) was observed in May. The percentage of feeding time on the natural food and the provisioned food was almost same in July (Fig. 4). Similar feeding peaks were also observed in rhesus macaques by (Southwick and Siddiqi, 1967) as well as other primate species (Stanford, 1989); Feeroz and Islam, 1992 a, b).

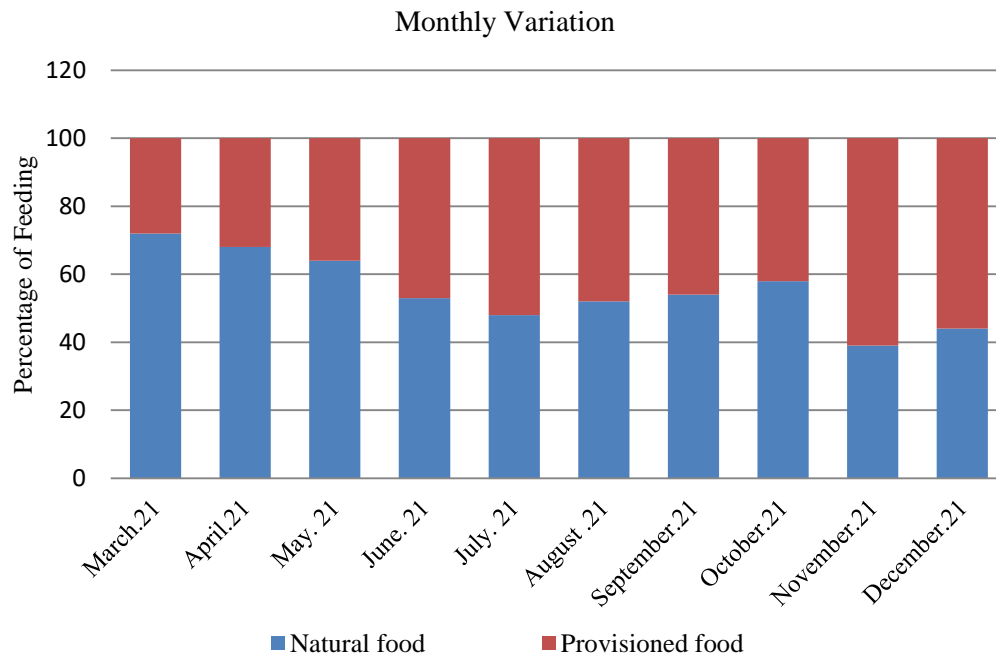
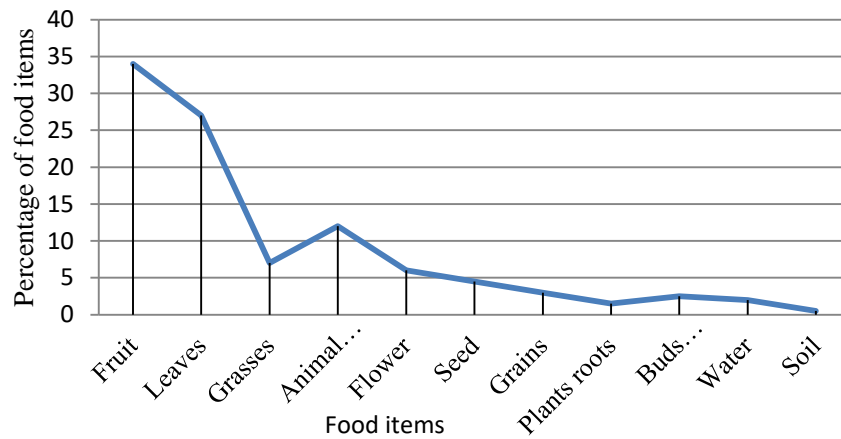


Fig. 4. Monthly variation in diet of *Rhesus macaque* at Charmuguria.

#### *Natural food items*

Natural food materials comprised 85.5 % plant parts, 12% animal matter, 2% water, and 0.5% soil. *Rhesus macaque* in Charmuguria depended on different plant species for natural food sources. A total of 24 plant species belonging to 20 families were recorded for natural food items during this study (Table 1). However, (Sarker *et al.*, 2008) reported 38 plant species representing 33 genera belonging to 20 families exploited by the study group as natural food in Barmi, Gazipur. Among the recorded plant families, plants of the Fabaceae family provided the highest portion of food throughout the study period. At the same time, the Poaceae family was mainly used as a plant family by the barmy group of Gazipur, as stated (Feeroz, 2008). During the study period, *Rhesus macaque* was observed to consume large quantities of fruits (34%) followed by 27% of leaves, 12% of animal matter, grasses (7%), flowers (6%), seeds (4.5%), grains (3%), buds & shoot (2.5%), drinking water (2%), plant roots (1.5%) and soil (0.5%) from the nature. (Fig. 5). On the other hand, (Sarker *et al.*, 2008) found more or less similar findings with some deviation from the macaque group at Barmi. Gazipur included fruits (12.6%), leaves (29%), grasses (42%), bud (4%), flowers (1.4%), animal matter (20.3%), and soil (0.3%) which were considered natural diets.

Fig. 5. Preference of natural food items of *Rhesus macaque*.Table 1. Natural plants food items used by the *Rhesus macaque* in the study area

Serial No	Family	Local Name	Scientific Name	Food items
1	Anacardiaceae	Am	<i>Mangifera indica</i>	Rf, Iml, Sh, Sd
2	Araceae	Kochu	<i>Colocasia esculenta</i>	Sh, L
3	Moraceae	Kathal	<i>Artocarpus heterophyllus</i>	Rf, Sd, Fl
4	Meliaceae	Mehogany	<i>Swietenia macrophylla</i>	Urf & Iml
5	Arecaceae	Khejur	<i>Phoenix dactylifera</i>	Rf, Sd
6	Musaceae	Kola	<i>Musa velutina</i>	Rf, Pr, Fl
7	Myrtaceae	Golap Jam	<i>Syzygium samarangense</i>	Urf, Sd
8	Solanaceae	Alu	<i>Solanum tuberosum</i>	Sh, Pr
9	Basellaceae	Pui shak	<i>Basella alba</i>	Iml
10	Poaceae	Rice	<i>Oryza sativa</i>	Rf, Bd, Gr
		Durba	<i>Cynodon dactylon</i>	Sh, Grs
11	Rhamnaceae	Boroi	<i>Ziziphus mauritiana</i>	Rf
12	Rosaceae	Jam	<i>Rubus ursinus</i>	Rf, MrL
13	Bromeliaceae	Anarosh	<i>Ananas cosmosus</i>	Rf, Fl
14	Arecaceae	Narikel	<i>Cocos nucifera</i>	Sh
15	Craicaceae	Pepe	<i>Carica papaya</i>	Rf, ImL
16	Phyllanthaceae	Amloki	<i>Phyllanthus embelica</i>	Urf, Fl
17	Oxalidaceae	Kamranga	<i>Averrhoa carambola</i>	Urf
18	Anacardiaceae	Amra	<i>Spondias mombin</i>	Urf, ImL
19	Rutaceae	Jambura	<i>Citrus maxima</i>	Urf & ImL
		Badam	<i>Arachis hypogaea</i>	Rf & urf
20	Fabaceae	Koroi	<i>Albizia procera</i>	Iml, Fl,
		Raintree	<i>Samanea saman</i>	L, Urf, Bd
		Tetul	<i>Tamarindus indica</i>	Rf, MrL

Note: Rf-Ripe Fruit, Urf-Unripe fruit, ImL-Immature leaf, MrL-Mature leaf, Sh-Shoot, L-Leaves, Gr- Grains, Sd- Seed, Grs- Grass, Pr-Plants root, Fl- Flower

Among the fruits, Rhesus macaque preferred ripe fruit (55%) more than unripe fruit (45%). Leaves were eaten regularly throughout the year, and young leaves (52%) were preferable to mature leaves (48%). The macaques are frequently found to take termites, which constitute 45% of their animal food. They also consumed ants (25.5%), caterpillars (13%), spider's egg (10.5%), grasshoppers (2.5%), and butterflies (1.5%) as invertebrate foods (Fig. 6). In this study, the macaque was observed to feed on a bird's egg for 2% as much as vertebrate foods. The way animal matter is collected differs depending on the type of food being eaten. They were also found to take smell in case of unknown foods. The local people claimed that the macaques snatched their food items from the house. In the drinking study, the macaques spent very little time (2%) on drinking. They collected their essential water from various sources, such as tube wells, ditches, stagnant water and rivers. Rhesus macaque was found to eat a small amount of soil (0.5%) from the study site. The soil-eating behavior of the macaques was also observed (Clutton-Brock, 1975), (Hladik, 1978), and (Kabir, 2002) for other species of primates.

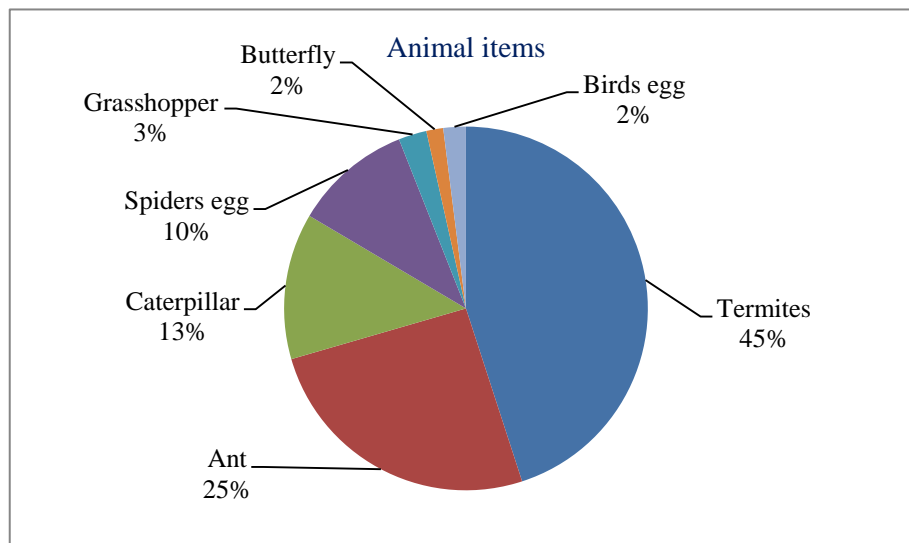


Fig. 6. Percentages of different animal items of *Rhesus macaque*.

#### Provisioned foods

During the study period, 11 types of provisioned foods were recorded as a diet of Rhesus macaque, of which 73% were unprocessed and 27% were processed. Among the unprocessed foods, banana was highly preferred (30%), followed by peanuts (28%), guava (7%), vegetables (5%), and other fruits (3%). On the other hand, the percentage of processed foods consisted of dry bread (10%), cooked rice (7%), pet foods (4%), snacks (3%), biscuits (2%), and chips (1%) (Table 2). Resting and feeding time of urban macaque was longer due to the regular supply of higher-quality provisioned food, for instances, fruits, bread, biscuits, vegetables, banana, and nuts offered by the local people, visitors, and governmental authorities, especially the forest



department (Neha *et al.*, 2021). Due to limited access to natural foraging sites, the urban macaques frequently rested after taking provisioned food by adopting a lower energy search strategy to meet their metabolic demands of a smaller amount of food in a limited amount of time (El Alami *et al.*, 2012; Jaman and Huffman, 2012).

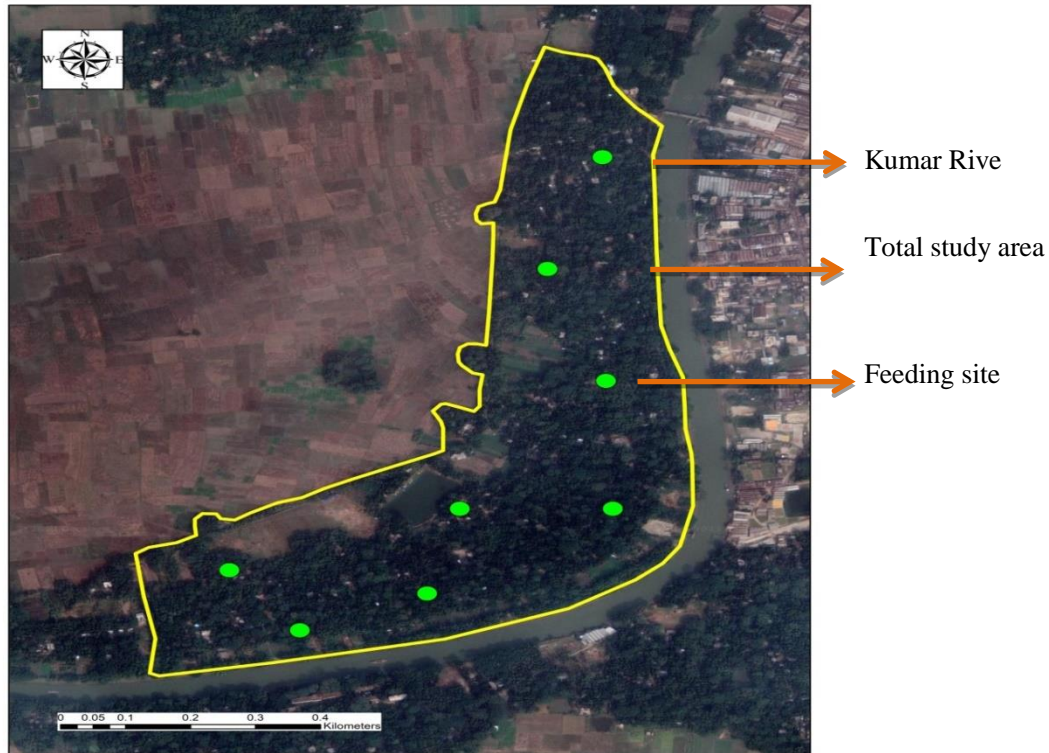


Fig. 7. Showing all the feeding points along with the total study area at charmuguria.

Table 2. Provisioned food items (processed and unprocessed food) of *Rhesus macaque* in the study area

Unprocessed foods	Percentage	Processed foods	Percentage
Banana	30%	Dry bread	10%
Peanuts	28%	Cooked rice	6%
Guava	7%	Pet Foods	5%
Vegetables	5%	Snacks	3%
Other fruits	3%	Biscuit	2%
	Total= 73%	Chips	1%
		Total = 27%	

## Behavioral activities of Rhesus macaques

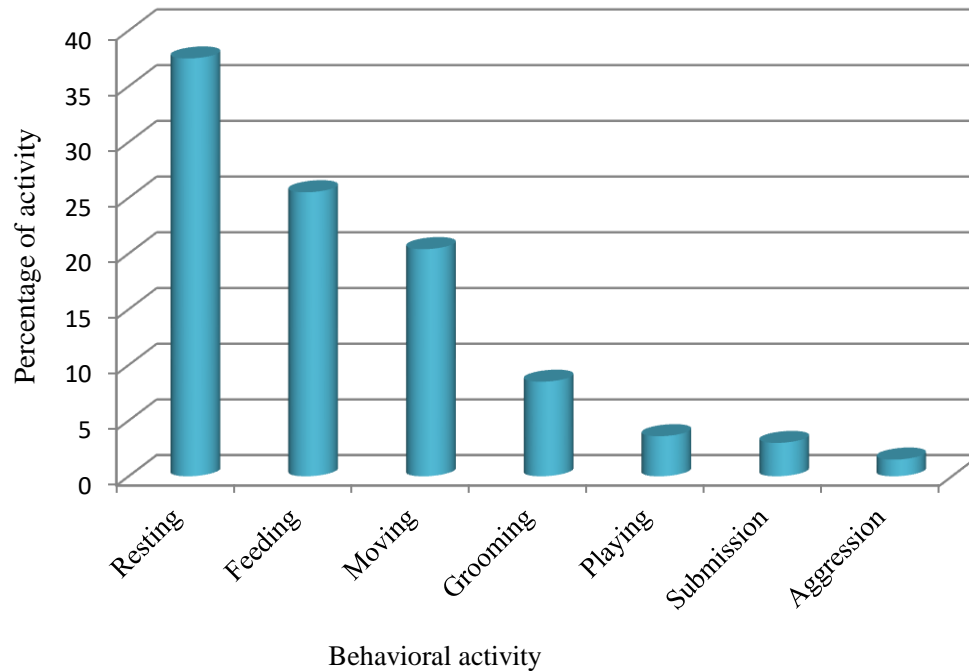


Fig. 8. Average percentage of different activities of *Rhesus macaque*.

Seven behavioral activities, namely resting, feeding, moving, grooming, playing, submission, and aggression, were observed during the study period. The highest period was spent on resting (37.5%), followed by feeding (25.5%), moving (20.4%), grooming (8.5%), and then playing (3.6%). In comparison, submission and aggression had 3% and 1.5%, respectively (Fig. 8). The percentage of time spent on behavioral activities of Rhesus macaque varied due to habitat differences, food availability, climate conditions, and age-sex-specific physiological factors (Jaman and Huffman, 2008). We obtained the highest behavioral activity from the study group was resting and feeding (37.5% and 25.5%, respectively), which was barely similar to (Jaman and Huffman, 2012), that Rhesus macaques spent 46.1% and 22.4% of their active time resting and feeding compared to other behavioral activities.

#### *Behavioral variation across all age-sex classes*

Activities of Rhesus macaque varied according to age-sex categories. Adult females spent the maximum time resting (35.5%) compared to adult males (22.5%), juveniles (20.5%), and infants (21.5%). However, adult males spent more time on feeding (30.5%) than adult females (25.5%), juveniles (20.5%), and infants (23.5%). Adult males also spent more time moving (38%) and aggression (39.5%) than adult females (22.5%, 26.5%), juveniles (18.5%, 18%), and infants (21%, 16%), respectively. On the other hand, The adult females spent more time on grooming (36%) and submission (36.5%) than the adult males (26%, 22%), juvenile (17.5%, same value),

and infant (20.5%, 24%) respectively. Infants spent more time for playing (37%) or being engaged in object manipulation than juveniles (26.5%), adult females (22.5), and adult males (14%) (Fig. 9). Our research showed differences in behavioral variation of Rhesus macaque among age-sex classes. The adult males spent more time feeding and moving than the rest of the group, as they are physically dominant and more capable of raiding crop fields, houses, and gardens and taking over the supplementary food than other members. Adult females spent more time resting and grooming. (Jaman and Huffman, 2012) showed similar results and reported that feeding is inversely related to resting, as adult females spent less time feeding, allowing them to rest for a more extended period. (Watanuki and Nakayama, 1993) stated that adult females groom more than adult males. Possible reasons for this may be that males are dominant over females as well, and sometimes adult males allow adult females who groomed them to also forage with them, which would allow some females greater access to high-quality food and maximum access to available food (Soumah and Yokota, 1991). Moreover, adult females were observed to groom infants, strengthening the kinship between them and other higher-ranking adult females to maintain hierarchy (Md-Zain *et al.*, 2010). Females also groom males after mating, which is common in other primates (Lazaro-Perea *et al.*, 2004).

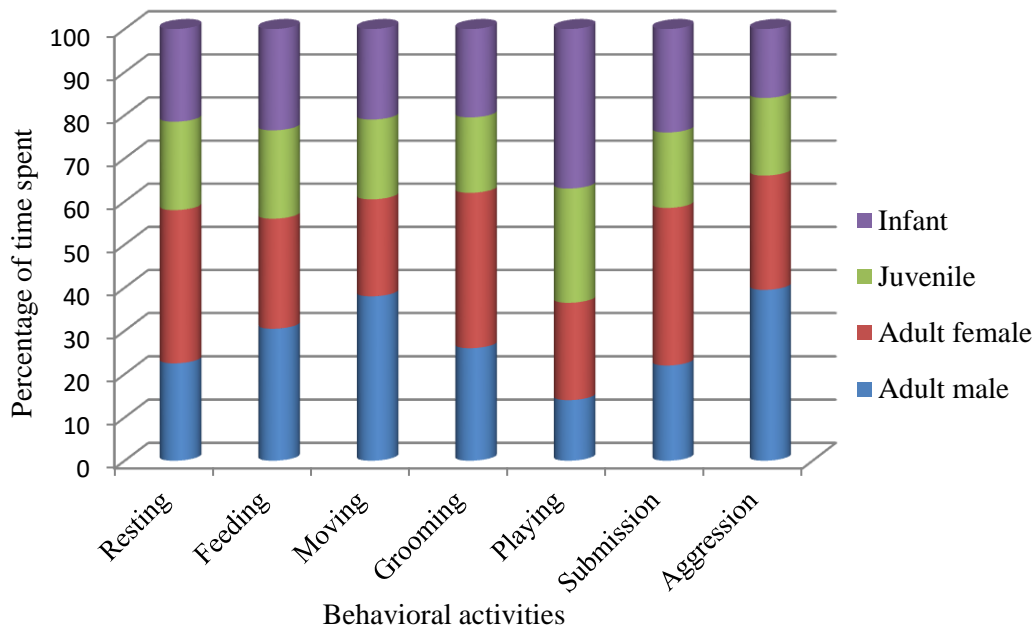


Fig. 9. Percentage of different activities of age-sex individuals.

Infants and juveniles spend more time playing or manipulating objects than adults. Sometimes, infants were observed hanging on tree branches, picking up sticks and other objects, false fighting with other individuals, and jumping on the back of the mother. Mothers often play with their children to pursue survival-related operations and keep them safe from predators (Naples and Rothschild, 2015).

### Diurnal variation of different activities

Rhesus macaques started their activity in the morning and ended in the afternoon. The percentage of time spent on different activities varied during the day. Times spent resting (34.5%), grooming (35.5%), and submission (37.5%) were highest in the late morning, while feeding (15%), moving (20%), and playing (12.5%) were lowest. Time spent on feeding (41.5%) and aggression (36%) was highest in the afternoon, while resting (17.5%), grooming (18.5%), and submission (16.5%) were the lowest. For moving, Rhesus macaque spent the most time (32.5%) around noon. Playing was also seen mostly at noon (Fig. 10). During the study, macaques rested more in late morning after their feeding turn. They spent the most time resting in hot weather (around 9 am to 12 pm) due to a lack of trees for shade and to avoid the high temperatures. Macaque also rests in the shade of buildings and the corridors of derelict buildings (Jaman and Huffman, 2012). They preferred *Mnagifera indica*, *Citrus maxima*, *Litchi chinensis*, and *Swetenia macrophylla* because they are abundant in Charmuguria. At noon, the macaque traveled more to find suitable areas with high food abundance where the group would remain safe until sunset. During the afternoon, group members spent more time for foraging and feeding in preparation to stay healthy for the whole night (Khan, 2020 and Akhter, 2021).

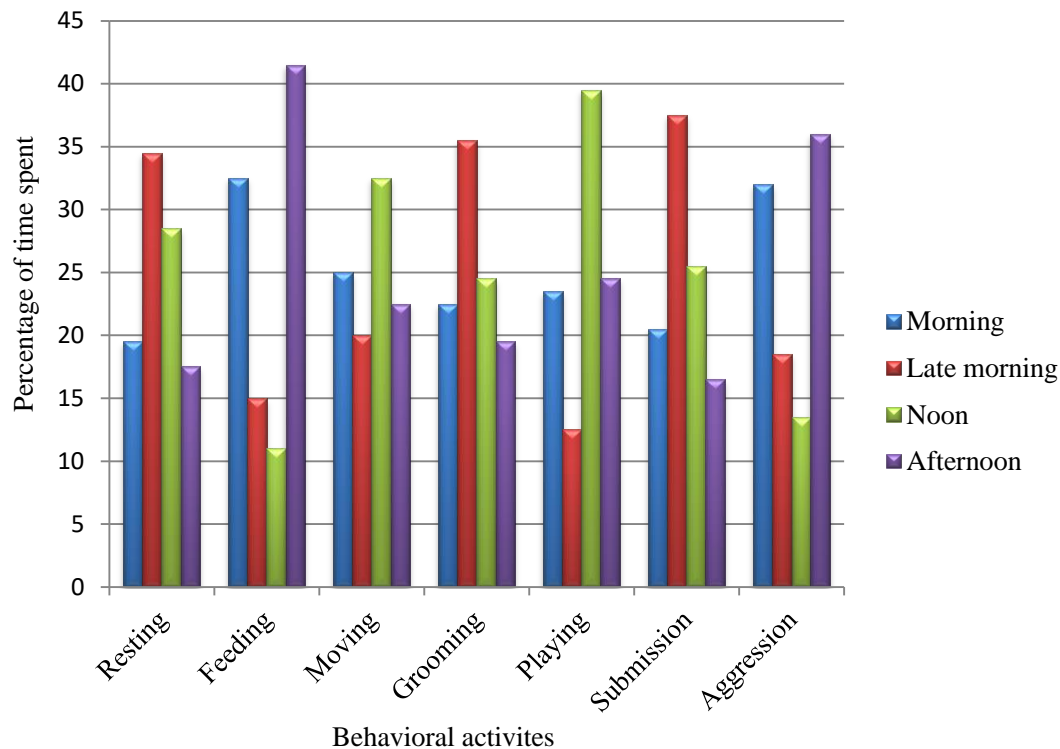


Fig. 10. Diurnal activities at different times of the day of *Rhesus macaques* in Charmuguria.

## Conclusion

The Rhesus macaque is vulnerable in our countries. They are facing many threats in this urban area. People are destroying their habitats, feeding plants, and making roads in their routes so they cannot move freely and cannot roam around. Several developmental activities have been taken in this region, destroying their habitats, losing their sleeping sites, and facing scarcity in food collection. That is why they are going to be in danger shortly. To reduce food scarcity, local authorities must increase their budget to provide food items besides natural foods. The government should be inquisitive about conserving habitats and the Rhesus macaque by developing infrastructure and supporting modern technologies in the concerned area. Lastly, mass awareness-building programs, developing research programs, and educating the future generation can be part of the site-specific conservation action plan for the betterment of the Rhesus macaques.

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