



Activity Pattern of the Malabar Giant Squirrel (*Ratufa indica maxima*) in Karikulam Forest Range of Ranny Division of Kerala, India

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Abstract: The Malabar giant squirrel (*Ratufa indica maxima* (Schreber 1784)) is an arboreal species, endemic to the forests of the Western Ghats, India. The present study was undertaken with the objective of systematically examining the activity patterns and feeding behaviour of the Malabar giant squirrel in the Karikulam forest of Kerala from March to November, 2021. The research employed the focal animal sampling method, to systematically collect data on the activity patterns and feeding behavior. Total of 13,590 minutes of focal sampling was conducted. Feeding and resting behaviors, accounted for approximately 86% of the squirrels' total observed activity. The squirrel exhibited significant feeding activity primarily during the early morning and late afternoon. The marked increase in resting behaviors was observed during the midday period. In terms of dietary preferences, the study indicate that the most frequently utilized species include *Xylia xylocarpa*, *Tamarindus indica*, *Terminalia paniculata*, *Terminalia crenulate*. The squirrels utilize 16 distinct tree species for nesting purposes. The trees predominantly selected for nesting include, *Xylia xylocarpa*, *Terminalia paniculata*, *Artocarpus hirsutus*, *Terminalia crenulate*. These findings highlight the species' dependence on specific tree species for both food and nesting, emphasizing the need to conserve these key resources to ensure the survival of *R. indica maxima* populations in the Western Ghats.

Keywords: Malabar giant squirrel, *Ratufa indica maxima*, Karikulam Forest

Malabar giant squirrel (*Ratufa indica maxima*) is widely distributed in the Indian peninsula (Agrawal and Chakraborty 1979, Jathana et al., 2008) and is predominantly found across a range of natural forests from moist deciduous to dry deciduous forests types, old mature teak forests (Ramachandran 1988), riparian forests (Baskaran et al., 2011), and teak-mixed forests (Kumara and Singh 2006). It is known for its striking appearance, with a colorful pelage and large, bushy tail. As an arboreal mammal, the giant squirrel exhibits a range of fascinating behaviors and adaptations that enable it to thrive in its complex forest habitat. Much of its activity is mainly concentrated in the top to mid-canopy (Kumara and Singh 2006) as they prefer higher taller trees (> 15 m) for feeding and nesting (Baskaran et al 2011). The nesting behaviour and tree selection observed in different landscapes, showing a strong preference for large, contiguous canopy trees for nesting (Mudappa and Raman 2007). Being an integral species to the forest ecosystems of Kerala, exhibits distinct activity patterns critical for its survival and ecological role. Despite ecological importance, detailed studies on the activity patterns of the Malabar giant squirrel are sparse. Understanding these patterns is vital for conservation, as they reveal critical insights into the squirrel's behavioral ecology. This study aims to document and analyze the activity patterns of the Malabar giant squirrel in Kerala Forest ecosystems, Karikulam forest range, which is a fragmented forest near to Perumthenaruvu Waterfalls, falling under the Ranny Forest division, Kerala.

MATERIAL AND METHODS

Site location: The study was conducted in the Karikulam forest station in the Ranni forest range, Kerala, India. The area lies between 9°23'42"N and 76°49'42"E, covering approximately 136.2 square kilometers (Fig. 1). This research area has evergreen, semi-evergreen, and deciduous types of forests.

Methodology: The study was conducted from March to November, 2021. Data on activity patterns and feeding were recorded through direct observation using the focal animal sampling method (Altman 1974). Focal animals were followed, and observations were recorded on CANNON Digital camera. Observations were made for 3 days per week (6 hours per day: 6:00 am-8:00 am, 10:00 am -12:00 pm and 4:00 pm -6:00 pm) per month. Focal sampling was made at 15 minutes intervals (10 min observations and 5-minute break). The activities of the giant squirrels were grouped in the following seven major categories: 1. Feeding, which includes the foraging and consumption of food sources; 2. Resting, involving periods of relaxation and repose; 3. Travel, encompassing movement from one location to another; 4. Intraspecific activity, referring to interactions and behaviors within the squirrel population; 5. Grooming involves the cleaning and maintenance of fur and body (cleaning, licking, biting through the hairs and scratching); 6. Community behaviour, encompassing social interactions and engagements within the squirrel community; 7. Dray-related

activities, include behaviors associated with the construction and use of drays, such as nesting and sheltering activities. The remaining activities, namely chasing, defecation, urination, calling, nest building, and mating, are collectively classified as 'others' (Borges 1989).

RESULTS AND DISCUSSION

Activity pattern: Total of 13,590 minutes of observation were conducted using the focal animal sampling method to analyze the activity budget of the Malabar giant squirrel. The collective duration allocated to feeding (46.8%) and resting (39.1%) accounts for 85.9% of the daily activity of the squirrels. Squirrels spend most of their time feeding, which accounts for the largest portion of their daily activities. Movement makes up 9.2% of time, while other activities such as grooming, searching for food, chasing, and nest building collectively makeup 4.9%. Specifically, grooming accounts for 0.7%, food searching for 2.3%, chasing and mating for 0.3%, and drey-related activities for 1.6% of their time (Table 1, Fig. 2). Similar findings were reported in earlier studies, where feeding and resting dominated their daily schedules (Bhaskaran et al., 2011)

Feeding behavior: The squirrels frequently ascend to the extremities of branches to procure food items using its mouth while foraging. It subsequently relocates to sturdier, horizontal branches, where it assumes a seated position for feeding. It secures the food items primarily within its mouth, occasionally utilizing its forelimbs for support on these robust branches. In the current investigation, movements occurring over short distances within the same tree during feeding, with food material in the mouth or forelimb, were categorized as

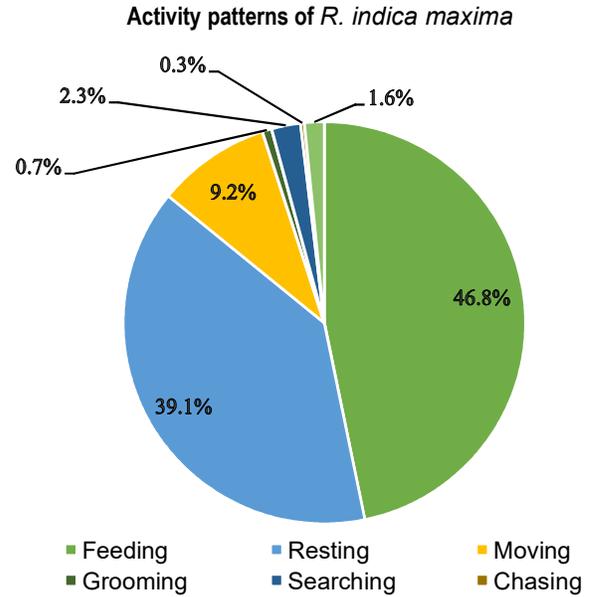


Fig. 2. Percentage of time spent on different activities

Table 1. Activity pattern and time spent for each activity by the Malabar giant squirrel

| Activity | Time spent (minutes) |
|--------------|----------------------|
| Feeding | 6356 |
| Resting | 5314 |
| Moving | 1241 |
| Grooming | 104 |
| Searching | 317 |
| Chasing | 42 |
| Nestbuilding | 216 |

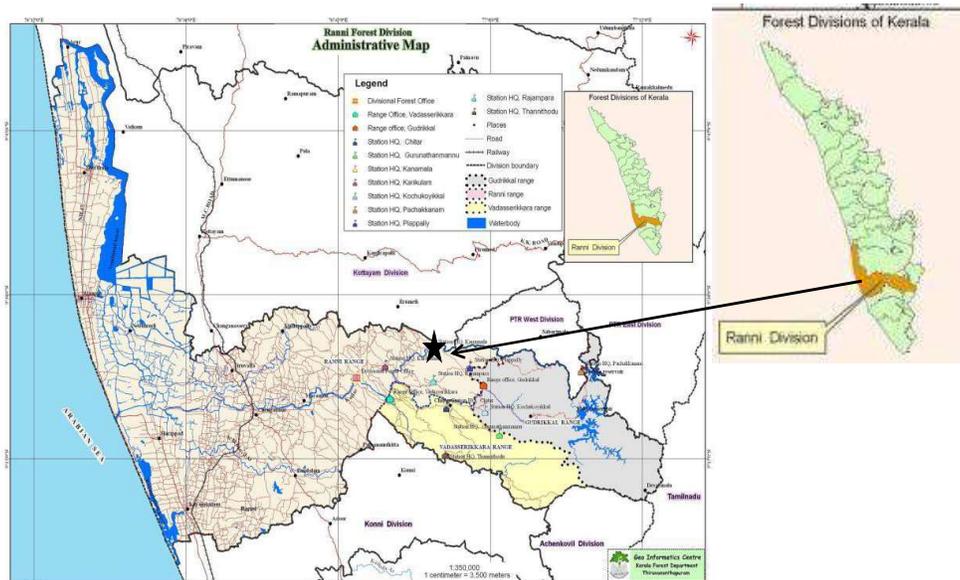


Fig. 1. Study area - Karikulam forest under the Ranni Forest division

part of the feeding activity. The allocation of time to various activities and the feeding behavior of different plant species were determined based on observations made over five months.

Food: *Xylia xylocarpa*, serves as a significant food source for the squirrels (Table 2). This tree bears flat seed pods, with its seeds being particularly favored during December through March. Giant squirrels play a crucial ecological role by dispersing seeds through consumption and defecation (Menon 2014). Conversely, the leaves of this tree are not preferred. Squirrels feed on the bark of seven plant species and consume termites. Their feeding behavior involves removing bark from trees to access termites. Among the tree species observed, *Xylia xylocarpa*, *Tamarindus indica*, *Terminalia paniculata*, and *Terminalia crenulata* are preferred for feeding by the squirrels. Nayak and Patra (2015) also observed that Malabar Giant Squirrels consume seeds, bark, and leaves, with seeds being the most preferred.

Feeding and other activities: The feeding behavior of the Malabar giant squirrels is predominantly observed during the morning and evening hours. This species is strictly diurnal, confining its activities to daylight hours. Upon daybreak, the squirrels emerge from their drey and proceed to the food tree to commence their feeding routine. The duration of feeding and resting activities was meticulously quantified. It was observed that the squirrels commenced feeding immediately upon emerging from their nests. A zenith in feeding behavior was observed in the morning, spanning from 6:00 am to 6:30 am, and in the late afternoon from 5:00 pm to 5:30 pm (Table 3). Feeding came to a complete halt after 11:30 am, during which time the squirrels engaged in complete resting (Table 3). In the morning, the squirrels journeyed away from their dreys, whereas in the evening, they gravitated towards their nests. The percentage of resting is higher during the mid-day and the animals are less active in this period (from 11.00 am-

12.00 pm). From the heat map it is evident that the two activities of the Malabar giant squirrel namely feeding and moving are positively correlated and are clustered together (Fig. 3). However, the time interval 6:00 am-6:30 am and 5:00 pm to 5:30, the animal shows less resting activity and is

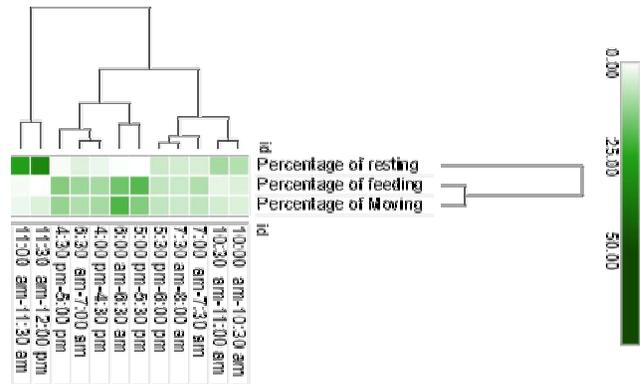


Fig. 3. Activity patterns of *Ratufa indica maxima* represented by a Heatmap (%)

Table 3. Time spent for various activity

| Time | Feeding (%) | Resting (%) | Moving (%) |
|-------------------|-------------|-------------|------------|
| 6:00 am-6:30 am | 16.00 | 0.35 | 19.98 |
| 6:30 am-7:00 am | 11.00 | 3.85 | 9.02 |
| 7:00 am-7:30 am | 9.00 | 4.45 | 7.01 |
| 7:30 am-8:00 am | 5.99 | 5.21 | 5.96 |
| 10:00 am-10:30 am | 4.00 | 8.42 | 4.03 |
| 10:30 am-11:00 am | 3.01 | 10.12 | 5.00 |
| 11:00 am-11:30 am | 0.99 | 25.86 | 2.01 |
| 11:30 am-12:00 pm | 0.00 | 32.91 | 3.95 |
| 4:00 pm-4:30 pm | 10.01 | 2.15 | 9.99 |
| 4:30 pm-5:00 pm | 14.00 | 0.85 | 12.01 |
| 5:00 pm-5:30 pm | 19.01 | 0.05 | 14.02 |
| 5:30 pm-6:00 pm | 7.00 | 5.78 | 7.01 |

Table 2. Parts of different plant species consumed by the giant squirrel

| Parts of plants | Plant species |
|------------------|---|
| Young fruit | <i>Xylia xylocarpa</i> |
| Sprouting leaves | <i>Zizyphus oenoplia</i> , <i>Bombax ceiba</i> , <i>Albizia odoratissima</i> |
| Fruits | <i>Bombax ceiba</i> , <i>Terminalia crenulata</i> , <i>Lagerstromiamicrocarpa</i> , <i>Acacia auriculiformis</i> , <i>Xylia xylocarpa</i> , <i>Mangifera indica</i> , <i>Grewia tilifolia</i> , <i>Pongamia pinnata</i> , <i>Terminalia bellirica</i> , <i>Careya arborea</i> |
| Leaf petiole | <i>Mangifera indica</i> , <i>Pongamia pinnata</i> |
| Bark | <i>Terminalia bellirica</i> , <i>Acacia auriculiformis</i> , <i>Terminalia crenulata</i> , <i>Xylia xylocarpa</i> , <i>Albizia odoratissima</i> , <i>Mangifera indica</i> |
| Leaves | <i>Albizia odoratissima</i> , <i>Mangifera indica</i> , <i>Terminalia crenulata</i> , <i>Xylia xylocarpa</i> |
| Twigs | <i>Artocarpus heterophyllus</i> , <i>Terminalia crenulata</i> |
| Flower | <i>Xylia xylocarpa</i> , <i>Terminalia crenulata</i> , <i>Lagerstromiamicrocarpa</i> , <i>Acacia auriculiformis</i> , <i>Mangifera indica</i> , <i>Xylia xylocarpa</i> |
| Seed | <i>Xylia xylocarpa</i> , <i>Terminalia crenulata</i> , <i>Albizia odoratissima</i> , <i>Careya arborea</i> , <i>Scheichera oleosa</i> , <i>Artocarpus hirsutus</i> |

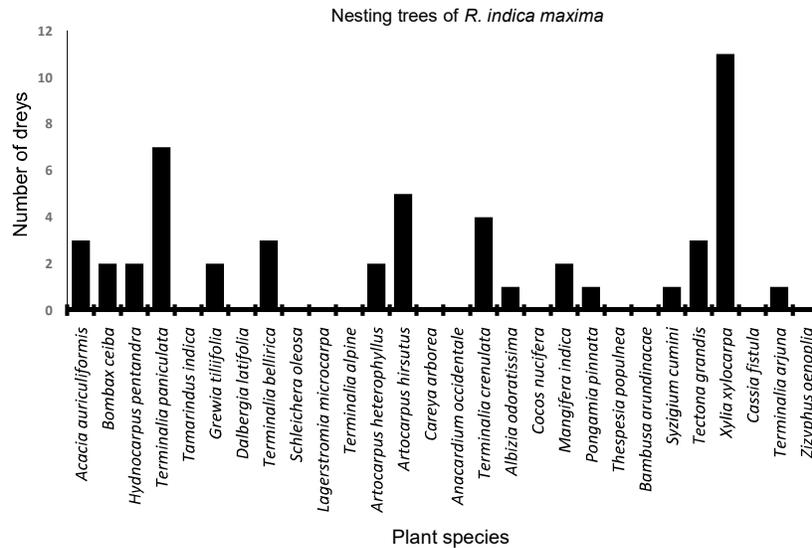


Fig. 4. Preference of nesting trees by *Ratufa indica maxima* based on drey count

contrary to the percentage of feeding and moving, which is more percentage in this particular time interval.

Nesting behaviour: The Malabar giant squirrels construct multiple large nests, known as dreys, using leaves and twigs within their natural habitat. A total of 49 nests were observed. Among the 28 tree species documented, the squirrels preferred only 16 species when building their nests. *Xylia xylocarpa* emerged as the most favored tree species for drey construction. The branches of the specific tree housed a total of 11 dreys. *Terminalia paniculata* holds the position of the second most favored tree species in this particular locale (Fig. 4). *Xylia xylocarpa* is a food tree and also used as a nesting tree. During the nesting period, squirrels bring small twigs of *Xylia xylocarpa* to build their nests. *Terminalia paniculata* is the second most frequently chosen tree utilized for nesting, although it is not the preferred food source for squirrels. The Malabar giant squirrels utilized building materials obtained from plant species such as *Pongamia pinnata*, *Xylia xylocarpa*, and *Terminalia crenulata* for the construction of their nests. These nests were meticulously erected in trees with broad, vertical spreads, systematically positioned at the lower extremities of the canopy and distanced from the primary trunk. The giant squirrel prefers the higher canopy positions for nesting as compared to the middle part of the tree (Samson 2020). Observations from the study revealed two instances of nest construction, with both efforts requiring a three-day timeframe for completion. The nesting behavior involved the procurement of materials such as twigs and leaves. Significantly, the placement of the nests was deliberate, as they were consistently situated at the apices of the trees, affording superior concealment and

maximal security. The high preference for these trees could offer better protection and escape from predators. Squirrels prefer trees that are tall and have a large number of branches for nest building (Mohan et al., 2023). The nesting trees were significantly larger in all aspects than the non-nesting trees. The selection of this type of tree could facilitate easy movement to and from the nest in all directions, a major advantage to escape from predators and to move to other parts of the home range for foraging and other activities.

Malabar giant squirrels were most active during early morning and evening, leading to more sightings during these times. The nest trees of the Malabar giant squirrel were predominantly from a selection of tree species, including *Acacia auriculiformis*, *Bombax ceiba*, *Hydnocarpus pentandra*, *Grewia tiliifolia*, *Terminalia paniculata*, *Terminalia bellirica*, *Artocarpus heterophyllus*, *Artocarpus hirsutus*, *Terminalia crenulata*, *Albizia odoratissima*, *Mangifera indica*, *Pongamia pinnata*, *Xylia xylocarpa*, *Terminalia arjuna*, *Syzygium cumini*, and *Tectona grandis*. The results of the nesting tree study indicate that squirrels tend to prefer the largest available trees and choose the highest locations within their home range to build their nests. However, their selection is significantly influenced by the species of the trees and their physical characteristics, including canopy contiguity (Pradhan et al., 2012, Pradhan et al., 2017).

CONCLUSION

The activity pattern of Malabar giant squirrel (*Ratufa indica maxima*) is characterized by nearly equal periods of feeding and resting. The availability and abundance of food

resources play a vital role in determining the survival of the animal species. It exhibits a strong preference for nesting in taller trees with contiguous canopies, which likely provide enhanced protection from predators and environmental stressors. It is recommended that conservation initiatives focus on preserving and restoring tall, continuous canopy forests, as these habitats are critical for sustaining viable populations and mitigating potential threats from habitat fragmentation and human encroachment.

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