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ECOLOGY AND BEHAVIOUR OF MALABAR GIANT SQUIRREL, *Ratufa indica maxima (Schreber)*

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INTRODUCTION

There are four species of diurnal giant tree squirrels in Oriental region belonging to the genus *Ratufa*. They are the cream coloured *R. affinis*, restricted to the Malayan forests; the black coloured giant squirrel *R. bicolor*, found in the Malayan region and north eastern region of India and Burma; the grizzled giant squirrel *R. macroura*, found in Sri Lanka and in the dry deciduous forests of Srivilliputtur area in Tamil Nadu; and the Indian giant squirrel *R. indica* found in peninsular India. The Malabar giant squirrel, *R. indica maxima* is one of the seven races of Indian giant squirrels which is found in the southern part of the Western Ghats and is the most colourful of all the races. This animal is distributed in evergreen and moist deciduous forests. There is very little information available on the ecology and behaviour of this species. The present study was conducted in the moist deciduous forests of Parambikulam Wildlife Sanctuary in Palghat District of Kerale State between January 1983 and June 1985.

STUDY AREA

Location

The study area is located in the Thellikkal region of Parambikulam Wildlife Sanctuary at about 10°27' N latitude and 76°45' E longitude at about 520 m. The area lies adjacent to the confluence of Thekkady river with the Vetiar river (Fig 1.) The area is frequented by elephants, gaur, sambar deer, spotted deer and wild boar. The arboreal animals of the area are giant squirrel, Nilgiri langur, bonnet macaque and flying squirrel.

Vegetation

The vegetation of Thellikkal area is of moist deciduous forests (Fig 4) with dominant trees like *Xylia xylocarpa, Terminalia paniculata, Lagerstroemia microcarpa, Dilienia pentagyna, Dalbergia sissoides, Grewia tiliifolia, Rader machera xylocarpa* and *Terminalia crenulata* which accounted for about 75% of the total trees. Teak plantations occupy the western and north eastern sides of the study area. The under growth is mainly of regenerating bamboe and species of *Chromolaena, Lantana,* grasses and species of *Curcurna.* Hugo lianas like *Zizyphus oenoplia, Acacia rugata, Spatholobus roxburghii, Calycopterus floribunda, Dalbergia volubilis* and species of *Cissus* are also found in this area.

METHODS

Phenological observation

Five trees each of the ten most important tree species in the study area were selected randomly and the abundance of flower, fruit, leaf flushing and leaf fall were noted and qualitative data were collected every month.

Observation of giant squirrels

Direct observation of activity pattern, feeding preference and social interaction were made in the field between dawn and dusk with the help of 10x35 Leitz binoculars. Observations were made for about seven days every month from January 1983 to June 1985 and activities were recorded.

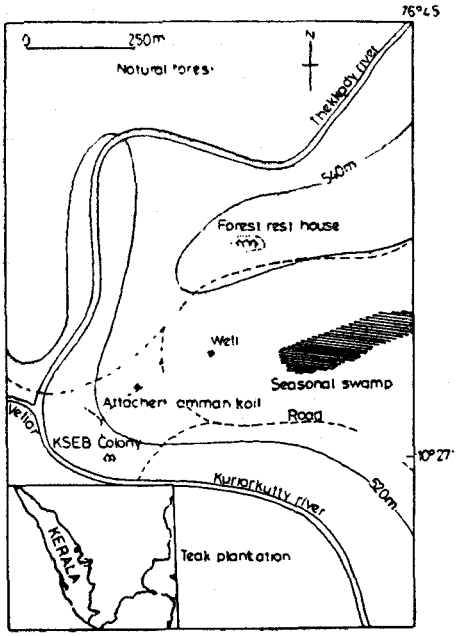

Fig 1. Study area, inset location

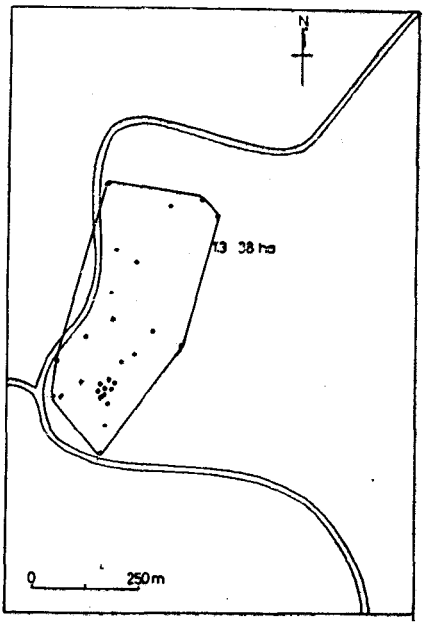

Fig 2. Feeding locations and home range of a female Malabar giant squirrel

No	Species	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	Xylia xylocarpa	↑⊕	↓⊕	↓⊕	↑	↑	↑	↑	↑	↑○	↑○	↑○	↑⊕
2	Dillenia pentagyna	↓	↓	↓○	↓○	↓○	↑●	↑⊕	↑	↑	↑	↓	↓
3	Lagerstroemia microcarpa	↓	↓	↓	↑	↑	↑	↑	↑	↑	↑	↓	↓
4	Radermachera xylocarpa	↑⊕	↓⊕	↓	↑○	↑	↑	↑	↑○	↑○	↑○	↑⊕	↑⊕
5	Grewia tiliifolia	↓	↓	↓	↑	↑○	↑○	↑⊕	↑	↑	↑	↑	↓
6	Terminalia crenulata	↓	↓	↓	↑○	↑○	↑○	↑○	↑○	↑○	↑○	↑⊕	↓
7	Terminalia bellerica	↑	↑	↓	↓	↑	↑	↑○	↑○	↑○	↑⊕	↑⊕	↑
8	Terminalia paniculata	↓⊕	↓⊕	↓	↑	↑	↑	↑	↑○	↑○	↑○	↑○	↓⊕
9	Schleichera oleosa	↑	↑	↑	↑○	↑⊕	↑○	↑○	↑⊕	↑⊕	↑	↑	↑
10	Cordia wallichi	↓	↓	↓○	↑○	↑⊕	↑	↑	↑	↑	↑	↑	↓

Key -

↑ Leaves growing
↓ Leaves falling
↑ Mature leaves
↓ Without leaves
○ In flower
⊕ Young fruit
⊕ Mature fruit

Fig 3. Phenology of ten tree species at study area

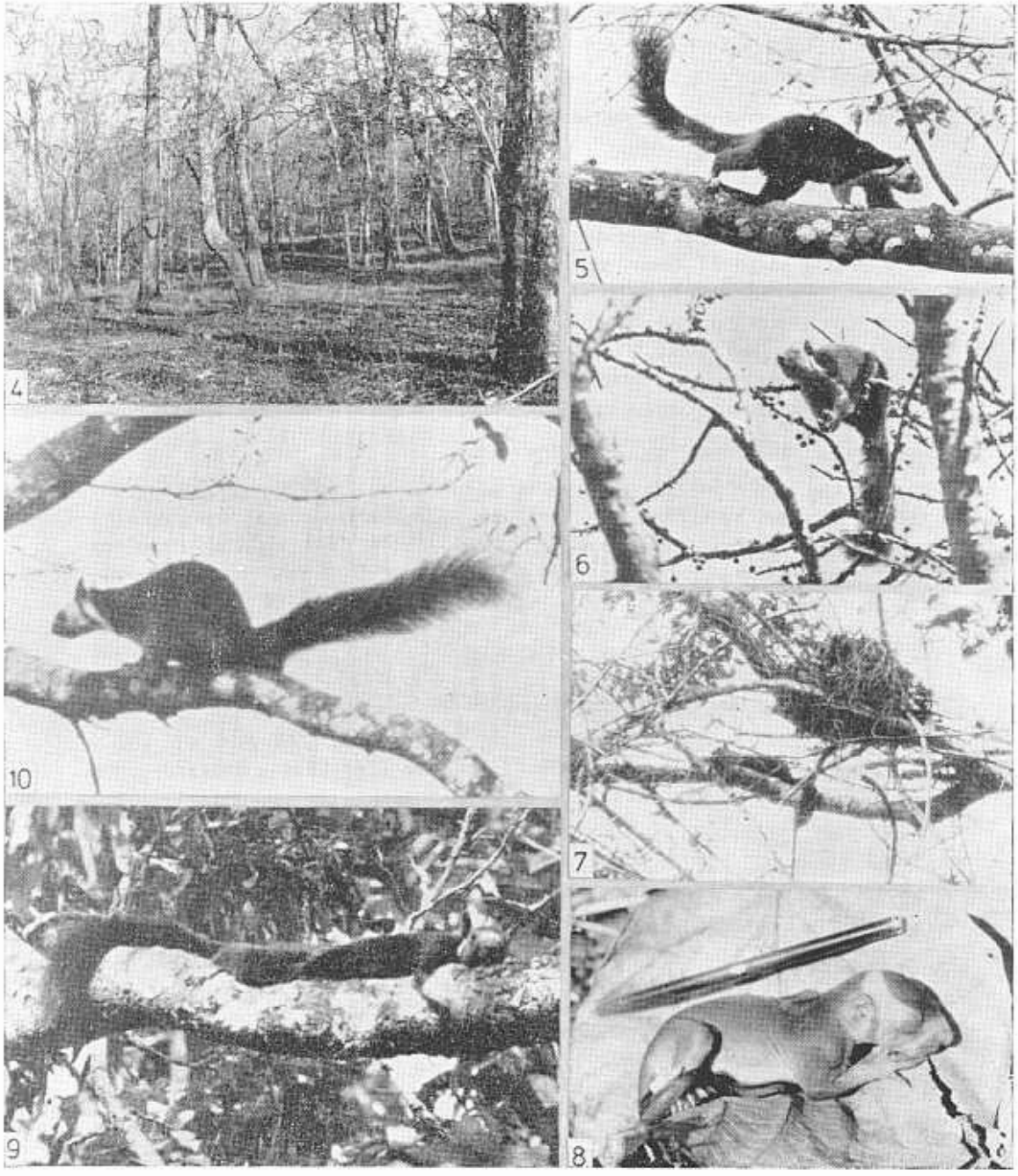

Fig 4. A view of the moist deciduous forest at Thellikkal in summer Fig 5. The female giant squirrel whose three breeding seasons were followed Fig 6. Squirrel feeding on DILLENIA PENTAGYNA seeds Fig 7. View of a nursery drey with the attendant mother near it Fig 8. Young one about fifteen days old whose eyes were not open Fig 9. Resting posture Fig 10. Marking posture.

As the squirrels were more active during the morning and evening hours, searches for them were concentrated in the morning and evenings to know the food preference for each season.

The activities were divided into eight major categories, viz., 1 feeding, 2 resting, 3 travel, 4 intraspecific activities, 5 grooming, 6 communicatory behaviour, **7** drey related activities and 8 other activities.

Recording of observation on behaviour

Complete record method (Altman, 1974; Slater, 1978) was employed for recording the behaviour of the squirrel. The position of the animal in the canopy was recorded together with the locality. Observation was discontinued if the animals were disturbed. Individual animals were recognised by noting some of their peculiarities. In one female (Fig 5), the tail was bent. In another individual the ear pinna was cleft. During the study period a young one of the 'Bent-tail' was captured from the drey and was freeze branded (Rood and Nellis, 1980) for identifying that individual later. Data on the behavioural observations were collected from four females, three males and two young ones.

Home range estimation

Home range of the giant squirrels was arrived at by plotting the sighting location of the known individuals. The drey use and foraging area were marked on a map by following the individuals. The sighting locations were analysed using minimum convex polygon method (Stuwe and Blohowiak,

RESULTS

Phenology of important tree species at Thellikkal

Details of phenology i. e., flowering, fruiting, leaf fall and leaf flushing of ten important tree species found in Thellikkal area are given diagrammatically in Fig 3.

Feeding habits

Food items eaten by the squirrels during different months of the year are given in Table 1.

Activity pattern

The Malabar giant squirrels were observed for a total of 303.5 hours. Out of this 46.90% were spent in feeding; 28.2%, in resting; 18.9% in travel; 2% in intraspecific activities;0.3% in grooming; 1.4%in communicatory behaviour; 2.2% were spent in drey related activities; 0.1% were spent in other activities namely drinking, urinating, defecating.

Hourwise distribution of the percentage time spent in feeding, resting and travel are diagrammatically represented in Fig 11. The animals activity is restricted to the day hours since the animal is strictly diurnal. In the morning as soon as the day light appears the animal comes out of the drey, reaches the food tree and starts feedings. From 0600 hrs to 1100 hrs feeding is the most dominant activity with a peak between 0700 hrs to

Table 1. Food items eaten by Malabar giant squirrel in Thellikkal during different months

Month	Plants species	Plant part (s) eaten
January	*Xylia xylocarpa*	Seed
	Zizyphus oenoplia	Fruit
	Bombax sp.	Flower
February	*Xylia xylocarpa*	Seed
	Radermachera xylocarpa	Seed
	Grewia tiliifolia	Leaves
March	*Xylia xylocarpa*	Seed & flower
	Dillenia pentagyna	Flower
April	*Cordia wallichit'*	Seed
	Dillenia pentagyna	Fruit
	Xylia xylocarpa	Seed
	Schleichera oleosa	Seed
	Zizyphus oenoplia	Fruit
May	*Cordia wallichii*	Seed
	Dillenio pentagyna	Flower
	Lagerstroemia microcarpa	Leaves & twigs
	Terminalia crenulata	Flower
June	*Schleichera oleosa*	Seed
	Ficus SP.	Leaves
July	*Dillenia pentagyna*	Seed
	Schleichera oleosa	Seed
	Lagerstroemia microcarpa	Leaves
August	*Lagerstroemia microcarpa*	Bark
	Grewia tiliifolia	Leaves
September	*Terminalia crenulata*	Seed
	Lugerstroemia microcarpa	Bark
	Grewia tiliifolia	Bark
	Ficus sp.	Leaves
October	*Terminalia crenulata*	Seed
	Lagerstroemia microcarpa	Twigs
	Grewia tiliifolia	Leaves
November	*Lagerstroemia microcarpa*	Twigs & leaves
	Radermachera xylocarpa	Seed
	Grewia tiliifolia	Leaf petiole
	Terminalia crenulata	Seed
	Bombax sp.	
December	*Radermachera xylocarpa*	Seed
	Bombax sp.	Flower
	Terminalia crenulata	Seed

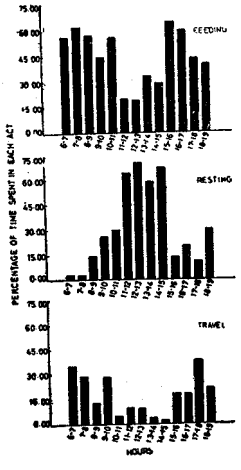

Fig 11. Percentage of time spent in feeding, resting and travel during day hours.

0800 hrs. In the afternoon the feeding activity is most in the 1500 hrs to 1600 hrs. There is a bimodal activity pattern for feeding (Fig 11). Majority of the resting occurred between 1100-1500 hrs with a peak between 1209-1300 hrs. Majority of the travel occurred during the morning hours and the evening hours. During morning hours the squirrel travels away from the drey and in evening the travel is towards the drey. Feeding (Fig 6) and resting (Fig 9) ranged from 10 minutes to over three hours but travel was comparitively of lesser duration.

Drey construction and occupancy

The location of dreys are mostly at the forked branch where crowns of neighbouring trees interlink so as to allow easy access for jumping and moving away from the drey. Sometimes the drey is situated inside the tree canopy in which lianas of *Zizyphus oenoplea* had grown entangled (Fig 7). The drey is usually lined with tender leaves. Drey maintenance in one instance lasted for about an hour continuously. During that period the squirrel brought small terminal twigs of *Xylia* sufficiently away from the drey eventhough there was sufficient foliage nearby.

It was observed that an individual giant squirrel would often construct several dreys within the home range during a season. A drey of the female Bent-tail with its newborn was located in January 1985. There was another drey in the adjacent tree. The distance between the two dreys was only less than 10 m. The frequency of visit by the lactating female to the drey seemed to be very few. Generally in the morning the/squirrel goes for foraging and, the young one is kept inside the drey. The female lactating squirrel visits the drey mostly in the mid day.

Home range

The sighting locations of the Bent - tail female squirrel for the whole study period were pooled for the calculation of the home range. The home range area (Fig 2) calculated by the minimum convex polygon method was 0.1338 km^2 (13.38 ha). There were 23 giant squirrels in an effective area of 70 ha which had canopy continuity. They consisted of six females, five males, four young ones and eight unsexed individuals. The density of squirrels in the study area was 31/$km.^2$

DISCUSSION

Feeding habits

Seeds of nine tree species given in Fig 3 are fed by giant squirrels but leaf petiole, twigs and bark of only two species namely *Lagerstroemia microcarpa* and *Grewia tiliifolia* were fed extensively. The most abundant tree in the study area is *Xylia xylocarpa* which is a good food tree. Seeds of *Xylia* are preferred during the months of December, January, February and

March but leaves of that tree is not preferred during any season. Second most abundant tree is *Terminalia paniculata* which is used as a drey tree bat not as a food tree. The non-dependnce on the abundant seeds of *Terminalia paniculata* is probably due to the availability of more bigger seeds such as *Xylia xylocarpa* during that period. In the month of August the animal fed mostly on the bark and leaves of *Lagerstroemia microcarpa* and *Grewia tiliifolia*. During this period the abundance of other seeds is very less. Through out the study period either one of the ten species (in Fig 3) were in flower or fruit. Cacheing behaviour was not observed in the animal. In the eight dreys inspected none had any food items cached in it. This is a dear indication of the abundance of food in the habitat.

Though there were a number of huge *Haldina cordifolia* trees in the study area the squirreis were not found to feed on them. Feeding is confined to the middle canopy and very rarely the animal came to the ground to feed on the scattered seeds. Since it gnaws the large seeds its role in dispersal of large seeds is unlikely. Unlike the debarking by grey squirrels (Kenward, 1982), debarking by giant squirrels does not lead to destruction of trees. In the study area, the squirrels were not found to feed on animal matter, though feeding on leaf petiole infested with coccid bugs was observed in Periyar Tiger Reserve. Krishnan (1975) reported it feeding on termites. It is not clear whether they act as dispersers of the small seeds on which they feed.

The animal probably meets its water requirement by feeding on the flowers and leaves. Only two observations were recorded in which two squirrels drank rain water from a hole in a tree trunk. The study area was by the side of a river but squirrels were not seen coming down to the riverside to to drink water.

The Malabar giant squirrels are generally restricted to the natural forests. However in older teak plantations in the sanctuary giant squirrels were sighted. As mentioned earlier, the animal's opportunistic dependence on seeds and switching over to leafy food items during the non-availabilty of seeds have made it possible for the animal to maintain a stable population in deciduous forest patches.

Home range

Malabar giant squirrels are solitary and each animal is restricted to a small home range. The males' home ranges were found to overlap with that of the females. This agrees with the results of Payne (1979) regarding *Ratufa affinis* and *Ratufa bicolor* in Malayan forests. The males and females occupy different dreys. A known Bent tail giant squirrel was found to use an area of 13.38 ha during the three year period. The longest foraging travel observed in a single day for that female was about 800 m. The centre of activity of a lactating female was restricted to an area of 2.5 ha. The nursery drey for each year was found to be different. Each year during the birth of a young one the centre of activity of the mother was changed. By this time, the weaned young one occupies the previous year's home range. This happens when the young one is pushed away to the periphery of the new centre of activity which is around the new nursery drey. Payne (1979) has estimated a

density of 11 *Ratufa biclor* / km2 and 26 *Ratufa affinis* / km^2. Based on sightngs of all the giant squirrels in the present study area the estimated density of *R..i. maxima* was 31 /km^2.

Intraspecific interaction

The mating season of the giant squirrel was found to be in the months of October and November. The cleft eared male was seen initiating a courtship by going near the female, then it moved away to a tree to cut a twig and brought it and placed on a forked branch. The female also came near the male and afterwards courting was initiated. In another mating a male (probably a dominant male) made a particular call with a low tone. In response, a female about 50 m away, which was chased by two other males came to the dominant male's area and the male initiated courtship. All the attempts of mating was seen on the vertical tree bole. The courtship involved was a series of run and chase by the female and the male. The male runs towards the female which is climbing up the tree and when the male almost reaches the female the female turns and rushes down the tree trunk in an agressive way. The male also turns and comes down the tree trunk a few meters. This chasing was seen repeated for about 15 times in one hour. In the three courtships observed during the study period two were unsuccessful and one resulted in successful mating. Mounting lasted for a few seconds.

It is reported that in captivity the gestation period is around 50 days. The pups are born naked and eyes are not open. Naidu (1986) has observed the birth and development of the young one of Malabar giant squirrel in captivity. **A** squirrel pup (Fig 8) captured from the drey had a body length of 13 cm (excluding tail) and weighed 80 g. The development after birth is very fast. After two months the young one has all the coat colour pattern of the adult, is about half the size of the mother. In the period before the young begins to follow the mother, the mother comes to the drey some time in the noon. After leaving the drey it returns to it before sunset, There is some sort of signalling between the mother and the young one. When the young one is about two months old, as soon as the mother squirrel comes near the drey, the young one comes out to join the mother. They together may go to the adjacent tree to feed. It is the mother giant squirrel that enters the drey first, followed by the young one. The young one begins to follow the mother three months after birth and imitates all the activities the mother does. Thus different parts of the home range are familiarized by the young. During the resting period the young one was seen grooming the mother and in evening it used to chase the mother in a play.

The major ioteraction observed between the individuals of Malabar giant squirrel are the mother-young interaction during the pre-weaning period. During the first two months after the birth of the pup it is nursed by the mother who visits the drey in which the pup is hidden.

The juveniles of giant squirrels are often chased by males which enter the fruit tree. In the early months of the young one tho mother giant squirrels are found to scare the intruders. No instance of infanticide was observed,

Female Bent tail's three breeding seasons were followed. The first two years' young ones survived. The third year's young one was not seen after one month. It is assumed that the young one was missing, probably due to some predation.

The present data do indicate the significance of Malabar giant squirrel's marking behaviour (Fig 10). The males are seen more often marking the arboreal pathways. It could be possible that by this behaviour the dominant male advertises its presence to other individuals. On several occasions the males were seen in the home ranges of females. The males when they meet the females on the arboreal pathways approached cautiously and most of the times gave way to the females. This behaviour of avoiding antagonism was seen in the case of Bent - tail and another male which was in the nearby area.

Interspecific interaction

It seems there are no mammalian predators to the giant squirrels in Thellikkal. In most cases the call of the crested serpent eagle *(Spilornis cheela)* and black eagle *(Ictinaetus malayensis)*, which soared over the canopy, made the squirrels to respond to by calling as to warn the presence of the potential avian predators to other squirrels. Cumulative effect of various giant squirrels calling at the instance of an avian predator alerted the whole set of squirrels. Three unsuccessful hunts by birds of prey were observed during the study period. The prey involved were solitary individuals. In all the cases the giant squirrels made alarm calls and moved away and froze.

CONCLUSION

Malabar giant squirrel, *Ratufa indica maxima,* feeds on a varietv of seeds. It also feeds on leaves, flowers and bark when the availability of seeds is scarce. The squirrel was not observed cacheing. They have over-lapping home ranges. A female used a home range of 13.38 ha during three years in the Thellikkal area of Parambikulam Wildlife Sanctuary. During the three successive years it had given birth to three young ones. A female giant squirrel had a centre of activity of about 2.5 ha during the lactating period. The density of giant squirrels in the study area was 31 individuals/km2. Out of the 303.5 hours observed, giant squirrels spent 46.9 % of time in feeding, 28.2% in resting and 18.9 % in travel which were the major activities. The female squirrels construct several dreys in its home range during the lactating period. These satellite dreys were used for shifting the young ones case of any danger to the drey. The young ones were kept hidden in the drey during early stages. The males and females were occupying different dreys. Mating season of giant squirrel was between October and November. Pups are born between December and January. The young one begins to follow the mother three months after birth. The major intraspecific interaction observed between the Malabar giant squirrels were the mother-young interaction during the pre-wea ning period. The male giant squirrels were observed to mark the arboreal path-ways. Alarm calling was observed to play an important role in antipredator behaviour. Birds of prey like crested serpent eagle and black eagle are the main predators of Malabar giant squirrel.

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