

Research Article**DISTRIBUTION, RELATIVE ABUNDANCE AND FEEDING BEHAVIOR OF SQUIRRELS IN AN URBAN PARK, DHAKA, BANGLADESH****Md. Nowshad Arefin and Md. Mahedi Hasan****Department of Zoology, Jagannath University, Dhaka-1100, Bangladesh**Received: 28 December 2021, Accepted: 12 May 2022***ABSTRACT**

The present research was conducted to assess the population size, distribution and feeding behaviors of two squirrel; *Callosciurus pygerythrus* (Irrawaddy squirrel) and *Funambulus pennantii* (Northern Palm Squirrel) at Ramna Park in Dhaka City between September 2019 and August 2020. A total of 807 squirrels were sighted where 485 individuals were *F. pennantii* and 322 were *C. pygerythrus*. We scanned through the selected seven transect lines and sighted squirrel individuals was average 33.63 individuals per day and the density was 4×10^{-10} /km² in Ramna Park. We found that squirrels were more active in morning than afternoon. So of the recorded squirrels, 494 individuals (61.21%) were sighted during morning shift of survey and rest 313 individuals (38.79%) were encountered at afternoon. A total of 372 (46.09%) squirrel individuals were encountered in ground and 435 (53.91%) individuals were sighted in climbing trees. Altogether 280 feeding events of squirrels were accomplished by two squirrels, among them 120 feeding occasions were observed in Irrawaddy squirrels and 160 feeding events were executed by Northern palm squirrels. Plants are the main food sources of squirrels in Ramna Park. Almost 24 plant species were used for feeding purpose, of these plant species, following 21.33%, 28%, 8%, 21.33%, 10.66% and 10.66% species were used for leaves, flowers, bark, fruit, seed and twig respectively. Few animal sources (termites, bird carcass, insects, ants, termites nest and meats) and additional food material (junk food, chocolate, banana, tea, breads, chips, ice-cream and juice) were also observed during feeding time. Population monitoring and further research on feeding activity and ecological aspects will help to understand their ecological adaptations to the urban habitat and their roles in ecological balance.

Keywords: *squirrels, ramna park, omnivore, population, feeding behavior***Introduction**

Bangladesh harbor 127 species of mammals in 87 genera, 35 families and 9 orders (IUCN Bangladesh 2015). They are predominantly distributed in the planted vegetation, mixed-evergreen forest; mangrove forest and deciduous forest (Ahmed *et al.* 1999). But in recent years, their

*Correspondence: *mahedi.1990@yahoo.com*

population has been decreased rapidly due to human disruption (Anwar 1999). Among mammals, only nine species of squirrels are inhabited in Bangladesh where three species are flying (gliding) squirrels and six species are tree squirrels (IUCN Bangladesh 2015).

Squirrels are usually arboreal animals hold a long bushy tail and large eyes with keen sight that belongs to the family Sciuridae under the order Rodentia of class Mammalia (Bradford 2014). In general, their fur is silky and soft, though much thicker in some species than others. Squirrels found in almost every habitat, from tropical rainforest to semiarid desert, but they avoid only the driest of deserts and the high Polar Regions (Haque and Sultana 1982). Their natural distribution does not amalgamate with human residence, so urbanization can alters their population status, abundance, distribution patterns, and ecology (Bonnington *et al.* 2014). Usually two squirrel species are common in Dhaka city. In between, *Callosciurus pygerythrus*, is endemical to the capital, and *Funambulus pennantii* absconding from the National Zoo in recent past (Khan 2015) and has extended throughout the city.

Squirrels have distinct dentition with powerful ever-growing incisors and a set of premolars and molars for grinding and gnawing their food (Gurnell 2002). Their dental formula is suited to consume variant types of food includes fruits, nuts, reptiles, small birds and to gnawing on bones (Thorington and Ferrell 2012). Their natural diets changes in different seasons depending on what is most plentiful. The autumn and winter diets are predominantly composed of fruits and seeds (Gurnell 2002). It is known that during autumn, squirrels often hoard their food items in a number of different locations in its own shallow hole in the ground when food is available; on the other hand, squirrels search their cached items and consume them during the winter (Tosi 2002). As food becomes scarce during the winter months, food is inadvertently shared communally with other squirrels (Wauters 2002). Squirrels usually consume a variety of fruits, flowers, vegetables, fungus, nuts, trees, plants, and insects that are vicinal to their environment (Thorington 2012). Fruit is devoured by squirrels with savour. Squirrels eat fruit from a range of trees, including pears, grapes, apples, kiwi, avocados, peaches, nectarines, figs, plums, mangoes, and citrus, among others (Wilson 1992). Squirrels benefit from fruit because it offers them a big sugar rush and give them plenty of energy to keep scrambling around and looking for more delicacies (Wilson 1992). Squirrels eat a wide range of veggies, as gardeners are well aware. They also prefer to eat tomatoes, radishes, corn, squash, beans, peas, root vegetables, greens (such as beet greens and the greens of any root vegetable), eggplant, carrots, broccoli, cabbage, cauliflower and leeks (Hoffmann 1993).

Very little information on the population trends and feeding habits of squirrels are available in urban habitats of Bangladesh and no extensive research has been done about their distribution patterns in any urban areas of Bangladesh. Therefore, the present study was conducted on population size, distribution patterns and feeding behavior of the squirrels at an urban park area in Dhaka city to have a better understanding of how these species are coping in a human-dominated area.

Materials and Methods

Study Area

Ramna Park is situated at Shahbag (23°44'14.70" N, 90°24'03.4" E) in the Dhaka metropolitan area of Bangladesh covering an area of 685 acres. The weather is hot and humid. In April and

May, the average maximum temperature was 30°C, with a minimum of 17°C in January (Rajia *et al.* 2015). In July, the highest amount of rain fell at 542 mm, while the lowest amount fell at 03 mm in February. It is a well-organized park, provides amusements and learning facilities.

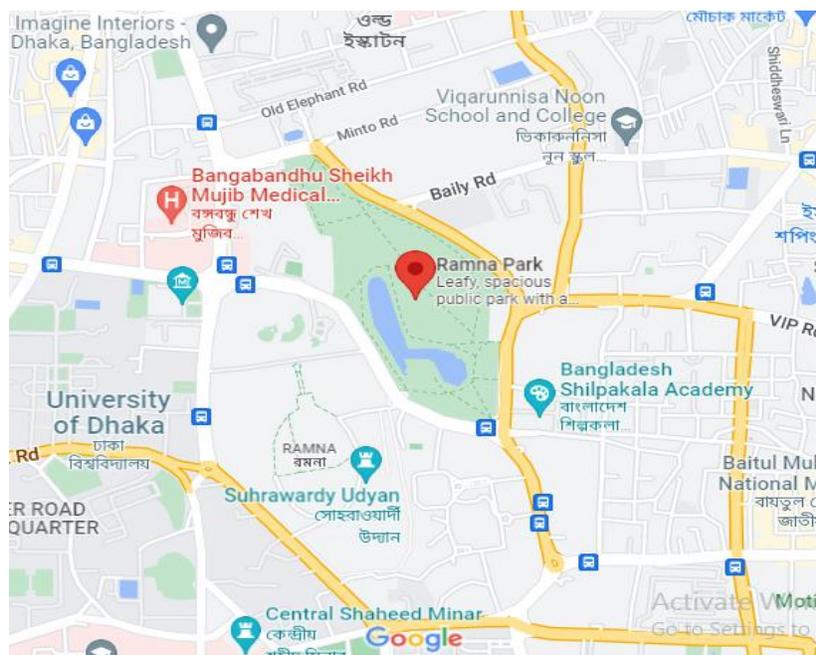


Fig.1. Location and map of Ramna Park (Source: Google map).

It is a piece of green on the busy and rush capital in Bangladesh and provides an escape to the nature. A huge lake residing on the middle of the park and six gates are placed in different position of the park area. The park usually closes at evening for security concerns although the area itself is secured enough. The park comprises of 71 species of flowering, shrubs, trees, perennials, and annuals. Thirty-three of these are medicinal plants, 41 are forest trees and 36 are fruit bearing plants (Rajia *et al.* 2015).

Study Species

There are two squirrel species (Irrawaddy squirrel and Northern palm squirrel) are found in Ramna Park of Dhaka City (Ahmed *et al.* 1999). Characteristically Northern palm squirrel is a diurnal, arboreal and terrestrial mammal, and inhabits crowded towns and cities or, in villages. In appearance, they have broad rounded head with prominent triangular ears, dense body fur and thick bushy tail, forelimb with four fingers and hind limb with five toes (Ahmed *et al.* 1999). They are light brown on the head, ears and feet and have deep red-brown dorsal fur (Khan 2015). Irrawaddy squirrel is also diurnal, arboreal and medium-sized elongated and non-patterned dark brown squirrel found in solitary or in pairs; prefers forest and well-wooded villages (Meena 2013). In summer and in the winter wet season, a pale bluff patch on the hips that fades when the winter coat appears, long tail without a dark tip (Khan 2015).



Fig. 2. Five Striped Palm Squirrel.



Fig. 3. Irrawaddy Squirrel.

Methods

From September 2019 to August 2020, a survey was conducted in Ramna Park to get information on squirrel population, its distribution and feeding behaviors over the course of 24 days (2 days in each month). 12 days out of 24 days were spent for conducting the research in the morning time (06:00 am to 12:00 Pm) and remaining 12 days were conducted on study in the afternoon time (12:00 pm to 6:00 pm). A total of 875 meters long transects line was walked using Line transect method in each day (Anderson 1979). Observations on population were made by “Direct Population Count” method (Sutherland 2000). Feeding behavior was observed by random scan sampling method and sometimes feeding data was also obtained either by a pair of 7×35 binoculars or by naked eyes (Shuttleworth 2000). Location data and the distribution of squirrels in the park area were recorded using a Garmin etrex10 GPS. During the feeding observation of squirrels, ingested food items were divided into three categories:

- (a) Foods from local plants,
- (b) Expletive foods discarded by visitors.
- (c) Animal or other matter. (Buckland *et al.* 1993)

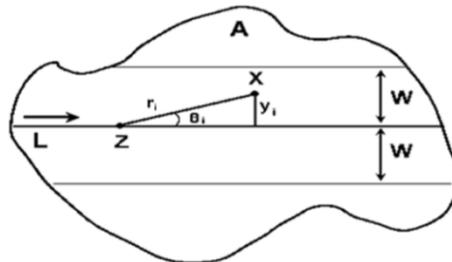


Fig. 4. Observing the target species along transects line using line transect method (Anderson *et al.* 1993)

L = transect line

Z = position of observer

X = position of object

W = strip width (1/2)

ri = sighting distance (flushing distance)

O_i (theta) = sighting angle

y_i = perpendicular distance (note: $y_i = r_i \sin \theta_i$) between transect and observed object

All of the data was put in a Windows Excel sheet that was used to categorize the analysis goals. The total population was calculated by averaging the observed persons with the number of visits. Squirrel density was come out by using this formula (Anderson 1979).

$$D = \frac{n}{2La}$$

Where,

D = Density

n = Observed Individuals Number

L = Total Transect Length

a = One-half the effective strip width (ESW)

Results

During one year of data collection, a total of 807 squirrels were encountered in among 7 transect line at Ramna Park, Dhaka. Of which 322 (39.9%) sightings were Irrawaddy Squirrels and 485 (60.1%) were of Five Striped Palm Squirrels (Table 1).

Table 1. Describing transect and sighting squirrel population at Ramna Park.

Transects	Length(m)	Width(m)	Sighted Squirrel Population (N)
1	100	20	141
2	150	18	89
3	100	20	134
4	200	14	197
5	85	20	65
6	90	15	58
7	150	20	123
Total	875	127	807

Highest population was sighted in transect 4 (N=197) and lowest was in transect 6 (N=58) (Table 1). Transect 4 is longest of all the transects and more disturbed due to its position from entry gate

to middle position of the park as there goes huge noise of busy road. Transect 6 is in the corner of the restaurant, as a result gradual disturbances occur there. Although, Five Striped Palm Squirrel was seen in this transect to make two nests and no food plant is present without a large *Ficus bengalensis*. However, the nests were found one in *Ficus* plant and other in *Eucalyptus* sp. Through the transect line the observed Squirrel population in Ramna park was average 33.63/day and the density was $4 \times 10^{-10} / \text{km}^2$.

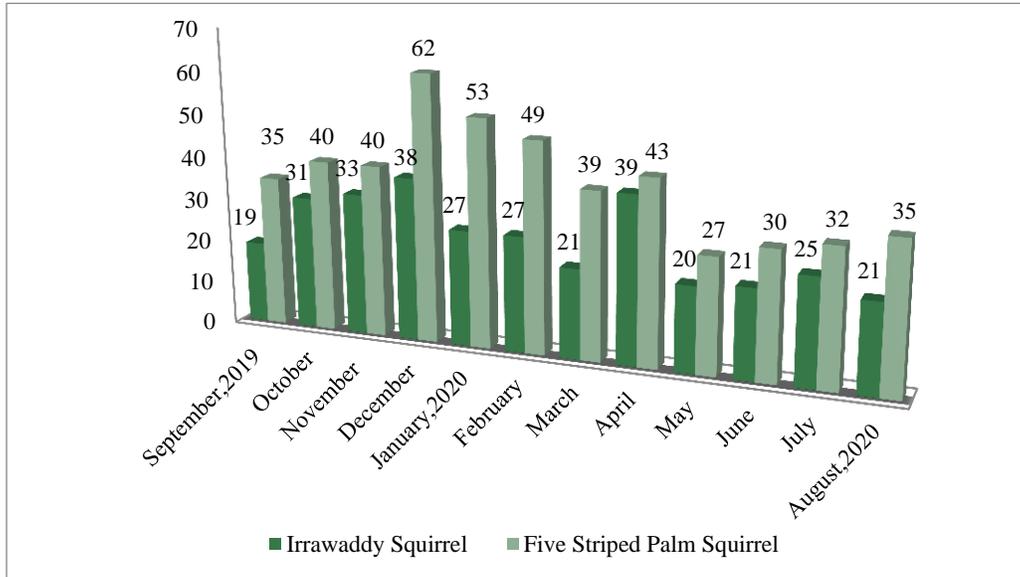


Fig. 4. Monthly observing of two squirrels at Ramna Park.

Highest sightings of Five striped palm squirrels were in December 2019 (N=62) and lowest observation was in May, 2020 (N=27). In case of Irrawaddy squirrel, highest sighting was observed in April 2020 (N=39) and lowest in September 2019 (N=19). (Figure 4). Squirrel was encountered greatly 12.39% in month of December 2019 and lowest encounter was 5.82% in May 2020. During data collection, highest humidity (94%) was recorded in July 2020 then total no of encountered squirrels was 57 individuals. In contrary, lowest humidity (49%) was in March 2020 and that time the total number of encountered Squirrels was 60 individuals. Highest temperature (38°C) was felt in May, 2020 then total number of sighted squirrels was 47 individuals. On the other hand, lowest temperature (15°C) was recorded in December 2020 and then total sighted Squirrels was 100 individuals. Observations suggest that diurnal squirrels are more active in morning than afternoon. The abundance of food is available in morning than afternoon because some morning visitors discarded some supplementary foods that also increase the chances of squirrels sighting at morning than afternoon. As they are not disturbed too much by the human, they are not afraid of human activities like other rodents so the abundance of squirrel is superfluous in the morning time. Of the recorded squirrels, 494 individuals (61.21%) were sighted during morning shift of survey and rest 313 individuals (38.79%) were encountered at afternoon. There 205 individuals of Irrawaddy squirrel (63.66%) and 289 individuals of Five striped palm

squirrel (59.58%) were encountered at morning. In contrary, 117 individuals of Irrawaddy Squirrels (36.34%) and 196 individuals of Five Striped Palm Squirrels (40.42%) were found at afternoon Fig (5&6). Although most significance differences were absent in preference of time in activeness of the two species.

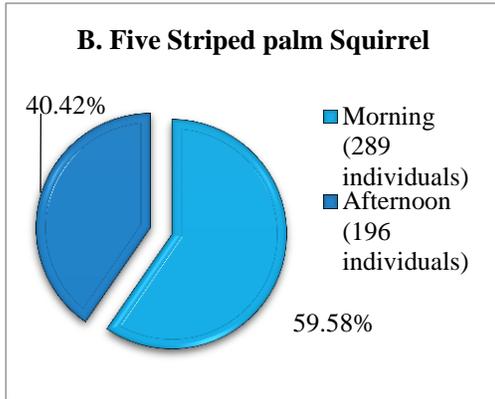


Fig. 5. Activeness of Irrawaddy squirrel.

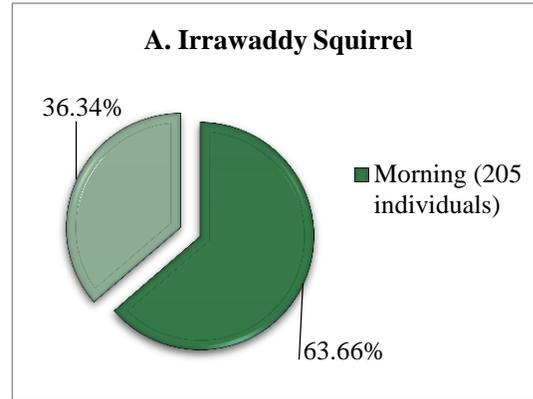


Fig. 6. Activeness of Five striped palm Squirrel.

Five Striped Palm Squirrels prefers ground than to be in trees. They are mainly ground dwelling rodents. In contrary, Irrawaddy Squirrels prefers tree than ground. However, in reacting to disturbance, to avoid predator attack, to pick up fruits, for mating and to stay at night Five Striped Palm Squirrels prefer trees. On the other hand, Irrawaddy Squirrels comes to ground mostly for feeding purpose and due to fragmentation effect. A total of 372 Squirrel individuals were encountered in ground and 435 individuals was found in climbing trees. However, 273 Irrawaddy Squirrel were spotted on tree and 323 Five Striped Palm Squirrels were found on ground.

Feeding behavior

Squirrels are primarily herbivorous and omnivores. A total of 280 feeding events of squirrels were accomplished by two squirrels, among them 120 eating events were observed in case of Irrawaddy Squirrels and 160 feeding events were executed by Five Striped Palm Squirrels. During feeding occasions, plant food, animal matter and additional foods were encountered for 70 times, 10 times and 20 times for Irrawaddy Squirrels and 120 times, 15 times and 25 times for Five Striped Palm Squirrel respectively (Fig. 7).

Table 2. Feeding Behavior of Irrawady Squirrel (Is) and Five Striped Palm Squirrel (Fsps) in Ramna Park on Various Food Items.

Plant Species Name	Plant type	Leaves	Flower	Bark	Fruits	Seeds	Twig
Black plum <i>Syzygium cumini</i>	Fruit Plant			Is	Is, Fsps	Is, Fsps	
Kathgolap <i>(Plumeria alba)</i>	Flower Plant		Is				Is
Durba grass <i>Cynodon dactylon</i>	Grass Plant	Is, Fsps					

Plant Species Name	Plant type	Leaves	Flower	Bark	Fruits	Seeds	Twig
Mango <i>Mangifera indica</i>	Fruit Plant				Is, Fsps	Is, Fsps	
Guava <i>(Psidium guajava)</i>	Fruit Plant		Is		Is, Fsps	Is, Fsps	Is
Kodom <i>Neolamarckia cadamba</i>	Flower Plant		Is, Fsps				
Gaub tree <i>Diospyros malabarica</i>	Fruit Plant		Fsps		Is	Is	
Amra <i>(Spondias pinnata)</i>	Fruit Plants	Fsps			Is, Fsps		
Jackfruit <i>(Artocarpus heterophyllus)</i>	Fruit Plant	Is	Is, Fsps	Is	Is	Is	
Papaya <i>(Carica papaya)</i>	Fruit Plants				Is		
Kathbadam <i>(Terminalia catappa)</i>	Fruit Plant				Is, Fsps		
Rose Apple <i>(Syzygium jambos)</i>	Fruit plant		Is		Is		
Coconut <i>(Cocos nucifera)</i>	Fruit Plant		Is, Fsps				Fsps
Dumur <i>(Ficus hispida)</i>	Fruit Plant		Is		Is		
Sofeda <i>(Manilkara zapota)</i>	Fruit Plant		Is, Fsps		Fsps		Is, Fsps
Tulsi <i>(Ocimum sanctum)</i>	Medicinal Plant	Is, Fsps	Is	Is			
Arjun <i>(Terminalia arjuna)</i>	Medicinal Plant	Fsps	Is, Fsps				
Vasak <i>(Adhatodavasica)</i>	Medicinal Plant	Is, Fsps	Is				
Neem <i>(Azadirachta indica)</i>	Medicinal plant	Is,	Is				Is, Fsps
Mehedi <i>(Lawsoniainermis)</i>	Medicinal Plant	Fsps	Fsps				Is
Beli <i>(Jasminum sambac)</i>	Flower Plant	Is	Fsps	Is			
Rangan <i>(Ixora coccinea)</i>	Flower Plant		Is			Is	

Plant Species Name	Plant type	Leaves	Flower	Bark	Fruits	Seeds	Twig
Jaba (<i>Hibiscus mutabilis</i>)	Flower Plant	Is, Fsp					
Grass (<i>Cyperus sp.</i>)	Grass Plant	Is, Fsp		Is, Fsp			Fsp
Animal Materials	Termites	Bird carcass	Insects	Ants	Termite's nest	Meats	
	Is, Fsp	Is	Is, Fsp	Is	Is, Fsp	Is	

* Here, Is = Irrawaddy Squirrels and Fsp = Five Striped Palm Squirrels

Addition al Foods	Junk food	Chocolate	Banana	Tea	Breads	Ice cream	Chips	Juice
	Is, Fsp	Fsp	Is,	Is	Is, Fsp	Is	Is	Fsp

Above data showed that plants were the main food sources of squirrels in Ramna Park. Few animal sources (Termites, Bird carcass, Insects, Ants, Termites nest and Meats) and additional food materials (Junk food, Chocolate, Banana, Tea, Breads, Chips, Ice-cream and Juice) were also consumed by squirrels during study period and both items were more preferable to Irrawaddy Squirrels compare to Five Striped Palm Squirrels. A total of 24 plant species were used that comprised of four types of plant species such as fruit plants, grass plants, flowering plants and medicinal plants (Table 2). Of these plant species, following 21.33% , 28%, 8%, 21.33%, 10.66% and 10.66% species were used for leaves, flowers, bark, fruit, seed and twig respectively as shown in (Fig. 8)

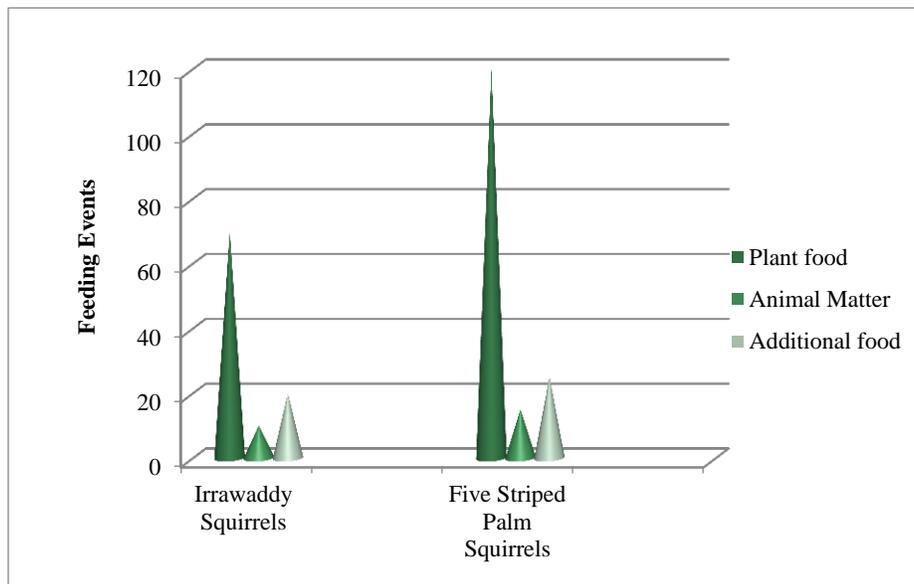


Fig. 7. Different feeding events of two squirrels at Ramna Park.

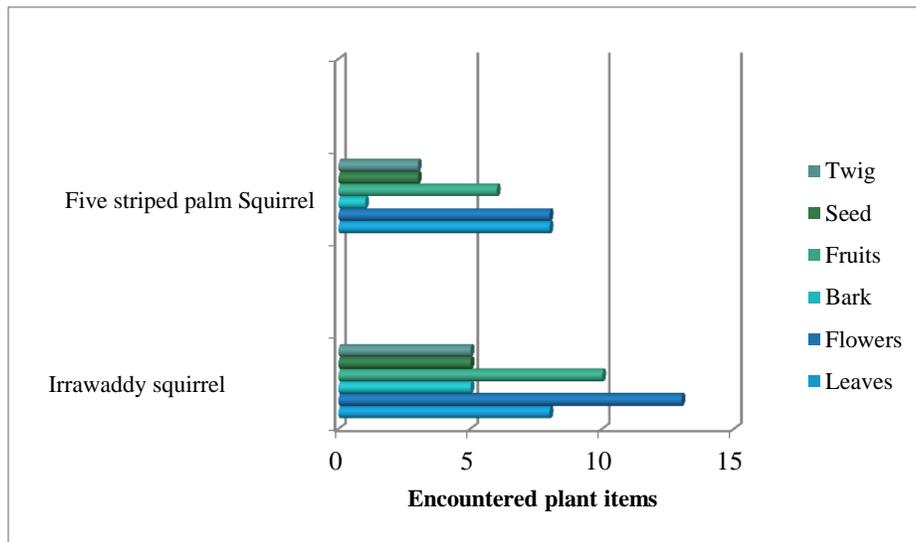


Fig. 8. Plant food items of two squirrels at Ramna Park obtained from different plant species.

The present study reveal that the Irrawaddy Squirrels consumed more fruits and flowers than Five Striped Palm Squirrel but the consumption rate of seeds and twigs were more or less similar in case of both squirrels.

Discussion

About 33.63 squirrels individuals on an average were sighted per day through the all transect lines in Ramna Park and obtained density was $4 \times 10^{-10} / \text{Km}^2$. We were unable to study their population trends because no earlier squirrel population data was available at the park. Irrawaddy Squirrels density was found to be higher in plantations (10.1 individuals per km^2) and severely logged woods (23.4 individuals per km^2) than in lightly logged woods (1.8 individuals per km^2) and unlogged primary forests (2.7 individuals per km^2) (Datta and Goyal 2008, Datta and Nandini 2014, Duckworth 2016).

Irrawaddy Squirrels was found in secondary forests more frequently than primary forests, and most frequently near communities, cane shrubs at the forest's edge, plantations, and agricultural regions (Smith and Xie 2008, Thorington *et al.* 2012, Thapa *et al.* 2016). Similarly, Five striped palm squirrels has been observed in a variety of habitats, including tropical and subtropical dry deciduous forests, montane forests, grasslands, scrublands, plantations, arable lands, rural gardens, agricultural lands, urban areas, and introduced vegetation (Molur *et al.* 2005, IUCN Bangladesh 2015, Nameer and Molur 2016).

During the nineteenth century, Five striped palm squirrels was introduced to Australian zoos and formed feral populations in metropolitan areas, which revealed greater numbers (10-130 squirrels per km^2) and higher densities (10-130 squirrels per km^2) (Seebeck 2013). Five striped palm squirrels density rose with the availability of additional meals, nesting, and fruiting trees,

according to Wright, 1972. In addition to dietary and nesting requirements, Datta and Goyal 2008 found that the degree of arboreality had an effect on squirrel population. Both squirrels were observed consuming both plant and animal materials. Squirrels were observed taking a wide array of foods including nuts, fruits, seeds, leaves, barks, flowers, palm juice, ants and other insects. However, as a human dominated place we observed its effect in feeding of squirrels. We found squirrels to take waste chocolate, rice, bread, ice-cream, chips, banana, and nuts etc. as additional food items that were given by the visitants of park areas. Although our data shows similarities to their known feeding behaviors, but we cannot say that these food elements are the main foods of squirrels based on our tiny data set of sporadic individuals. Smith and Xie 2008, Thorington *et al.* 2012, IUCN Bangladesh 2015 stated that leaves, flower buds, fruits, bark seeds, insects, nectar, latex, lichen, vertebrates, and date juice had been reported as food sources for Irrawaddy Squirrels. On the other hand, Five striped palm squirrels is known to feed on tender shoots, leaves, fruit, vegetables, puffed rice and bread offered by the visitant, some small animals (such as birds, lizards), honey from unprotected beehives, bird's eggs and insects (coleopteran larvae, termites, dipteran larvae and caterpillars) (Thorington *et al.* 2012, Shihan 2013, IUCN Bangladesh 2015, Thapa *et al.* 2016) which are more or less similar to the present findings of both squirrels of Ramna Park. Higher consumption of fruit and leaves was recorded for both squirrels at Ramna Park whereas (Shihan 2013) reported that grass leaves (*Cynodon dactylon* and *Cyperus* sp.) was the most preferred food item of Five striped palm squirrels in rural habitats. In human dominated forest flower, fruit and bark were found as important resources for five striped palm squirrels (Datta and Nandini 2014). Sometimes *Funambulus* sp, preferred insects as a protein source over nuts and fruit (Méndez-Carvajal *et al.* 2016). Chocolate is indeed a delicious treat and squirrels will steal it if they get a chance. Chocolate contains an alkaloid called Theobromine which is harmful to most mammals (Young 2013). In our findings both Irrawaddy squirrel and five striped palm squirrel are very much fond of white chocolates. If eaten in large quantities, squirrels will end up having a lot of theobromine in their system and it could be fatal to them. To prevent this from happening, it's best not to give chocolates to squirrels. Inadequate nutrition causes Metabolic Bone Disease (MBD) in squirrel it causes a squirrel's bones to weaken (Oshida 2013). Junk food like salted and sugared snacks has little nutritional value (Young 2013). The salt is also very bad of squirrels while the sugar has much the same effect as in children (Nameer 2016). We observed that squirrels were consumed the wasted part of human throwing junk food at Ramna Park it contains sugar and salt that might be causes to create problem to their body mechanism so their natural food habit is interrupting slowly because of these supplemental foods which are available in urban area like Ramna Park. In spite of these discarded foods Ramna Park represent a good number of local food resources to support a variety of animals (Nahar *et al.* 2017). In Ramna Park the squirrel population is relatively safe and satisfactory there. *Funambulus pennantii* is richer than *Callosciurus pygerythrus* in terms of abundance. Squirrel is mainly herbivore and omnivore and their food items were adequate in the park. Squirrel displayed a variety of feeding behavior but their diet was generally dominated by leaves and grass with comparatively less composition of fruits and flowers. This suggests that squirrel of Ramna Park is more herbivorous and omnivorous than frugivorous. Squirrel love to eat human supply food

which diverts them from natural food findings. It is a concerning issue because all human supply food do not produce enough nutrition and some are toxic too. Feeding the squirrels also makes them lose their natural fear of humans. Next, the squirrels move into people houses where food, safety and warmth are plentiful. Some squirrels are also known to get aggressive when not fed. These critters can easily become a nuisance once they stop fearing humans. During the research period, no predator attacks were observed. Disturbing factors were low and human movements were not available there because of COVID pandemic. Aside from that, the park Authority aims to protect and recover endangered species.

Conclusion

The squirrel population in Ramna Park might be decrease due to noise, pollution, human disturbances, neglected concerns, and uncontrolled park management. Therefore, more fundamental and ecological studies are needed to address the concerns and efforts for protection and to assist conservation biology of other endangered animals and priority basis investments to the neglected group are needed to understand its void ecology, because these squirrels are both economically and environmentally important. Squirrels harm crops as pests. Squirrels, on the other hand are essential seed dispersers. Park staff must be trained in scientific methods of squirrel monitoring in their locations. For the survival of these attractive and fascinating species, new and innovative measures must be employed.

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