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Status, distribution, food and feeding of Malabar Spiny Dormouse (*Platacanthomys lasiurus* Blyth) in the Western Ghats of Kerala

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(FINAL REPORT OF THE RESEARCH PROJECT KFRI/378/02)

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ABSTRACT OF THE PROJECT PROPOSAL

1. Project No.	: KFRI/378/02
2. Title of Project	: Status, distribution, food and feeding of Malabar Spiny Dormouse (*Platacanthomys lasiurus* Blyth) in the Western Ghats of Kerala

3. Objectives:

a) To determine the population status and distribution of the species in the Western Ghats of Kerala.

b) To assess the food and feeding behaviour of the species in evergreen and moist deciduous forests.

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5. Scheduled date of completion	: July 2005
6. Funding agency	: Department of Science and Technology Govt. of India
7. Project Team	
Principal Investigator	: Dr. E. A. Jayson
Research Fellow	: K.M. Jayahari
8. Study area	: Kerala
9. Duration of study	: 3 Years
10. Project budget	: Rs.10, 40,000/-

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ABSTRACT

Malabar Spiny Dormouse (*Platacanthomys lasiurus*) is an endemic rodent found in the Western Ghats of South India. The species inhabits the tropical evergreen and riverine patches in the tropical moist deciduous forests. A study was conducted from February 2002 to June 2005 in the Western Ghats of Kerala to determine the status, distribution, food and feeding of the species. Intensive studies were conducted in the Peppara Wildlife Sanctuary, Thiruvananthapuram District, Kerala, India. Live trapping, questionnaire survey, direct observation, spot lighting and radio telemetry were used to assess the status, distribution, food and feeding behaviour of the species. Sherman live traps were used for detecting the presence of the species in different protected areas of Kerala.

The species was recorded from ten protected areas in Kerala and from twenty one forest Ranges. The Malabar Spiny Dormouse was newly recorded from nine protected areas of Kerala namely Neyyar, Periyar Tiger Reserve, Thattekkad, Idukki, Chinnar, Eravikulam, Chimmony, Parambikulam and Aralam Wildlife Sanctuaries. Male of the species was having a weight of 80 gm and female 70 gm. Hbl of male was 110 mm and tail length 105mm, similarly female was having a Hbl of 108 mm and a tail length of 110 mm. Trapping studies indicated that the species occur in extremely low densities in the protected areas of Kerala.

Six species of Murid rodents and one insectivore were also identified from the protected areas namely the Black Rat (*Rattus rattus)*, Blanford's Rat (*Cremnomys blanfordi*), Spiny Field Mouse (*Mus platythrix),* Indian Bush Rat (*Golunda ellioti*), *Millardia meltada* and House Mouse (*Mus musculus)*. Overall capture success of rodents was 3.62 %. *Mus platythrix* distribution in the Kerala part of the Western Ghats is a new report. Rodent species richness is positively correlated to the tree species richness and the diversity of trees nurtures the diversity of rodents. *Rattus rattus* is the most abundant rodent species of the region and rodents have only low density in the region.

The Malabar Spiny Dormouse feeds on a variety of food items available in the habitat. Common food plants of the species were *Terminalia bellerica Persia macrantha*, *Hydnocarpus pentandra*, *Tamrindus indica*, *Bombax ceiba* and

Shumanianthus virgatus. Favorite food items included endemic genus like Piper, exotic species like *Theobroma cacoa* and *Anacardium occidentale.* Mode of feeding was unique and the openings made on the seeds or fruits were of different sizes but they were of circular shape. The animal was highly selective of the status of the fruits or seeds and different mode of handling of food was observed according to the size of edible portion.

Twenty five food plants of Malabar Spiny Dormouse were recorded using location telemetry and other methods. Foraging decisions are influenced by the predator pressure. Sexual dimorphism exist in the anti predator behaviour and females are bolder than males. Two major types of foraging movements were observed in the species. One type is limited to a distance of 30 m from the nest and other beyond this distance. In the case of males, short feeding bouts were observed during the short distance foraging and long feeding bouts in long distance foraging. In females, considerably long feeding bouts were recorded during the long and short distance foraging movements. Observations indicated that the species is completely arboreal. The male moved to a maximum of 1 km during foraging and the female 80 m and the feeding range of the species is about one km. The animal spent short periods at a point when the foraging was within 35 m from the nest. But when long periods were utilized for foraging they intermittently changed the feeding points or moved to areas with thick canopy. The species utilized long time periods at feeding points when they were beyond 35 m from the nest, but such long trips were made only occasionally.

The home range of the species is 4.91 ha and home range of the colonies overlapped. A total of 3 males and 5 females of Malabar Spiny Dormouse were captured for telemetry experiments giving an over all capture successes of 15%. The sub adult female with radio transmitter was predated on the first day of observation by an owl. Frequent movement is within 30m from the nest. Twenty three nests of Malabar Spiny Dormouse were located in the intensive study area at Peppara Wildlife Sanctuary. Males were carrying out the nest hole maintenance activity by gnawing the nest entrance for removing the continuous growth of bark. Female was never observed carrying out the nest maintenance activity. All the nests were vertical hollows with opening at the bottom and two of the nests were abandoned during the study. Of this one nest was on a *Persea macrantha* which was dried so that the canopy connection of this tree with the other trees was lost. Another nest on *Vateria* *indica* was filled with rain water and subsequently the nest was deserted. Nests were made on 11 species of trees. The behaviour of nest hole maintenance can be attributed to the antipredator behaviour strategy. *Lagerstroemia microcarpa* is a preferred nesting tree of Malabar Spiny Dormouse and birds of prey and owls are the main predators recorded.

Modelling the microhabitat preference of Malabar Spiny Dormouse indicated that the species inhabits not only in the evergreen species but also in the riverine patches of the moist deciduous forests. It is found that the Malabar Spiny Dormouse is highly selective in choosing the microhabitat and high degree of preference is given to the dense canopy cover and crown density. Preference for canopy cover is an antipredator strategy. Only weak trend is showed towards food availability. GIS modeling showed that Malabar Spiny Dormouse prefers the riparian forest at Peppara Wildlife Sanctuary. The species is being used in tribal medicine, for preparing drugs for the cure of acute Asthma, which is detrimental to its survival.

1. Introduction

About 40 percent of the 4200 species of mammals are Rodents. The 2050 species of the world's rodents comprise one of the largest mammal groups, the Rodentia, which is divided into 29 Families. Rats and mice are grouped together in the largest Family Muridae, which contains 16 distinct sub-families. They are considered as the integral part of the forest ecosystems due to their multiple role as predator, pray and insectivores. They serve the ecosystem as seed predators and even as distributors of mycorrhizal fungal spores (Ure *et al.*, 1982). For humans they are food, pests, vectors, indicators, medicine and myth and the anthropogenic relationship of rodents in India can be traced back up to Vedas.

When viewed through the modern Metabolic Theory of Ecology their r-reproductive strategy, mobility, competitive abilities and feeding behaviours can be considered as a result of their high metabolic rates (Brown *et al*., 2004). They invade almost all sorts of habitats, consume wide range of food items and predated by an array of small carnivores and birds of prey. Ninety-nine percent of the mouse genome is identical to humans (Abbott, 2002). The physiological, anatomical and metabolic parallels of rodents especially mice; with humans make them an excellent model system in medical, toxicological and molecular research (Bradley, 2002). The capacity of rodents to modify their environments in such a way as to provide habitat and easy acclimatisation to any sort of environment makes them well known invaders. Out of the fourteen world's worst invasive species, three are rodents.

Hundred and one species of rodents and twenty-eight species of insectivores are recorded from India and out of these twenty species of rodents are endemic to India. Forty three percent are in Low Risk category of IUCN classification. And more than fifty percent of these species are in the Threatened category and Status Unknown (Data Deficient). One species is extinct (*Ratufa indica dealbata*) and one is critically endangered. A total of 72 percent of the species lack proper IUCN status evaluation either globally or nationally due to deficiency of data, but under rigorous control solely for economic purposes. Thirty-seven species are in Low Risk category, nine species in vulnerable category and 11 are considered as Vulnerable as the status is not yet evaluated (Molur *et al*., 1998). Eight of the twenty endemic species are in vulnerable category, one is critically endangered, one endangered and three are in data deficient. Many of the rodent species are treated only as pests, which showed the lack of proper demographic studies.

As far as the mammalian biodiversity of the Western Ghats is concerned, out of the one hundred and twenty species of mammals reported from the Western Ghats, fourteen are endemic. The fauna is dominated by Insectivores (11 species), bats (41 species) and rodents (27 species). Few studies have paid attention to the community structure and organization of these small mammals in the Western Ghats even though there have been attempts to review our understanding of the status and ecology of the small cats and lesser carnivores (Daniels, 2003).

Malabar Spiny Dormouse

Dormice are distributed in Africa, Europe and Asia except Malay region and Islands. Malabar Spiny Dormouse (*Platacanthomys lasiurus* Blyth), Family Muridae, is about the size of common rat and lives on the tree holes in colonies. The best distinguishing marks of the species are the spiny fur, claw less hallur and bushy tail and the ears are also very prominent. The species is endemic to Western Ghats and locally called "Mutteli or Mulleli". The species is found in tropical moist deciduous and tropical evergreen forests of the Western Ghats. It feeds on *Terminalia bellerica, Persia macranta* and pepper and to some extent; these animals are considered as pests on the cash crops. Loss of habitat and poaching are the serious threats to the survival of the species.

A detailed study on the man-wildlife conflict in Peppara Wildlife Sanctuary, Trivandrum District, Kerala was carried out during the period March 1993 to March 1996 (Jayson, 1998). During of the study, Malabar Spiny Dormouse was relocated in its original locality after 40 years during 1995 (Jayson and Christopher, 1995). This finding generated interest in the species and a detailed study was initiated. The known distribution of the species is from South of Shimoga and when this study was initiated, the species was known only from four occurrence reports. No detailed information on the ecology and behaviour of the species was available. The status of the population and the distribution pattern of the species in its range were not known and whether the species was threatened with extinction was also not known. Earlier reports (Rajagopalan, 1968) emphasized its role as minor pest on pepper, cassava and cashew.

Classification

ORDER Rodentia: Rodents

Family Muridae: Mice, rats etc.

Sub Family: Platacanthomyinae

Genus: *Platacanthomys*

Species: *Platacanthomys lasiurus* Blyth 1859a

As the Malabar Spiny Dormouse is restricted to the Western Ghats and no information is available on the species from other countries. The present study reports detailed information on the distribution, population status and behaviour of the species. The population status of the species gathered will enhance our knowledge on the present conservation status of the species. The present study was conducted from July 2002 to July 2005.

Objectives

Most important objectives were to find out the details of the ecology and behaviour of the species and to assess the threats to the survival of the species. Therefore the specific objectives are,

1. To determine the population status and distribution of the species in the Western Ghats of Kerala.
2. To assess the food and feeding behaviour of the species in evergreen and moist deciduous forests.

1.1. Study areas

Kerala part of the Western Ghats forest is comprised of fourteen protected areas including 12 Wildlife Sanctuaries and two National Parks. During the study period three more National Parks were newly announced. A brief account of the protected areas where the study was conducted is given below.

1.1.1. Forests of Kerala

The population status of Malabar Spiny Dormouse and other rodents were assessed in the twelve wildlife sanctuaries and two National Parks of Kerala namely the Peppara, Neyyar, Shendurney, Idukki, Periyar Tiger Reserve, Chinnar, Parambikulam, Peechi, Chimminy, Wayanad, Aralam, Thattekkad Wildlife Sanctuaries and Silent Valley and Eravikulam National Park by trapping (Fig. 1). Apart from these, questionnaire survey and transect survey were carried out in the 76 Forest Ranges belonging to 25 Forest Divisions.

Aralam Wildlife Sanctuary

Aralam Wildlife Sanctuary has a forest area of 55 km^2 accommodating rich diversity of flora and fauna. The sanctuary is located in the south-eastern side of the Kannur District of Kerala State. The area geographically lies between $11^o50'$ to $11^o52'$ N and $75^o49'$ to $75^o57'$ E. Geologically the area can be grouped into two main rock types *vis* Laterites and Crystalline rocks. The habitat constitutes evergreen forests of 21.52 km^2, semi evergreen forests with an extent of 25.97 km^2 areas and moist deciduous forest of 1.11 km^2. The estimated area of other minor cover types is 6.12 km^2 (Menon, 1999).

Wyanad Wildlife Sanctuary

Wyanad, consisting of the forests under the administration of North Wyanad, South Wyanad and Wyanad Wildlife Sanctuary form a major portion of Nilgiri Biosphere Reserve. The sanctuary has a total extent of 344.44 km^2 and is a part of the Mysore plateau. The terrain is almost flat and the slope varies from 5^0. to $10^{\ 0}$ in the western part (Easa and Sankar, 2001). The altitude varies between 850 m and 1147 m. The broad type of soil is Ferrolite and sub type is Ustic Altisol. The forest types could be broadly classified into the following categories (Champion and Seth, 1968) namely the West coast semi-evergreen forests, southern moist mixed deciduous forests, southern dry mixed deciduous forests and plantations. The name 'Wyanad' derives its name from the numerous swamps locally called as *vayals*. Francis (1994) studied the earlier political history, forest and agriculture and Wildlife in Wyanad.

Silent Valley National Park

Situated in the Palghat District of Kerala between latitude 11^0 3' and 11^o 15' N and longitude 76^o 23' and 76^o 30' E, Silent Valley National Park is one of the core zones of the Nilgiri Biosphere Reserve. The area was declared as a National Park in 1984 and it falls under the Malabar Rainforest Realm. Covering an area of about 90 km^2 this reserve is situated more or less on a plateau of about 1000 m (KFRI, 1999). The altitude of the habitat varies between 658 to 2383 m above msl. The vegetation is of west coast tropical evergreen type. Manilal (1988) made a detailed account of the flora of Silent Valley, which consists of 966 species belonging to 134 families and 559 genera. Structure, diversity and seasonal distribution of birds have been studied by Jayson and Mathew (2000, 2002, and 2003).

Parambikulam Wildlife Sanctuary

The Parambikulam Wildlife Sanctuary is located in the Palghat District of Kerala State. Geographically the area lies between 76^o 35' and 76^o 50' E and 10^o 20' and 10^o 26' N at an elevation of 600 m above msl. The altitude varies between 300 m and 1400 m. The sanctuary was declared in 1962 and has an extent of 270 km^2. The topography is hilly terrain with undulating plains interspersed with marshy fields in the valleys. The mountain ridges of the sanctuary have well defined valleys and slopes to streams, which permit denser growth of vegetation in those regions. Some of the hilltops have stretches of grasslands above 1000 m. Vegetation include moist deciduous forests to tropical wet evergreen rain forests. Semi-evergreen forests appear where moist deciduous forests merge into evergreen forests. Nair and Jayson (1988) had described the habitat use of herbivores in the sanctuary.

Peechi- Vazahani Wildlife Sanctuary

The Peechi-Vazahani Wildlife Sanctuary is situated in the Trichur District, Kerala State between 10^o 28' and 10^o 38' N and 76^o 18' and 76^o 28' E. The sanctuary was established in 1958 with an extent of 125 km^2. The area includes the Reservoirs of Peechi and Vazahani dams. The reservoir area is of 12.95 km^2 and 1.843 km^2 respectively (Narayanankutty and Nair, 1990). The sanctuary is well connected with the forest areas of Nelliampathy and Palappilly Reserves and Chimmony wildlife sanctuary. The continuity of the Peechi Forest Range with the Vazahani side is lost due to the Trichur-Palakkad National Highway. The terrain is undulating and the elevation varies from 45 to 900 m. The habitat is dominated by the tropical moist deciduous forests and semi evergreen forests, which are confined to the upper regions.

Chimmony Wildlife Sanctuary

Chimmony Wildlife Sanctuary is located in the Thrissur District of Kerala State between 10^o 22' and 10^{o}26' N and 76 ^{o}31' and 76 ^{o}39'E on the western slopes of Nelliampathy forests. The extent of sanctuary is 85.067 km^2 of which the reservoir of Chimmony dam occupies 5.68% (Menon, 1997). The habitat is contiguous with Parambikulam and Peechi-Vazahani Wildlife Sanctuaries. Elevation of the terrain varies from 1126 m to 2500 m above msl. The vegetation of the sanctuary consists of west coast tropical wet evergreen forests at higher reaches, west coast semi evergreen forests of an extent of 35.035 km^2 and south Indian moist deciduous forests of 31.206 km^2 Jayson (1997 and 1999) reported the status and habitat utilization of large mammals of the sanctuary.

Chinnar Wildlife Sanctuary

Chinnar Wildlife Sanctuary, geographically located between 10^o 15' - 10^o 21' N and 77^o 05' - 77^o 16' E comprises 90.44 km^2. The sanctuary comes under the political boundary of Idukki District of Kerala State. The terrain is highly undulating. The different regions of the area experience varying climate reflecting in the different vegetation types (Sasidharan, 1999). The altitude ranges from 400 to 1883 m above msl. The terrain is much undulated with hills and hillocks of varying altitude from 400 m at Chinnar to 1883 m at Vellakkalmalai. The vegetation of the Sanctuary can be broadly classified into six types (Champion and Seth, 1968). They are southern tropical thorn forest (scrub jungle), southern dry mixed deciduous forest (dry deciduous forest), southern moist mixed deciduous forest (moist deciduous forest), tropical riparian fringing forest (riparian forest), southern montane wet temperate forest (hill Shola forest) and southern montane wet grassland (grassland). The habitat is also rich in fauna and the habitat utilization of large mammals was reported by Jayson (2004).

Eravikulam National Park

Eravikulam National Park is famous as the natural habitat of the world's largest Nilgiri Tahr (*Hemitragus hylocrius*) population. Rice (1984) has given a detailed description of Eravikulam National Park. The flora could be subdivided into grassland, shrub land and forests. The terrain above 2000 m is covered primarily by rolling grasslands with small patches of shola forests. The shola forests mostly located in the valley can be classified as southern montane wet temperate forest (Chandrasekharan, 1962). Sixteen mammalian species were reported from the National Park (Easa, 1995).

Thattekkad Bird Sanctuary

Thattekkad Bird Sanctuary well known for the birds is having an extent of 25 km^2 lying in between 77^0 - 76^0 E and 10^0 - 11^0 N. This sanctuary has low altitude forest with elevation varying from 60 to 450 m above msl. The habitat consists of evergreen, semi evergreen and moist deciduous forest types and teak, mahogany and rosewood plantations. All the plantation activities were stopped for the last 15 years and the regeneration is copious in the old plantations. The sanctuary is situated around the reservoir area of Bhoothathankettu Dam.

Idukki Wildlife Sanctuary

Idukki Wildlife Sanctuary with an area of about 77 km^2 is located between $09^o45'$ - $09^o55'$ N and $76^o50'$ - 77°05' E. The area includes 33 km^2 reservoir area of the Idukki dam. The terrain is undulating with an elevation varying from 800 m to 1272 m above msl. Vegetation could be classified into west coast tropical evergreen forest, west coast tropical semi-evergreen forest, south Indian moist deciduous forest and south Indian sub-tropical hill savannah. West coast tropical evergreen forests are mainly confined to Vagavanam and Kizhukalachimala and also in some isolated locations. West coast tropical semi evergreen forests are found in the transitional zones of evergreen and deciduous forests and occupy only a very small patch. South Indian moist deciduous forest forms sixty percent of the vegetation in the Idukki Wildlife Sanctuary. South Indian sub-tropical hill savannah type of forests is dominated with grasslands and sparse tree growth occurs mostly in the hilltops (Easa, 1997).

Periyar Tiger Reserve

Periyar Tiger Reserve is a protected area with an extent of 777 km^2. The altitude of the area is up to 1808 m and lies between 76^0 55’ - 77^0 25’E and 9^0 18’ - 9^0 40’N. The soil is mainly fine loamy in character as it is derived from disintegrated Laterites and gneisses. In higher altitudes the soil is coarse with large amount of quartz gravel formed from crystalline rock. The underlying rock formations consist mainly of granites and gneisses. Laterite occurs at the lower reaches of the Reserve. By following Champion and Seth (1968), the vegetation of the Periyar Tiger Reserve can be classified into seven types namely, West coast tropical evergreen forests (evergreen), West coast semi-evergreen forests (semi-evergreen), Southern moist mixed deciduous forests (moist deciduous), Southern hill-top tropical evergreen forests (hill-top evergreen), Southern montane wet temperate forests (Shola), South Indian sub-tropical hill savannahs (savannah) and Southern wet montane grasslands (grassland). The flora of Periyar Tiger Reserve was studied in detail by Sasidharan (1998).

Schenduruni Wildlife Sanctuary

Shendurney Wildlife Sanctuary is located between 77^o 4' and 77^o 17' E longitude and between 8^o 48' and 8^o 58' N latitude in Kollam District, Kerala State. The name 'Shendurney" is derived from a rare timber tree *Gluta travancorica* which is locally called '*Chenkurinji*'. The elevation of the area varied from 120 m to 1550 m above msl. As per the management plan (Vighnarajan, 1990) there are 40 km^2 of evergreen forest, 10 km^2 of semi-evergreen forest, 15 km^2 of moist deciduous forest, 5 km^2 of grassland and 6 km^2 of reed and canebrakes in the sanctuary.

Neyyar Wildlife Sanctuary

Neyyar Wildlife Sanctuary with an extent of 128 km^2 forest lies at the southern tip of Kerala part of the Western Ghats. The area lies between 8^0 17’ - 8^0 53’ N and 76^0 40’ - 77^0 17’ E. Sanctuary has a varying altitude up to 1868 m above msl at Agasthyamala peak. The forest constitutes of evergreen, semi evergreen and moist deciduous types and the sanctuary includes the reservoir of Neyyar Dam also. An evaluation of the Crocodile introduction programme carried out in the Sanctuary was reported by Jayson *et al.* (2006).

1.1.2. Intensive Study Area – Peppara Wildlife Sanctuary

In an earlier study (Jayson and Christopher, 1995) Malabar Spiny Dormouse was located at Peppara Wildlife Sanctuary in Trivandrum District, Kerala. Since this is a known location, intensive studies were carried out in the Peppara Wildlife Sanctuary. Situated in the southern tip of the Western Ghats in the Agasthiamalai ranges in the extreme South to the Aryankavu pass, the Peppara Wildlife Sanctuary comes under Nedumangad Taluk of Thiruvananthapuram District, Kerala State (Fig. 2). It is located between 8^o 34' to 8^o 42' N latitude and 77^o 7' to 77^o 14' E longitude. The State capital is 50 km away from the sanctuary. The extent of the sanctuary is 76 km^2 and is under the control of Assistant Wildlife Warden stationed at Peppara Dam site and the Wildlife Warden stationed at Thiruvananthapuram. The altitude varied from 98 m to 1594 m above msl. Forests surround all the sides of the sanctuary. On the northern side lies the Bonacord estate and eastern side borders with the Mundanthurai-Kalakkad Tiger Reserve of Tamil Nadu. Southern portion adjoins with the Neyyar Wildlife Sanctuary and western portion borders with the eucalyptus plantations of Trivandrum Division. The highest peak is Athirumudi Peak (1594 m) and the entire area is the catchment of Karamana River, which originates from the Chemmungi peak. The area forms the part of the Agasthiamalai Biosphere Reserve.

Climate

Sanctuary has a tropical hot and humid climate with a dry summer. Even during this period, the high ranges maintain a cool and dry climate. Daily temperature varied from 32^0 C to 20^0 C in plains whereas it varied from 25^0 C to 16^0 C in high altitude. Average rainfall was around 4810 mm in the catchment of Peppara Dam (Fig.3).

Vegetation

The Peppara Wildlife Sanctuary has all typical vegetation types found in the tropical areas like tropical moist deciduous forests (29 km^2), tropical evergreen forests (10 km^2), tropical semi evergreen forest (14 km^2), shola forests (0.79 km^2), reed brakes (2 km^2), bamboo areas (0.5 km^2) and grass lands (2 km^2) (Menon, 1999). Nair (1991) has also described the vegetation of the area in detail. A recent floristic study by Mohanan *et al.* (1997) documented 1084 species of flowering plants from the area. *Terminalia paniculata*, *T. bellerica*, *Carea arborea*, *Dillenia pentagyna*, *Pterocarpus marsupium*, *Phyllanthus emblica*, *Lannea coromandelica*, *Lagerstroemia microcarpa*, *Hopea parviflora*, *Olea dioica*, *Buchanania longan*, *Bombax insigne* and *Wrightia tinctoria* were seen in the moist deciduous forest.

Common trees in the evergreen forests were *Cullenia exarillata*, *Dimocarpus longan*, *Mesua nagasarium*, *Diospyros candolleana*, *Bischofia javanica*, *Cinnamomum verum*, *Vateria indica, Xanthophyllum arnottianum, Syzygium caryophyllatum, Palaquium ellipticum, Garcinia gummi-gutta and Holigarna arnottiana.* Semi evergreen forests have trees such as *Aporusa* sp. *Artocarpus hirsutus, Mesua nagasarium, Persea macrantha, Terminalia paniculata, Vitex altissimia, Mangifera indica, Madhuca neriifolia, Alstonia scholaris, Bridelia retusa and Calophyllum apetalum.*

Tribals

There are seventeen Kani tribal settlements inside the Peppara Wildlife Sanctuary. They are distributed in the buffer zone as well as in the core area of the sanctuary. The Kani tribes of Thiruvananthapuram and Kollam Districts contribute to the major part of the total tribal population found in the forests of Kerala (Anonymous, 1994). Like the other aboriginal hunting and gathering tribes, Kani's also have the primitive history of hunting, gathering and shifting cultivation. Long back, the Kanikkars were employed by the Travancore Government to collect honey, wax, ginger, cardamom, dammar and elephant tusks (Thurston, 1909). Many anthropologists highly regarded their adventurous honey collection from the highly rugged rock cliffs and treetops, which can be seen even today. Though the insidiously spreading modern civilisation polluted the tribal culture, some Kani settlements still preserve their ancient traditions (Jayson, 1998).

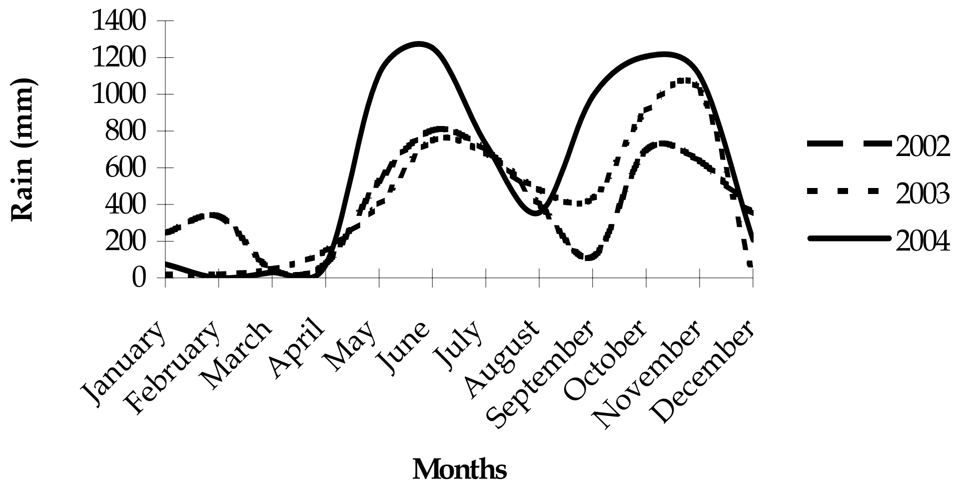


Fig. 3 Rainfall at Peppara Wildlife Sanctuary

Fauna: Thirty species of larger mammals were recorded from the sanctuary. Among the larger mammals Elephant, Wild boar and Malabar giant squirrel were sighted in all the months. Four species of primates were recorded from the sanctuary. Among the cats, Leopard and Jungle cat was recorded in previous studies. Leopard cat was recorded from Ennakkunu (Jayson, 1998). Common palm civet, Small Indian civet, Common mongoose, Wild dog and Sloth bear were reported. Seven species of rodents were identified from the sanctuary in the earlier studies. Malabar giant squirrel, Blacknaped hare, Indian Porcupine and Large brown flying squirrel were also reported.

Kani tribals caught Malabar spiny dormouse from the nearby forests when they needed them for medicinal purposes. The nests of these animals were identified by observing the water oozing out of the holes on trees. For catching the animals, they either cut open the trees or blow smoke into the holes. They believe that the flesh and spines of this species are a cure for respiratory diseases. Gaur, Sambar, Barking deer and Indian pangolin were also reported from the sanctuary.

1.2. Review of literature

The status and distribution of the small mammals in the Western Ghats region are poorly known. There exists a high necessity for studies which can bring out the details of species distribution and coexistence at macro habitat level. The extend of distribution of rodents was also not clearly understood. There is no information on the status, food and feeding and other behaviour of the Malabar Spiny Dormouse, which is one of the endemic mammals of the Western Ghats. Detailed information on the home range and activity pattern of the species is also lacking

Most of the small mammal studies carried out globally was confined to the temperate regions and the species diversity, complex pattern of co-existence and the species distribution of the small mammals of the tropics remain unexplored. Diversity, structure of species assemblage, the spatial scale of small mammals and various biotic and abiotic factors responsible for these were the matter of interest for ecological studies in Australia for the last many years (Stephan *et al.*, 2002; Hockings, 1981; Laurance, 1994). Studies regarding distribution and ecology have been conducted in Africa (Cheesman and Delany, 1979), Madagascar and Panama (Seamon and Adler, 1996) also.

Despite an increased interest in biodiversity conservation and high species richness, Rodentia are often neglected by conservationists (Amori and Gippoliti, 2001). Since they are an important component of the forest ecosystem, being the connecting links between many of the biotic elements of the ecosystem and due to their 'r-reproduction strategy', their population and demographic studies are crucial for their conservation. Western Ghats accommodates 25 percent of the mammalian diversity in India. As some of theses species are endemic to the region their population changes will indicate the climatic changes caused by the anthropogenic and non-anthropogenic factors. Many of these species have complex relationships with humans, not only for the tribes but also for the urban population. Since the rodents are the reservoirs of Leptospira, causing the disease Leptospirosis (Weil's disease), the knowledge on the wild rodent community will help in the control of the disease. Only few studies have been carried out on the small mammal community and especially on the rodent communities of the Southern Western Ghats.

Small mammals in India

The studies on small mammals in India started during the first half of the 19th century, by the description of Indian Gerbil (*Tatera indica*) by Major General Hardwick (Kinner, 1968). Followed by this a series of major works were carried out by Hodgson and Blyth. Jordan published "Mammals of India", which was considered as the standard book of mammal identification for the next twenty years. The volumes of “Fauna of British India” by Blanford replaced the book. Jordan was imperfect in dealing with small mammals since most of the specimens collected by the earlier workers like Gray and Hodgson were not available in Asiatic Society of Bengal (Kinner, 1968). In 1867 Captain Glen Liston read a paper before the Asiatic Society of Bengal on plague, rats and fleas, which discussed the relation between plague and rats. He concluded the paper by saying “What do we know about rats very little”. The paper initiated wide attention towards the lack of knowledge about rodents and small mammals. During the Golden Jubilee of the Asiatic Society of Bengal in 1911, India’s first mammal survey had begun. During the survey, Bombay Natural History Society had contributed much and in later period, they have made an extensive collection of specimens from different parts of the country. The contribution of Prater (1948) is outstanding in the mammalian studies during the survey and in the remaining period. The checklist of paleartic and Indian mammals generated from the mammal survey by Ellerman and Morison-Scott (1953) had described 291 rodent species and subspecies of 44 genera where as Blanfrod’s “Fauna of British India” (1891-1988) described only 92 species and 22 genera of rodents. Even today the standard work of rodent taxonomy is the volume of Rodentia in the Fauna of British India by Ellerman (1961).

In the recent past many individual workers contributed to the distribution pattern of rodents through out India. But most of these were carried out at the taxonomical level rather than assessing the ecological species assemblage, coexistence and diversity in the natural habitat. A sum total of these efforts came out as compilations and Ellerman *et al.* (1953) published a checklist of Indian rodents. Considerable information about the distribution of rodents in India was given by Biswas and Tiwari (1969). The distribution of Indian Rodents was also compiled and published by Prater (1988), Corbet *et al.* (1992) and Musser *et al.* (1993).

Species distribution of rodents in Indian sub continent was reported by many workers in the recent past. Chakraborty (1983) studied the rodent distribution in Jammu and Kashmir region. Mahajan and Mukarjee (1972, 1974) prepared a checklist of rodents in Himachal Pradesh. Sood and Dilber (1977), Sood and Gurya (1978), Sood and Ubi (1978) have worked on rodent species of Punjab. Sheiker *et al.* (1983) and Jain (1975) have reported the rodent species in Uttar Pradesh. Rodent fauna of

Indian desert of Rajasthan was studied in detail by Agarwal (1976), Biswas and Gosh (1968), Ghose (1976) and Prakash (1963, 1959, 1972, 1977). Hill (1958), Jain (1985) and Khajuria and Ghosal (1981) have reported the rodent fauna of Madhya Pradesh. Pradhan (1979) brought out an account of the Rodent species of Bombay and Maharashtra. Agarwal (1973) reported detailed account of the rodent species in Goa region. Agarwal and Bhattacharyya (1987) supplemented the rodent distribution in West Bengal. Agarwal and Bhattacharyya (1977), Roonwal (1948, 1950) have made remarkable contributions to the Rodent distribution from the North East India.

Rodents in the Western Ghats

Only few studies were carried out on the species composition of rodents in the Western Ghats, apart from the works conducted during the British era. Similarly Agarwal *et al.* (1969) reported a new rat species *Rattus renginiae* from this region. Meena (1997) reported the rodent diversity in the Mudumalai Wildlife Sanctuary, Tamil Nadu. Easa *et al.* (2001) conducted a survey on the small mammals of this region with a conservation point of view. Shankar (2000) conducted a detailed study on the metapopulation dynamics of rodents in the Upper Nilgiri region of Western Ghats. Kumar *et al.* (2001) studied the distribution of rodent species in the Kalakkad Mundanthurai Wildlife Sanctuary, Tamil Nadu. Apart from these no reports were available even though the area is affirmed as the hot spot of biodiversity and the small mammals as highly significant ecological component.

Behavioural studies

Most of the behavioural studies on rodents in India are concerned with the crop damage caused by rodents in the agriculture fields. Barnet and Prakash (1975) reported considerable information about the food and feeding behaviour of *Rattus rattus* in the agriculture fields. Behaviour of desert rodents was well studied by Calhoun (1969), Agarwal (1967), Fitzwater and Prakash (1969, 1973), Prakash (1975, 1981), Prakash and Jain (1971) and Prakash and Ojha (1977).

Prakash (1959, 1974, 1975, and 1977) extensively studied the food preference of several species of rats and gerbils in the Thar Desert. Roonwal (1949) investigated the food preferences of *Rattus manipulus* in Manipur State of northeast India. Agarwal (1968) and Jain (1984) have reported the cannibalism among *Rattus rattus*. Asari

(1975) reported food preference of *Rattus rattus* on variety of tapioca. Feeding related behavioural patterns were worked out by many workers (Kumari and Khan, 1984; Sridhara, 1978; Srihari and Sridhara, 1979 and Chakraborty and Chakraborty, 1982). The feeding behaviour of Spiny Field Mouse *Mus platythrix* was subjected to detailed studies in the laboratory (Srihari and Sridhara, 1978). Behavioural characteristics of wild rodent species were not studied in detail in the natural habitats of India.

Malabar Spiny Dormouse

As the distribution of the Malabar Spiny Dormouse is restricted to the Western Ghats of India, no literature is available from other countries on the species. Malabar Spiny Dormouse belong to a monotypic genus *Platacanthomys* which itself is the one and only genus of the subfamily *Platacanthomyinae* (Corbet and Hill, 1992). As far as Malabar Spiny Dormouse is concerned the type locality is Bonacord, Thiruvananthapuram (Blanford, 1888). Except for the occurrence reports, no detailed studies were carried out to determine the status and distribution of the Malabar Spiny Dormouse in India. Ellerman and Morrison-Scott (1951) and Ellerman (1961) have reported the occurrence of the species from Bonacord area in Trivandrum District, Kerala. Rajagopalan (1968) reported this species from Shimoga in Karnataka State. After a spell of forty years recently the occurrence of the species was reported from Peppara Wildlife Sanctuary, Trivandrum District (Jayson and Christopher, 1995). After this report many short notes on the Malabar Spiny Dormouse appeared in the literature. Shankar (1996) recorded the species in the Upper Bhavani hills of the Nilgiris. Prabhakar (1997) has recorded it from Kariyanshola of Indira Gandhi Wildlife Sanctuary, Tamil Nadu State. Mudappa (2001) sighted it in the Kalakkad Tiger Reserve of Tamil Nadu. Apart from such records, there is no published information available on the ecology and behaviour of the species and it is reported that the species also not held in captivity in India. Many studies were conducted on the ecology, behaviour, morphology, anatomy, physiology and genetics of the species of Dormouse's (Family: *Gliridae*) in Europe, Japan, South America and in Afghanistan. Most of these research works were conducted in open woodlands and in captivity. As the Malabar Spiny Dormouse occupies the evergreen and moist deciduous forest there is not much relevance in comparing the studies on the dormouse of temperate region belonging to family *Gliridae* to the Malabar Spiny Dormouse of south Indian tropical forest, which belongs to *Muridae* and live in a different habitat.

Bright *et al.* (1989) have published a practical guide to dormouse conservation in Europe and some years later standardized the survey techniques (Bright *et al.*, 1994). The distribution of different dormouse species was studied by many workers across Europe (Foppen *et al.*, 1989; Jackson, 1994; Bright, 1995; Krystufek, 1994; Buchenr, 1997; Botond, 1998), population density of Edible Fat Dormouse *Glis glis* (Hoodless and Morris, 1993) and population dynamics of European Dormouse(Berg, 1996) and Fat Dormouse (Morris *et al.,* 1997) was well analysed. Abundance dynamics of three species of Dormouse was observed using nest boxes by Rimvydas (2000).

Behavioural responses of European Dormouse (*Muscardinus avellanarius*) to habitat corridors (Bright, 1998) and influence of vegetation changes especially shrub vegetation on the population dynamics are well documented (Berg, 1996). Dispersal behaviour of Edible Dormouse in Germany was well documented (Bieber, 1994). Ecological requirements of Dormouse species of Hungary have reported by Backo *et al*. (1998). The habitat selection criteria in relation to food availability of Hazel Dormouse (*Muscardinus avellanarius*) (Berg and Berg, 1999) and *Myoxus* sp. (Franco, 1990) and woodland requirements of Dormouse *Muscardinus avellanarius* (Bright, 2000) were subject of behavioural studies in the past decade. Spatial ecology and habitat selection of Hazel Dormouse was recorded and a criterion of habitat selection was identified by Berg (1997). Behavioural development of Japanese Dormouse was well observed by Minto (1996). Habitat utilization of *Glis glis* in two different forests was compared in relation to habitat fidelity by Schlund *et al*. (1997).

Food and feeding behaviour of *Glis glis* was studied in relation to body weight and juvenile development by Ercument (1994) and hazel nut feeding was studied by Rodolfi (1994). The faecal analysis of *Glis glis* was carried out by Antonio *et al.* (1999). Similarly, food availability was correlated to the reproductive behaviour in *Glis glis* by Rodolfi *et al*. (1994). Vocalization of *Muscardinus avellanarius* was described by Movchan and Korotetskova (1987).

Many studies were reported on the related species of Dormouse in European countries. Morris *et al*. (1990) studied the use of nest boxes by the Dormouse

(*Muscardinus avellawarius*). He compared the efficiency of Sherman traps and local traps for catching Dormouse. He has concluded that Sherman traps are more effective than the locally made ones. The use of arboreal vegetation by the populations of *Muscardinus avellawarius* was reported by Tattersall and Whitbread (1994). Distribution, survey techniques, insular ecology and selection of sites for conservation of the same species have been reported by Bright *et al*. (1994). The same author has reported the ranging and nesting behaviour of the Common Dormouse (Bright and Morris, 1992). Morris and Whitbread (1986) have reported a method for trapping the Common Dormouse. Another species of dormouse studied in detail in England is the Fat Dormouse (*Glis glis*). Hoodles and Morris (1993) have studied the population density of the species. Similarly, Japanese Dormouse (*Glirulus japonicus*) was studied by Otsu and Takeji (1993).

Abundance estimation

Abundance estimation is important in the study of mammals (Seber, 1982). Capture Mark Recapture methods (here after referred as CMR) is the basic tool for estimating survival, density in probabilities (Williams, 1996) breeding probabilities (Williams *et al.*, 2002), survival and animal behaviour like temporary emigration (Schaub *et al.*, 2004). The history of Capture Mark Recapture techniques can be traced back to 17th Century and the basic principles were formulated by Lincoln (1930) and Jackson (1933) independently. Otis *et al.* (1978) proposed five models for estimating abundance and recapture probability distributions. This was modified later by White *et al.* (1982) who suggested eight models for estimation. The software PROGRAM CAPTURE was created based on the models suggested by Otis *et al*., 1978 and White *et al.*, 1982.

An array of capture mark recapture based census of small mammals studies have been conducted in the past. Based on the small mammal trapping experience in montane forest patches of Western Ghats, Shanker (2000) has concluded that since low densities existing in the tropical forests resulted in low capture probabilities, these models may not be as useful as in temperate regions. Shanker (1998) suggested a revision of methodologies designed in temperate region for the use in tropical region. Capture mark recapture was criticized mostly on the ground of minimum number alive (Jolly and Dickson, 1983; Nichols and Pollock 1983). The assertions for use of

'Central Limit Theorem' in setting large sample confidence intervals with considerably narrow width makes the Otis *et al*., 1978 and White *et al.*, 1982 based models unsuitable for small sample size and there by program CAPTURE. The incapability of program CAPTURE was described by Menkens and Anderson (1988) especially when the trapability is less than thirty percent (0.30).

For abundance estimation of small mammals direct enumeration method was proposed by Krebs (1966). This method cannot be applied, if capture probabilities are very low (<0.5). Menkens and Anderson (1988) suggested Lincoln-Peterson estimator as an alternative. Lincoln-Peterson estimator methodology involves one session of catching and marking and one session of recapture. This will not be suitable for small mammal studies on behalf of the high behavioural heterogeneity of the animals. Schnabel method (Coughly, 1977) which is based on the same assumptions of Lincoln-Peterson method but appropriated to capture on several occasions. The goodness of fit of the data should be assured by conducting a G-test in case of no batch specific capture and by confirming that the frequency distribution of the recapture probabilities does not fit a zero truncated poison distribution in case of batch specific data. Burnham and Overton method (Burnham and Overton, 1979) also can be applied for the batch specific sampling. Jolly Seber method independently formulated by Jolly (1965) and Seber (1965) can be used for the sampling data from open populations.

Assumption of homogeneity in tradability between time and animals is the main limitation of most of the conventional CMR models when operating in tropical habitats (Otis *et al.*, 1978; White *et al.* 1982; Nicholas and Pollock, 1983; Shanker, 2000; Vieira, 2004). The solutions to overcome the problem of heterogeneity also have designed both statistically (Otis *et al.*, 1978; White *et al.* 1982) and non mathematically (Minta and Mangel, 1989; Wileyto *et al.* 1994). Models M_t, M_b, M_h, M_{th}, M_{bh} and M_{tbh} (Otis *et al.*, 1978; White *et al.*, 1982) attempts to resolve the problem heterogeneity over animals and time. Out of these M_t, M_b and M_h need considerably large sample size, M_{th} and M_{bh} are conceptual models and M_{bh} can be applied only if any of the generalized removal models fit to the data (Otis *et al.*, 1978) Pollock (1981) suggested the Jackniff method for the situations with high degree of heterogeneity of capture probabilities. This needed considerably long sampling periods to attain the minimum sample size. White *et al.* (1982) suggested the increase in trap density and sampling area as a technique to overcome the problem of small sample size. Taylor *et al.*, 1981 brought out the use of different methodologies as a solution for the problem.

In tropical conditions increasing the sampling period for more than four days was found to cause more trap death (Shanker, 2000) and so can not be practiced on conservation point of view. Another problem of increasing the sampling periods for more than four days is the immigration, which will break the demographic closure assumption necessary for CMR operations other than for open population models (Shanker, 2000; Vieira, 2004). The use of different methods like transects and grid together has resulted in problems to determine the trap ability and habitat specificity statistically (Vieira, 2004). No study has been reported from tropical areas using CMR in considerably large area as the Kerala part of Western Ghats with uniform methodology so that the heterogeneity in trap ability over similar large-scale demographic changes could be assessed.

Behaviour studies

Animal behaviour studies were mostly confined in laboratories than in the field due to the problems of feasibility, especially when the study animal is nocturnal and small to locate in the field. Most of the behavioural studies conducted in the natural habitat are in arid or semi arid habitats. The escape behaviour of lizards, which are arboreal, was studied in detail in laboratories (Jonathan *et al.,* 1996). The differences in open field behaviour of many nocturnal small rodent species are interpreted on the basis of their different ecological strategies and adaptations were well studied in laboratory by measuring and comparing their exploratory behaviour (Frynta, 1994). The sex and species differences have been observed in occurrence and patterns of association between exploratory behavioural events of different individuals of *Mus spicilegus* and *Mus musculus.* The study revealed sexual behavioural dimorphism in exploration of new environments in both species (Daniela and Simeonovska-Nikolova, 2000).

Habitat selection has been proved as species specific in two lemur species (*Microcebus murinus* and *M. ravelobensis*) at Madagascar, which is important for their survival. The abundance and the dbh of forest trees were also well correlated to the specific habitat selection of the species (Antje *et al.*, 2003). Tree species richness and diversity of microhabitat structures also have been positively correlated to lemur species diversity (Ganzhorn *et al.,* 1997). The social organization and sexual selection of lemurs were also well studied in captivity (Radespiel *et al.*, 2002). The social organization and activity pattern of Slender Loris, which is a nocturnal mammal, was well studied in their natural habitat in Southern India (Radhakrishna and Mewa Singh, 2002). Habitat selection of *Marmota bobak* (Rodentia, Sciuridae) was studied in connection with the foraging quality of the habitat (Ronkin and Savchenko, 2000). Factors of forest and landscape structure influencing the presence and abundance of rodent species were modelled using logistic and Poisson regression models in the rain forest of Ranomafana National Park in the south-eastern Madagascar (Lehtonen *et al*., 2001). Four soricid and five rodent species in five macro habitats on the Coastal Plain of Virginia, USA were studied by Bellows *et al*. (2001). Three species-specific characteristics influencing the habitat selection of small mammals were identified in this study such as shrub frequency, canopy openness and diameter of downed woody debris. The study also revealed the fact that the capacity to access resource from different sources makes some of the species broad niche species and less selective to habitats.

Predation is one of the key and fundamental factors in community ecology and autecology (Kotler and Holt, 1998). Observations on Israeli gerbils (*Gerbillus pyramidium* and *Gerbillus allenbyi*) confirmed the influence of predator pressure on general behaviour. Works on *Gerbillus tytonis* and *Rhabdomys pumilio* revealed that these two species prefer shrub habitat than open habitat for foraging (Hughes *et al.* 1994). The influence of predator pressure was supported by correlating the exploratory behaviour of these rodents to lunar cycle. Yunger *et al.* (2002) was able to quantify the predator influence in foraging decisions of small mammals creating a predator excluded experimental condition. This was carried out in Semi Arid scrub jungle of Chile. The study revealed that the temporary exclusion of predator for a brief period could not influence the foraging behaviour of small mammals.

Douglas *et al.* (2004) used an artificial feeding patches to study the food selection and also for quantification of feeding. They used Giving Up Densities (GUD) for estimation. The study also identified demographic factors such as competition affecting foraging movement rather than predation. The food and feeding of Slender

Loris was studied in natural habitat by Nekaris and Rasmussen (2003) using focal-animal instantaneous point sampling. Food and feeding behaviour of Malabar giant squirrel (*Ratufa indica*) was studied in detail in Western Ghats (Borges *et al 2001*.**).** Foraging behaviour of *Rattus rattus* was studied and correlated to the reproductive ecology of the bird dispersed tree species in island biota (Delgado, 2000). The differential maternal investment and sex-specific resource allocation was examined by manipulation of dietary protein on captive multi-mammate mice (*Mus coucha*) (Lamb *et al*., 2001). Tristiany *et al.* (2000) correlated the home distribution and the patterns of rice plant damage distribution caused by Rice field rat *Rattus argentiventer*. The study also unearthed the sexual dimorphism in foraging behaviour and home range establishment of this species.

There are many methods for studying the small mammals and direct observation and food patch experiment are some of them (Yunger *et al.,* 2002). Location telemetry is the best mechanism to locate and study animal behaviour in the field. This method has lot of limitation when used in the case of small animals, which move comparatively short distances and live in a habitat, where GPS cannot operate accurately. Telemetry enabled Accelradio-telemetered accelerometer collar that continuously monitors the acceleration of the animal has been newly designed to monitor the movement of nocturnal organisms, but it is not cost effective (Sellers *et al.*, 1998).

2. Methods

The study was mainly based on direct observational methods (Altman, 1974). The study areas were surveyed on foot and vehicle. Observations were mainly done with the help of binoculars (10 x 40) and on an average 20 days were spent in the field in a month. Detailed methodology of each aspect is presented in the concerned Chapters (Plate 1).

2.1 Status and Distribution

To determine the population status and distribution of Malabar Spiny Dormouse, questionnaire survey, live trapping and indirect evidences were mainly relayed.

***Questionnaire survey*:** Intensive field surveys were carried out in the tropical evergreen and moist deciduous forests of Kerala. Using a structured questionnaire and photographs, potential sites of the species were identified in the State. The questionnaire survey was conducted among the Forest Department officials, local communities, N.G.O's and non-tribal people inhabiting the forest fringes who regularly visited forest. Hundred and eleven respondents were contacted for the survey. But more individuals shared the information since most of the tribal people were illiterate, the format was filled by the researchers communicating to a group of people of a settlement at the time and the names of those with distinct opinion were only noted down. The collective opinion of the group was recorded as of the group. The survey was conducted in 76 Forest Ranges of Kerala part of the Western Ghats belonging to 25 Forest Divisions including the 14 protected areas. The format of the questionnaire is given in Appendix 1. To record the presence of the species in an area, indirect evidences were also collected. Indirect evidences included nest on tree cavities and discarded fruits after feeding. Feeding signs on the discarded seeds were characterised to identify the presence of the species from the fruits and seeds left out after feeding.

***Trapping*:** Population status was determined by capture-recapture method using Sherman traps. A total of 6400 trap nights were attempted to study the abundance and distribution. The trap night efforts were employed in 17 sessions in 17 protected areas. Traps were placed in grids at an interval of 10 m x10 m. Forty-eight traps were accommodated in a grid and two such grids were operated at a time. Traps were baited with grated coconut and checked in the morning hours. Trapped individuals were marked by ear clipping and released. Population status in the intensive study area was monitored throughout the study period and only once from other areas. In the entire 14 protected areas one trapping programme was carried out irrespective of the seasons. Trapping was carried out on four consecutive days. The location for trapping in each protected area was selected to conduct the trapping study in maximum diverse habitats, so that the habitat peculiarities of each protected area could be utilized and the trapping could be carried out at maximum diverse habitats. The location of trapping in each protected area was identified based on the altitude and vegetation.

The traps were operated in one hectare (100 m X 100 m) square grids. One trap station was established in each 10 sq m of the grid area so that the over all trap density was 1 trap/10 sq m. At some locations two grids of 0.5 ha were established. A trap night is defined as the use of one trap for one night. The standard Sherman live traps (22.9 cm X 7.6 cm X 8.9 cm) were used for the trapping. The traps were placed in the forest floor at each trap stations. The traps were kept near to trees, rock, fallen logs or any other probable run way of the rats if available in the 100 km^2 area. The traps were baited with grated coconut, which was standardized by the 550 trap nights attempted in the Kerala Forest Research Institute campus at Peechi Initially baits like, roasted coconut, peanut butter and dry fish were used but after the standardization of baits based on the capture success, grated coconut was permanently used.

Traps were usually kept near the base of the trees and in open areas. Pre-baiting was practised initially but later avoided, since no change in the capture success was recorded. During the early morning the trapped individuals were identified and sexed, the individuals were then marked by ear punching and released after measuring the weight and in the evening, the traps were freshly baited. Trapping was carried out in the fourteen protected areas of Kerala namely Peechi, Chimmony, Peppara, Parambikulam, Chinnar, Idukki, Wyanad, Thattekkad and Periyar Tiger Reserve Wildlife Sanctuaries and Silent Valley National Park.

2.2 Food and feeding

Food and feeding behaviour studies were carried out at Peppara Wildlife Sanctuary and Chimmony Wildlife Sanctuaries. Animals were observed during night and the discarded seeds and fruits were collected from the feeding sites. Direct observations were carried out in the moist deciduous forests, evergreen forests and in the areas where the cash crops were cultivated. Detailed observations were carried out to assess the food materials and feeding habits. Nests were searched to identify the food particles from the leftovers.

Direct Observations: Direct observations on the food and feeding behaviour of the Malabar Spiny Dormouse were carried out in the intensive study area at Peppara Wildlife Sanctuary. The observer walked through the forest at night slowly, listening to the sound discarded food falling from the trees. After identifying the tree from where the discarded food was rejected, the approximate position of the animal was determined and two or three searchlights were flashed to detect the animal. The feeding of the animal and other observations were recorded. If any suspected food remains of the Malabar Spiny Dormouse was observed, the feeding of the animal was confirmed after waiting for the arrival of the animal and feeding.

***Indirect Observations*:** Indirect observations were also carried out with out directly observing the feeding process. The feeding remains of the seeds were compared for the specific pattern of gnawing by Malabar Spiny Dormouse. In some cases the animals were sighted on the trees along with the falling of food remains and where no other rodent species of similar size was sighted on nearby trees. Food patch experiment was carried out to confirm the feeding of Malabar Spiny Dormouse on the Rhizome of *Schumarianthus*. The food patch was created in the canopy where the animal was observed foraging and the patches were checked in every hour.

***Telemetry*:** As the species is nocturnal, radio telemetry was essential to locate the animal during night and to identify the individuals. Radio telemetry studies were carried out and four animals were studied with radio transmitters (Company - Telonics, USA, Transmitter weight is 6 gm and Battery life is 3 months and coverage was 1. 5 km). These studies were conducted in the moist deciduous forests for observing the foraging behaviour and the activity pattern of Malabar Spiny Dormouse. Radio transmitter was attached to the dorsal side of the Malabar Spiny Dormouse. The movement pattern and the feeding behaviour of the species were recorded using the telemetry. The observations at night were difficult as wild elephants traversed the area frequently. Malabar Spiny Dormouse was captured by keeping the Sherman traps near to the known and identified nests of the species. The trapped animals were sexed and weighed. Location telemetry transmitter was attached on the neck of the animals and the animals were released near the nests. Tracking of the animals started at 18.30 hrs in the evening and proceeded till the animal returned to the nest in the early morning. Several times the tracking was interfered by rain or intervention of other large mammals especially the elephant.

The position of the animal was noted in each ten-minute interval. Initially attempts were made to sight the animals but later this was abandoned as it interfered with the natural movement of the animals. Deliberate sightings were avoided and accidental sightings were recorded. The locations of the animals were not able to mark in GPS as the animals foraged in dense canopy areas where GPS signals were not available. Apart from these short distance movement of the animals were not markable with the aid of GPS. The positions of the animals were recorded to the nearest trees of the location. In the case of long distance movements the pathway was mapped by following the transmitter and by marking all the trees of which the canopy was used. The measurement of distance was carried out on the next day. The calls and sightings of other animals of the species were also recorded. It was not possible to study any other activity other than feeding in canopy due to the poor visibility of these nocturnal animals at night. Artificial searchlights disturbed the natural movement of the animals and the thick canopy where the animal used to forage restricted visibility in general.

2.3. Behavioural observations

The nesting behaviour and microhabitat selection of Malabar Spiny Dormouse were studied in detail. Twenty-four nests were located in the intensive study area and they were numbered and observed regularly once in two weeks for different parameters. All possible nests were located in the intensive study area. The liveness of nests was confirmed by the presence of fresh leaves in the nest, wetness of the nest hole and markings of nest maintenance at the entrance of the nest hole. One hectare plots were taken around 12 identified nests and 13 control plots were studied for recording the habitat parameters. Wetness of the nest, liquid oozing out of the nest, urea content on the leaves in the nest and the presence of spines/hairs were taken as the indicators of active nests. All confirmed nests were measured for the diameter of the entry hole and the length. The wet leaves collected from the nests were chemically analysed and the presence of urea was confirmed on the leaves.

Habitat Parameters: Following ecological parameters of the trapping plots were recorded. Diversity index of trees was worked out by measuring the number of tree species in the plot. Altitude, distance to the near by water body and distance to the nearby human habitation were measured using GPS. Canopy cover was qualitatively estimated manually from five points in the plot (four corners and centre) and the mean is used. Under growth is scaled qualitatively 1 to 4 by counting the number of shrubs other than grass in 1 m^2 from five points of the plot (four corners and centre). Litter quantity was measured as the thickness in centimetres using standard engine divided scale.

***Statistical analysis*:** All the trapping results and the field data were subjected to statistical analysis using the programs CAPTURE, SPSS Version 11, Staistica Version 6 and BIODIVERSITY PRO.

3. Results and Discussion

3.1. Status and distribution of Malabar Spiny Dormouse

3.1.1. Geographic Distribution

The single species *Platacanthomys lasiurus* is found in southern India (Ellerman and Morrison-Scott, 1966). *Platacanthomys,* along with *Typhlomys,* has sometimes been placed in a separate family, the Platacanthomyidae and sometimes in a subfamily, the Platacanthomyinae of the family Gliridae. In accordance with Corbet and Hill (1992), the Platacanthomyinae are here considered as a subfamily of the family Muridae. Recently one fossil species has been described from Yunnan, China *P. dianensis* Qiu, 1989 of the period Upper Miocene. Nearest related living species is *Typhlomys cinereus* distributed in South China from South Shaanxi to Yunnan, Guangxi and Fujian and in North Vietnam. Four subspecies has been recognised in this. Apart from these, two fossil species also has been reported recently namely *T. primitivus* and *T. hipparionum* (Asakawa *et al*., 2001)

Head and body length of the species is about 130-212 mm and tail length is 75-100 mm and the weight of an adult female was 75 gm (Corbet and Hill 1992). The upper parts are densely covered with sharp, flat spines intermixed with thin, delicate under fur, but the under parts have fewer, smaller, and finer spines. The basal half of the tail is sparsely haired and scaly and the terminal part bears long hairs that form a brush. The general coloration of the upper parts is light rufescent brown; the forehead and crown are more reddish and the under parts are dull whitish. The tail is somewhat darker than the general body color, becoming paler at the thick, bushy tip and the feet are whitish.

Malabar Spiny Dormouse is much like the Gliridae in form. The muzzle is pointed, the eyes are small, the ears are thin and naked and the hind feet are broad and elongated. The first toe barely reaches the base of the second toe. The thumb on the forefoot, although short, is well developed. The claws of the digits are slender and compressed. Unlike the Gliridae, *Platacanthomys* has no premolar teeth, and its dental formula is the same as that of the Muridae. The incisors are smooth and compressed. The cheek teeth tend to be high-crowned and generally have parallel oblique cross ridges of enamel on the crown. These ridges are broadened and the depressions tend to become isolated, on the surface of the crown.

The Malabar Spiny Dormouse inhabits evergreen forests and riverine forests at elevations of 100-900 meters. Its nest is constructed mostly of leaves. The long, tufted tail is helpful as a balancing organ as the animal moves about and leaps in trees. Rajagopalan (1968) reported that a female caught in the wild was still living after 20 months of captivity. In some areas, the Malabar Spiny Dormouse is so plentiful that it is considered a pest in the past. The people call it the "pepper rat," because it destroys large quantities of ripe peppers. Dormouse is the common name for several rodents that live in Europe, Asia, and Africa. Dormice generally have large ears, long, bushy tails, and soft fur. They feed at night on seeds and nuts. They hibernate in the winter, often for as long as six months, depending on the climate. One species of European dormouse, the edible dormouse, is so named because it can be eaten when it has fattened up for its winter hibernation. Other species include the Small (or Common) Dormouse of Europe and Asia, the Desert Dormouse of Africa, the Malabar Spiny Dormouse of India and the Pygmy Dormouse of China. This chapter describes the status and distribution of Malabar Spiny Dormouse in the forests of Kerala.

3.1.2 Methods

The method of questionnaire survey is already described in the Chapter 2.

Live trapping**:** The location for trapping in each protected area was selected by purposive sampling, so that the habitat peculiarities of all the protected areas in Kerala were represented in the samples (Table 1). The traps were baited with grated coconut between 17.00 h and 18.30 h and checked for animals between 05.30 h and 07.30 h. Trapped rodents were identified, sexed, weighed and marked permanently by ear punching using an ear punch (National Band and Tag Co., U.S.A. No. 1538). Rodents were identified up to the species level using the reference books (Prater, 1988; Corbet and Hill, 1992). The animals were photographed and photographs were kept for later reference.

Table 1. The habitat characteristics of the trapping sites

No.	Protected areas	Habitat characteristics
1.	Neyyar WLS	Low altitude moist deciduous forest, 12 km away from human habituation.

2.	Peppara WLS	Low altitude moist deciduous forest, 1 km away from human habituation
3.	Schenduruni WLS	Low altitude moist deciduous forest
4.	Periyar Tiger Reserve	High altitude evergreen forest
5.	Idukki WLS	Semi evergreen forest, boarded by 2 km wide grassland
6.	Thattekkad BS	Teak plantation converting into natural forest, due to lack of plantation activities for the past twenty years
7.	Chinnar WLS	High altitude shola of moderate size, which lies 3 km away from the nearby shola.
8.	Eravikulam NP	Shola of moderate size and grassland
9.	Parambikulam WLS	Evergreen forest, 12 km away from human habituation, at the junction of the near by reserve forest ranges.
10.	Peechi WLS	Moist deciduous forest and mixed evergreen forest 6 km away from the human habitation.
11.	Chimmony WLS	Low altitude moist deciduous forest and mixed evergreen forest each 3 km away from human habituation
12.	Silent Valley NP	Ecotone of the evergreen forest and grassland
13.	Wayanad WLS	High altitude Semi evergreen forest of the plateau
14.	Aralam WLS	Low altitude moist deciduous forest.

Adult animals were sexed based on the morphology of their genitalia and the sub adults by the distance between the anus and genital opening. Morphological measurements of head and body length and tail length were made and the fur coloration was also noted and photographed. The animals were released at the spot where they were trapped.

3.1.3 Result

Morphology

Adult females of Malabar Spiny Dormouse weighed 70 g (N = 2) and pregnant females 90 g (N = 2). Female hbl was between 108 mm to 110 mm and the tail length were between 100 mm to 105 mm. Adult male was of 80 g weight, 110 mm hbl and 105 mm tail length (N = 1). Sub adult was having 50 g weight and 80 mm tail and hbl. No morphological variations were observed across the region among the individuals of the species. Sub adults were grey in colour where as the adults were more brownish in colour. A photograph of Malabar Spiny Dormouse is given in (Plate 2). Only one photograph of the species was published before this study was initiated. A white patch was observed at the tip of the tail of the sub adults, which was dark black in case of adults (Plate 3). The morphological measurements of Malabar Spiny Dormouse are given in Table 2.

Table 2. Morphological measurements of Malabar Spiny Dormouse

Categories	Weight (gm)	Hbl (mm)	Tail (mm)
Male	80	110	105
Female	70	108	110
Female (Pregnant)	90	108	110
Sub Adult	50	80	80

Distribution

The presence of Malabar Spiny Dormouse an endemic rodent species to the Western Ghats was recorded for the first time from ten protected areas of Kerala. The questionnaire survey and field observations proved that the Malabar Spiny Dormouse is distributed in 33 out of the 39 Forest Ranges (Fig. 4) and 11 Protected Areas of the Kerala Part of the Western Ghats. The species was recorded for the first time from the Chimmony, Chinnar, Parambikulam, Idukki, Neyyar and Aralam Wildlife Sanctuaries and also from Periyar Tiger Reserve, Eravikulam National Park, and Thattekkad bird sanctuary. It is observed that trap response of rodents was species specific.

A total of 6400 trap nights were attempted and the percentage trap success was 3.625. Maximum trap success was obtained from Shendurney Wildlife Sanctuary. Malabar Spiny Dormouse was captured in the traps laid on the floor from the three protected areas namely the Chimmony Wildlife Sanctuary, Eravikulam National Park and Thattekkad Bird Sanctuary. Trap nights attempted and trap success from each protected areas, is given in the Table 3.

Lowest trap success was recorded in second session at Peechi Wildlife Sanctuary and maximum trap success was in Chinnar Wildlife Sanctuary. Other than by trapping the presence of Malabar Spiny Dormouse was confirmed from Protected

Areas namely Neyyar, Peppara, Periyar Tiger Reserve, Idukki, Chinnar, Parambikulam and Aralam. The species was recorded by direct sightings, nest studies and identification of feeding remains from Neyyar, Peppara, Idukki, Chinnar, Parambikulam and Aralam Wildlife Sanctuaries and the Periyar Tiger Reserve.

Animals were seen living as colony in the nests (N = 12), and a few animals were seen living solitarily (N = 3). Colonies were having more than one adult female (N = 4), and a detailed observation on the strength and sex ratio of the colony was not possible as the study strictly followed non-destructive methods. The capture data from the protected areas was insufficient for carrying out any of the CMR analysis. It was unable to workout a reliable sex ratio from the data collected. The occurrence of Malabar Spiny Dormouse recorded from the protected areas of Kerala is given in Table 4.

Table 3. Trap nights attempted in each sessions and corresponding trap success

Sl. No.	Trapping sessions	Trap nights attempted	Trap Success (%)
1.	Peechi I	500	2
2.	Chimmony I	500	0.6
3.	Peechi II	750	1.5
4.	Chimmony II	250	0.6
5.	Peppara	400	5
6.	Parambikulam	200	2.5
7.	Chinnar	200	2.25
8.	Silent Valley	400	2
9.	Idukki	400	0.13
10.	PTR	400	3.75
11.	Wyanad	400	3.5
12.	Thattekkad	400	4.25
13.	Eravikulam	400	4.5
14.	Aralam	400	7.25
15.	Shendurney I	200	19
16.	Shendurney II	200	5.75
17.	Neyyar	400	7.75
	Total	6400	3.625

Table 4. Occurrence of Malabar Spiny Dormouse in the different protected areas of Kerala

Sl No.	Protected Areas	Status
1.	Neyyar WLS	P*
2.	Peppara WLS	P***
3.	Shendurney WLS	A
4.	Periyar Tiger Reserve	P*
5.	Thattekkad BS	P
6.	Idukki WLS	P***
7.	Chinnar WLS	P***
8.	Eravikulam NP	P
9.	Chimmony WLS	P
10.	Peechi WLS	A
11.	Parambikulam WLS	P***
12.	Silent Valley NP	A
13.	Wayanad WLS	A
14.	Aralam WLS	P*

P - Present
* - Confirmed by feeding remaining
** - Confirmed by direct sighting,
*** confirmed by nest identification

Peppara Wildlife Sanctuary

The Malabar Spiny Dormouse was recorded from most of the areas in the Peppara Wildlife Sanctuary. Some of the locations were Chemmankala, Podiakala and Chathankode. The result of biased trapping of Malabar Spiny Dormouse in the intensive study area is given in the Table 5. Twelve individuals were trapped from the intensive study area.

Table 5. Trapping of Malabar Spiny Dormouse in the Peppara Wildlife Sanctuary

3.1.4 Discussion

The Malabar Spiny Dormouse was newly reported from nine protected areas in Kerala. Terrestrial trapping is a not a good method for catching the Malabar Spiny Dormouse. The Malabar spiny Dormouse is distributed widely in the forests of Kerala and in the southern Forest Ranges the species is familiar to the Kani tribals. But in the central and northern Forest Ranges the animal is not familiar with the tribal people. Live trapping using Sherman traps yielded result from two sanctuaries and the trapping studies indicated that the species occur in extremely low densities. Spines on the dorsal side of the body are very prominent (Plate 4). Apart from the tropical evergreen forests the species was recorded from the moist deciduous forests also (Plate 5).

3.2. Distribution and diversity of Rodents

3.2.1. Introduction

Data obtained while trapping the Malabar Spiny Dormouse in the different protected areas of Kerala is presented in this chapter. This was attempted as no substantial data is available on the abundance of rodents from the protected areas of Kerala. Capture Mark Recapture (CMR) method is the basic tool for estimating the survival, density (Williams, 1996), breeding probabilities (Williams *et al.*, 2002), and temporary emigration (Schaub *et al.*, 2004) in rodents. No study has been reported from the tropical areas using CMR in considerably large extent as the Kerala part of Western Ghats with uniform methodology so that the heterogeneity in trapability over similar large-scale demographic changes could be assessed. Taking into account of the limitations of CMR and the suggestions to overcome the problems in operating CMR, the present study was designed.

3.2.2. Methods

Procedure adopted for trapping the rodents was described in Chapter 2 on methods. Capture Mark Recapture (CMR) models were used for the analysis of the multi stage recapture data. The history of Capture Mark Recapture techniques can be traced back to 17th Century and the basic principles were formulated by Lincoln (1930) and Jackson (1933) independently. Otis *et al.* (1978) proposed five models for estimating abundance and recapture probability distributions. This was modified later by White *et al.* (1982), who suggested eight models for estimation. The software PROGRAM CAPTURE was created based on the models suggested by Otis *et al.*, 1978 and White *et al.*, 1982.

***Basics of CMR*:** Basically there are four assumptions based on which the whole CMR technique has been built up (Otis *et al.*, 1978).

a. The population must be closed.
b. Marks are permanent; the marked animals will not lose the marks during the study period.
c. All marks are noted and recorded in each sampling occasions.
d. Each animal has a constant and equal probability of capture on each occasion.

The closure refers to both geographical and demographical where as the demographic closure has been relaxed in open models. Open models, which relaxed closure requirement are used for long term studies to observe survival and recruitment rates etc. where as the closed models are for short time studies (Otis *et al.*, 1978). The simple theory behind the abundance estimation can be explained based on the Peterson Lencoln estimator.

$$N = n_1 n_2 / m_2$$

Where N is the total number of individuals in the population, n_1 is the number of animals captured and marked in the first sampling, n_2 the number of animal in the second sampling and m_2 the number of marked animals in the second sampling. In multi sampling Capture Mark Recapture models the equation becomes much complicated to be solved directly and so the capture probability is taken as an estimator to work out the abundance (N).

***Analysis*:** All the trapping results and the field data were subjected to statistical analysis using the programs CAPTURE, SPSS Version 11, STAISTICA Version 6 and BIODIVERSITY PRO. CAPTURE was used for the analysis of the capture recapture data and model selection. SPSS Version 11 was used for the Multidimensional scaling of the trapping sites. BIODIVERSITY PRO was used for the estimation of different diversity indices. STAISTICA was used for all the other statistical analysis used throughout the study. Abundance estimation models *vis* M_0, M_t and M_{bh} was applied using the capture data. An x matrices history of binomial capture history was not possible since the marking was done only by ear punching and no individual animal identification markings were attempted. The models were tested using the program CAPTURE version 1.0. The standard error of all the estimators produced by all the models was less than half of the estimator. Even though the program was having a facility of model selection it was not able to perform this facility since the x matrices of the recapture history was not able to create. In this situation the model selection was based on the relative precession, using Coefficient of variation of the abundance estimator worked out using the formula

$$\text{Coefficient of Variation} = \frac{SE \times 100}{N}$$

Where SE = the standard error and
N = the Population size estimated.

Out of the nine capture histories model M_t was chosen for seven data sets and M_{bh} for two. No data set has chosen the model M_0. Density was estimated using the selected models in possible cases and in other cases the Minimum Number Alive has taken as the abundance to work out the density. Schnabel method (Schnabel, 1938; Schumacher and Eschmeyer, 1943) was attempted for all the data set using the formula

$$N = \frac{\sum(MtCt)}{\sum(Rt)}$$

Where N = the population size

M_t= the number of marked individuals

C_t, = total number of individuals in the sample (marked and unmarked)

and R_{at} = number of marked individuals recaptured in the sample (values taken at time t).

This attempt was not able to produce any result on behalf of the small sample size, which is unable to generate reliable upper and lower values for N at 95% confidence limits. The trends in new capture were observed by plotting the new capture per day. Vegetation data and habitat parameters of the trapping plots were collected and subjected to a multi dimensional scaling and the stimulus configurations were plotted. Initially the variable altitude was used and the result was highly biased by the effect of comparatively large range of the altitude data, which was between 250 m to 1750 m from msl. So this was removed from the variable list and only variables regarding the vegetation and topography was used for the analysis.

Following habitat parameters and vegetation data of the trapping sites were recorded.

1. Number of trees in each species category
2. Altitude
3. Forest type
4. Canopy cover (Qualitative estimation in a scale of 1-10)
5. Under growth (Qualitative estimation in a scale of 1-4)
6. Slope of the land (Angle of inclination)
7. Litter quantity (Thickness in cm)

8. Distance to the nearby water body in meters
9. Distance to human habitation in kilometres

3.2.3. Results

Occurrence of Rodents

Altogether 131 Murid rodents of seven species and six insectivores of the genus *Suncus* were trapped from fourteen protected areas of Kerala. Among the rodents trapped 68.7 percent was the Black Rat *Rattus rattus* (Plate 6) followed by Blanford's Rat *Cremnomys blanfordi* (13.7 percent) and Spiny Field Mouse (*Mus platithryx*) constitute 11.4 percent of the capture. The remaining was the nominal capture of *Golunda ellioti* (Plate 7), *Millardia meltada* and *Mus musculus*. Maximum species richness was recorded from the Peppara Wildlife Sanctuary (Table 6). Trap mortality was not observed prominently but occurred on the fourth day at Chinnar Wildlife Sanctuary at an altitude of 1650 m above sea level during the period of monsoon (July). Capture success of rodents in different protected areas are given in Fig. 5. Capture and recapture rate of rodents is given in Fig. 6.

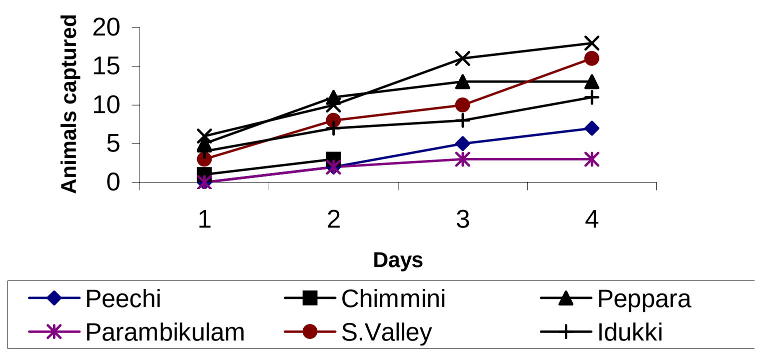
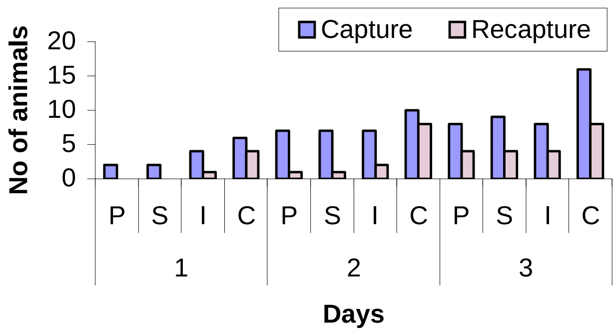


Fig. 5 Capture success in different protected areas



P-Peppara, S – Silent Valley, I – Idukki, C - Chinnar

Fig. 6 Capture and recapture rate of rodents from four Protected Areas

Table 6. Rodent species recorded from the protected areas of Kerala

Sl. No	Protected Areas	*Rattus rattus*	*Cremnomys blanfordi*	*Mus platithryx*	*Mus musculus*	*Golunda elioti*	*Tatera indica*	*Millardia meltada*
1.	Neyyar WLS		P	P				
2.	Peppara WLS	P	P	P			P**	
3.	Shendurney WLS	P						
4.	Periyar Tiger Reserve	P		P				
5.	Thattekkad WLS	P		P				
6.	Idukki WLS	P						
7.	Chinnar WLS	P						
8	Eravikulam NP	P						
9.	Chimmony WLS	P						P
10.	Peechi WLS	P	P		P			
11.	Parambikulam WLS			P		P		
12.	Silent Valley NP	P		P				
13.	Wayanad WLS	P	P					
14.	Aralam WLS		P	P				

P - Present, ** - direct sighting,

In the case of insectivores, *Suncus* sp. was collected from Chimmony, Peechi and Parambikulam Wildlife Sanctuaries and Silent Valley National Park and there was no recapture from anywhere. Common House Mouse *Mus* sp. was also collected from Peechi Wildlife Sanctuary. Indian Gerbil *Tatera indica* was observed at the outskirts of Peppara Wildlife Sanctuary but was not trapped or located in the evergreen forest. *Rattus rattus* was the most common rodent recorded from the protected areas.

A. House Rat *Rattus rattus*

Rattus rattus was captured during 13 trapping sessions from 11 protected areas namely the Wayanad, Silent Valley, Peechi, Chimmony, Thattekkad, Chinnar, Eravikulam, Idukki, Shendurney, Peppara Wildlife Sanctuaries and Periyar Tiger Reserve. From Chinnar, Shendurney and Idukki only the species House Rat was recorded. The species was not trapped from Neyyar, Parambikulam and Aralam Wildlife Sanctuaries. The Minimum Number Alive (MNA) derived from the data for this most abundant species was up to 18 (Table 7).

Table 7. Number of House Rat trapped from different protected areas

Sl. No.	Protected areas	House Rat (Minimum Number Alive)
1.	Chimmony	1
2.	Chinnar	17
3.	Eravikulam	9
4.	Idukki	11
5.	Peechi I	1
6.	Peechi II	2
7.	Peppara	7
8.	Periyar Tiger Reserve	5
9.	Shendurney	6
10.	Silent Valley	14
11.	Thattekkad	12
12.	Wayanad	5
	Total	**90**

***Male to female ratio*:** Male to female ratio of the species was highly skewed towards male (9:1) at Eravikulam National Park and towards female (0:7) at Peppara Wildlife Sanctuary (Table 8). The pattern of new capture of males and females were entirely different (Figs. 7 and 8). Only sixteen percent of the total males were captured on the first day of the capture where as the percentage of the total female captured on the first day was 31. Only at Eravikulam and Thattekkad the numbers of trapped males were more than trapped females. In the case of Thattekkad the numbers were more close to the normal value 1:1 and at Shendurney it was 1:1.

Table 8. Male to female ratio of *Rattus rattus* recorded from the protected areas

Sl. No.	Protected Areas	Male to female ratio
1.	Peppara	0:7
2.	Peechi II	0:2
3.	Shendurney	1:1
4.	Periyar Tiger Reserve	1:4
5.	Wayanad	1:4
6.	Idukki	1:5
7.	Silent Valley	3:11
8.	Chinnar	3:14
9.	Thattekkad	6:5
10.	Eravikulam	9:1

Morphology**:** Morphological measurements of the species House Rat of different sexes captured from different protected areas were not compared since the trapping was conducted across a large area irrespective of the seasons on which the morphological characters may vary drastically (Table 9). Body colour or the fur colour and the hair pattern were varying across each protected areas especially across the habitat types. This has not been recorded numerically. In general thickness of fur was high in the evergreen and shola habitats and low in the moist deciduous habitats. Fur colour was light in sub-adults and dark in adults and feeble variation were observed through out the region.

Rattus rattus was the most abundant species captured during the study. Out of the 17 trapping sessions conducted in the 14 protected areas *Rattus rattus* was captured during 13 sessions in the 11 protected areas namely the Peppara, Chinnar, Idukki, Wyanad, Thattekkad and Shendurney Wildlife sanctuaries and Eravikulam and Silent Valley National Parks. From Chinnar, Shendurney and Idukki wildlife sanctuaries only *Rattus rattus* was recorded but the species was not trapped from the Neyyar, Parambikulam and Aralam Wildlife Sanctuaries.

Table 9. Morphological measurements of House Rat

Protected Areas	Sex	Weight (mg)			Tail (mm)		Hbl (mm)		Tail/Hbl (%)	
		Minimum	Maximum	Mean	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Chinnar (N = 17)	Male	160	170	163.3	230	240	130	170	135	170
	Female	80	150	98.7	190	230	105	170	129	200
Eravikulam (N = 9)	Male	100	240	136.7	178	24	125	150	123	177
	Female	150	150	150	208	208	150	150	139	139
Idukki (N = 1)	Male	100	170	135	230	230	120	170	135	135
	Female	70	170	105.6	140	240	133	130	140	184

Peechi (N = 3)	Male	No capture								
	Female	No capture			90	190	80	118	140	156
Periyar Tiger Reserve (N = 5)	Male	100	100	100	190	190	123	123	154	154
	Female	95	120	98.8	185	200	113	135	140	167
Shendurney (N = 6)	Male	150	200	176.7	210	225	143	165	130	175
	Female	150	160	155	225	235	130	145	155	180
Silent Valley (N = 14)	Male	130	130	130	220	220	140	140	157	157
	Female	40	170	121.7	130	230	93	150	123	200
Thattekkad (N = 12)	Male	180	230	205	210	250	130	160	150	167
	Female	100	150	120	175	190	105	120	152	174
Wayanad (N = 5)	Male	No capture								
	Female	60	110	93	170	200	105	142	140	162
Peppara (N = 7)	Male	No capture								
	Female	No capture			140	215	100	140	140	156

Hbl = Head and body length

Body weight of the males and females were compared for each region. The mean body weight of the males was higher than the mean body weight of the females in all the areas other than the Eravikulam National Park, where the mean weight of males was only 0.91 times of that of females. The difference between mean weight of males and females were highest at Thattekkad Wildlife Sanctuary (1.70 times), at Thattekkad the male to female ratio was close to the normal value of 1:1. Tail length of the males were between 135 to 177 percent of the head and body length of the animals through out the region and that of female were 139 to 200 percent. Females possessed more long tails compared to their body size.

Age class: Most of the House Rat captured was adults. There was a possibility to misinterpret the weak females as sub adults. Pregnant female was observed at Peechi-Vazhani Wildlife Sanctuary during the pre-monsoon season of May. Sub adults were trapped from three protected areas namely Silent Valley, Wayanad and Shendurney. They were trapped from Silent Valley and Wayanad during the monsoon season, during the months of August and June respectively where as from Shendurney the sub-adult was trapped during the month of January. Out of the 91 animals captured during the study 78 were hidden in burrows, under rock or under litter when released from trap, 12 animals climbed on the branch of near by trees and hidden in the clefts on the lower branches or in the holes on the branches.

The House Rat was found absent in the sampling plots at Aralam, Neyyar and Parambikulam Wildlife Sanctuaries. The plot at Parambikulam Wildlife Sanctuary was in an evergreen forest and the plot at Neyyar Wildlife Sanctuary was in a moist deciduous forest, but both of plots were more than 12 km away from human habitations. In Aralm Wildlife Sanctuary the plot was at 2 km away from the human habitation and the area was moist deciduous forest.

***Abundance*:** Sufficient capture and recapture data required for statistical analysis was available only from 9 sessions from 9 protected areas. The trends in new capture were studied by plotting the new capture on each day (Fig. 9). The pattern of capture for the initial three days was similar in the case of seven sessions with highest number of capture on the second day and then a decrease in the number of capture. The trends in initial three days were different in other two sessions; the second day capture was less than that of first and third days (Fig. 9 – H and I). For four days of capture as whole the trends fall in four categories. In the case of three sessions (Fig. 9 – E to G) an increase in fourth day new capture was recorded.

Out of the nine capture histories model M_t was chosen for seven data set and M_{bh} for two. Four data sets the model M_{bh} failed on behalf of the mathematical criterion (Table 10). Model M_0 was unable to apply for any dataset. Density was estimated using the selected models in possible cases and in other cases the MNA has taken as the abundance to work out the density.

Fig. 9 Patterns of new capture per day distribution of House Rat in different trapping sessions

Table 10. Abundance of House Rat estimated with different models of CMR

Protected areas	Model M0			Model Mbh			Model Mt		
	N_0	SE	CV	N_{bh}	SE	CV	N_t	SE	CV
Chinnar	21	4.2308	20.15	24	8.8151	36.73	16	0.5189	3.24313*
Idukki	16	3.5177	21.99	**			15	2.7533	18.3553*
Peppara	6	0.4751	7.91	**			6	0.0041	0.06833*
Eravikulam	14	5.1955	37.11	**			11	2.1512	19.5564*
Shendurney	6	0.374	6.23	6	0.3205	5.34	6	0.0041	0.06833*
Thattekkad	11	1.4889	13.54	10	0.7081	7.081*	11	0.9972	9.06545
Silent Valley	25	7.3399	29.36	**			22	5.1408	23.3673*

Periyar Tiger Reserve	5	1.3215	26.43	5	0.004	36.73	5	0.0038	0.076*
Wyanad	12	5.3451	44.54	8	2.8454	35.57*	11	4.438	40.3455

* - least value of CV ** - Model failure **$N_{0=}$** **$N_{bh=}$** **$N_{t=}$**

The highest density of House Rat was obtained in the shola forest of Eravikulam National Park (Table 11).

Table 11. Density of House Rat estimated in different protected areas

Protected areas	Animal density (Animal/ha)	95 % Confidence interval
Chinnar	16	16-19
Chimmony	1	--
Idukki	15	13-25
Peechi	2	--
Peppara	6	6-7
Eravikulam	22	20-29
Shendurney	6	6-7
Thattekkad	10	10-10
Silent Valley	22	17-40
Periyar Tiger Reserve	5	5-5
Wayanad	8	8-25

B. Branford's Rat *Cremnomis blanfordi*

The species was recorded from Aralam, Wayanad, Peechi, Peppara and Neyyar Wildlife Sanctuaries in the evergreen and moist deciduous forest types (Plate 8). The altitude ranged between 250 m above msl at Peppara and 1050 m above msl at Wayanad and a total of 16 individuals of this species were trapped from the five Wildlife Sanctuaries. The male to female ratio is a highly negatively skewed ratio at Peppara (0:3) to a highly positively skewed ratio at Peechi (3:0). Among the other areas Aralam has a male to female ratio of 1:3 and other areas have 1:1.

There was not considerable difference in weight between males and females. No obvious dimorphism in head and body length and tail length was observed based on sex. The tail was always more than 120 percent of the head and body length. Most of the animals trapped were adults but two sub adults were also trapped from Wayanad and Aralam Wildlife Sanctuaries. The sub adults were trapped during the months of December and March and no pregnant animals were captured at any of the trapping period. Sixty five percent were hiding in burrows, under rocks or under litter when released from the traps but others climbed on trees. At Peppara Wildlife Sanctuary one individual was regularly climbing on a tree 6 m away from the trap station.

***Abundance*:** Sufficient number of capture and recapture data to carryout the CMR analysis was available only from two protected areas for this species *viz.* Aralam and Peppara Wildlife Sanctuaries. Model M_t was selected for the data set from Aralam Wildlife Sanctuary. Model M_0 was selected for the data from Peppara Wildlife Sanctuary, which was enough to work out Model M_0 only. For the data set from Aralam wildlife Sanctuary the Model M_{bh} showed failure on behalf of the mathematical criterion (Table 12). Density was estimated based on the model selection in possible cases and MNA in cases where the capture data was not enough to select the models (Table 13).

Table 12. Abundance of Blanford's Rat estimated under the three possible models of CMR

Protected areas	Model M_0			Model M_{bh}			M_t		
	N_0	**SE**	**CV**	**N_{bh}**	**SE**	**CV**	**N_t**	**SE**	**CV**
Aralam	4	0.825	20.625		**		4	0.003	0.075*
Peppara	3	0.336	11.2*						

N_0, N_{bh} and N_t – Abundance of Blanford's Rat, * - least value of CV ** - Model failure

Table 13. Density of Blanford's Rat estimated in different protected areas

Protected areas	Animal density (Animal / ha)	95% confidence interval
Aralm	4	4 - 4
Peppara	3	3 - 4
Peechi	3	--
Wayanad	3	--
Neyyar	2	--

C. Spiny Field Mouse (*Mus platythrix*)

A total of 17 individuals of these ground dwelling species were captured from the seven protected areas (Plate 9). The male to female ratio ranged between 0:4 at

Peppara and 3: 2 at Thattekkad. This was 1:1 at Neyyar and 1:2 at Periyar Tiger Reserve. No morphological differences were observed in the fur colour and hair growth across different protected areas. Male varied from 30 g to 100 g and females between 30 g to 70 g in the case of body weight and no sexual dimorphism was observed in the case of body weight. Length of the tail varied from 50 percent of the head and body length to 100 percent. All the trapped animals were adults and no sub adults or pregnant individuals were trapped.

Abundance**:** The capture recapture data from two protected areas were sufficient to carry out the estimation of abundance based on Otis *et al*. (1978). Two of the data sets failed on behalf of the mathematical criterion when Model M_{bh} was attempted and the Model M_t was chosen considering the least CV value (Table 14).

Table 14. Abundance of Spiny Field Mouse estimated with three possible models of CMR

Protected areas	Model M_0			Model M_{bh}			M_t		
	N_0	SE	CV	N_{bh}	SE	CV	N_t	SE	CV
Peppara	6	3.7834	63.0567		**		4	0.0959	2.3975*
Thattekkad	5	0.8668	17.336		**		5	0.0038	0.076*

N_0, N_{bh} and N_t – Abundance of *Mus platythrix* * - least value of CV ** - Model failure

Density was estimated based on the model selection in possible cases and MNA in cases where the capture data was not enough to select the models (Table 15).

Table 15. Density of Spiny Field Mouse estimated in different protected areas

Protected areas	Animal density (Animal / ha)	95% confidence interval
Aralam	1	--
Parambikulam	2	--
Peppara	4	4 – 4
Periyar Tiger Reserve	3	--
Silent Valley	1	--
Thattekkad	5	5 – 5
Neyyar	2	--

Habitat analysis of Rodent Community

Habitat parameters and vegetation data recorded form the plot where trapping was carryout is given in the Table 16. Correlation between rodent community and individual parameters were worked out and given below. A positive correlation was obtained between the number of tree species and the number of rodents captured from the protected areas (t=0.422, P=0.047 and N=16). Litter thickness was positively correlated to the under growth (t=0.629, P=0.003, N=16) and canopy cover (t=0.5226, P=0.23, N=16). Number of tree species in the plots was negatively correlated to altitude (t = -0.586, P=0.002, N=16) and as expected the canopy cover was positively correlated to the tree density (t=0.517, P=0.008, N=16).

Habitat data from the trapping plots were subjected to a multi dimensional scaling and the stimulus configurations were plotted. Initially the variable altitude was used and the result was then highly biased by the effect of comparatively large range of the altitude data, which was between 250 m from msl to 1750 m from msl. So this was removed from the variable list and only variables regarding the vegetation and topography was used for the analysis. Among the sixteen protected areas used for the analysis eight was plotted in the negative side of the second dimension axis and eight in the positive side and (Fig. 10). In all the protected areas which have a value less than 0.0002 for the stimulus coordinates dimension for the second coordinate the mostly trapped rodent species from the region House Rat was absent or coexisting with some other species other than *Mus platithryx*. Neyyar and Aralam Wildlife Sanctuaries where *Rattus rattus* was found absent and *Cremnomys blanfordi* was predominant were having least values of the stimulus coordinates dimension for their second coordinate. In Peppara, Wayanad and Peechi Wildlife Sanctuaries, which have their stimulus, coordinates dimension for second coordinate less than 0.0002, *Rattus rattus* was seen coexisting with *Cremnomys blanfordi*. At Thattekkad Bird Sanctuary and Chimmony Wildlife Sanctuary *Rattus rattus* was seen coexisting with *Platacanthomys lasiurus*. In Parambikulam Wildlife Sanctuary, which also lies in the negative side of the second coordinate *Rattus rattus* was not trapped, but the rodent species *Gollunda elioti* was trapped.

In the case of protected areas, which had their value of the stimulus coordinates dimension for their second coordinate greater than 0.002, lies in the positive side of the axis, except Eravikulam either *Rattus rattus* was the only rodent species trapped or found coexisting only with *Mus platythrix*. In all other protected areas which had their value of the values of the stimulus coordinates dimension for their second coordinate was less than 0.002 *Rattus rattus* was found absent or coexisting with *Platacanthomys* *lasiurus* or *Cremnomys blanfordi*. Eravikulam National Park has got a high positive value for the second of the stimulus coordinates dimension but both *Platacanthomys lasiurus* and *Rattus rattus* was trapped from there.

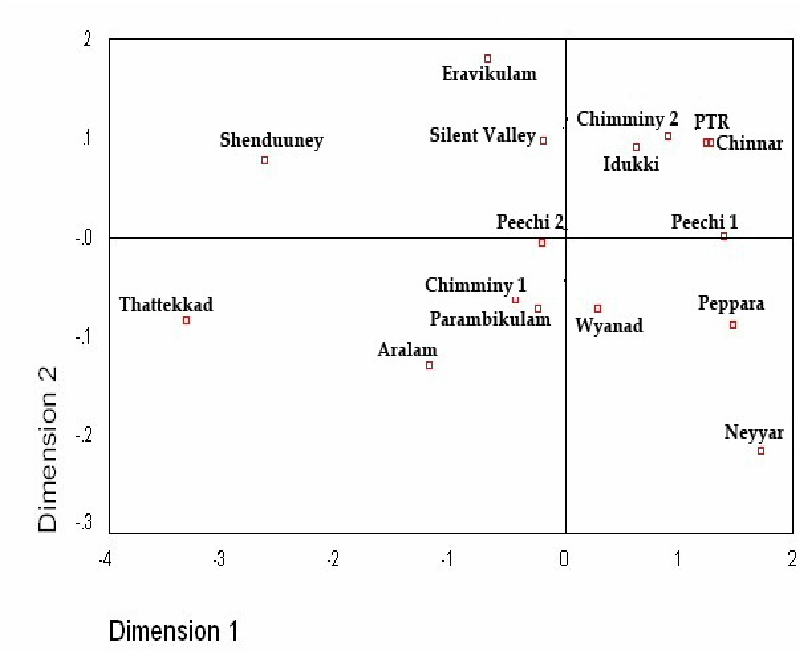


Fig. 10 Multi dimensional scaling of the protected areas based on the habitat parameters and Rodent Community

3.3. Food and feeding behaviour

3.3.1. Introduction

Food and feeding studies on small mammals have proved that the regeneration in natural and logged forest is highly influenced by the foraging of small mammals (Adler and Kestell, 1998; Guariguata *et al*., 2000). Studies on the diet of small mammals are tantamount in understanding the energy budget of the species in explaining the demographic aspects like population structure and population fluctuations (Anderson and Jonasson, 1986) and understanding the trophic relationship and resource partitioning in the community (Meserve, 1981a and b). Information on the food and feeding behaviour is crucial to understand the role of any organism in an ecosystem. No detailed information is available on the food and feeding behaviour of the Malabar Spiny Dormouse. Mudappa *et al.,* (2001) reported few species of plants as the food of Malabar Spiny Dormouse and earlier reports mentioned its preference for Pepper and Cashew. Detailed observations were carried out on the food items and feeding behaviour of the species with the assistance of radio telemetry. The food and feeding behaviour of the Malabar Spiny Dormouse was studied for better understanding of the ecological relationships of this endemic species and to find the position of the species in the food web in the tropical forest ecosystem.

3.3.2. Methods

The study was conducted in the intensive study area at Peppara Wildlife Sanctuary. Three methods were adopted to study the food and feeding of the Malabar Spiny Dormouse namely the direct observation, indirect observation and radio telemetry assisted observations. Food and feeding observations were carried at two locations in the intensive study area separated by an aerial distance of 9 km. The feeding behaviour was observed directly and on the radio tagged animals. Phenology of the area has been worked out in an earlier study (Jayson, 1998).

Direct Observation: Direct observation on the food and feeding behaviour of the Malabar Spiny Dormouse was carried out in the intensive study area. The basic method of focal animal sampling was employed (Altman, 1974). The observer walked through the forest, at night very slowly listening to the sound of falling discarded food from the trees. After identifying the tree from which the discarded food remains were fallen the approximate position of the animal was determined and two or three flashlights were used to detect the animal. Usually the feeding of the animal in the canopy was observed. The focal animal was observed till it moved away from the sight. This was carried out when the feeding remains were spotted under a tree, suspected to be that of Malabar Spiny Dormouse. In the case of suspected food remains the feeding of the animals was also confirmed by waiting for the arrival of the animal and the initiation of the feeding. A total of 52 nights were utilised in the intensive study area during the summer and monsoon seasons for telemetry assisted observations.

***Indirect Observation*:** The food species was also confirmed with out directly observing the feeding process but depending on indirect evidence. The feeding remains of seeds were compared for the specific pattern of gnawing by the species; in some instance the Malabar Spiny Dormouse was sighted on the plant along with the feeding remains falling and where no other rodent of similar size was sighted. Food patches were also used to confirm the feeding of Malabar Spiny Dormouse in the intensive study area. The food patch was created in the canopy using the rhizomes of Shumanianthus were the animals were observed foraging and the patches were checked in every hour. Food patch experiment was attempted only once.

***Telemetry assisted observations*:** Telemetry assisted observations were carried out at three locations in the intensive study area at Peppara Wildlife Sanctuary (Plate 10). Malabar Spiny Dormouse was captured by keeping the live Sherman traps near to the known and identified nest of the species. The traps were fixed on poles cut from the same tree. The poles were tied to the branch on which the nest was situated. In some cases artificial bridges were created using sticks for leading the Malabar Spiny Dormouse into the traps. The traps were baited with grated coconut and fifty one traplights were attempted in the intensive study area for catching the individuals. The trapped animals were sexed and weighed. Radio transmitters (Telonics, USA; CHP-3; Weight 6 gm) were attached on the neck region of the animals and were released near their nests on the tree (Plate 11). The transmitters were having a battery life of 3 months. Tracking was started at 18.30 hrs in the evening and preceded till the animal returned to the nest early in the morning. A total of 16,200 minutes of observations were made on four animals at three locations from March 2004 to February 2005. Attempts were made to quantify the feeding in *Theobroma cacao* but the quantification could not be done as the local people collected the cocoa fruits before ripening for commercial purpose, otherwise the Malabar Spiny Dormouse will consume them. Similarly the attempt to quantify the pepper feeding was also failed due to the same reason mentioned above.

Feeding activity was detected by the sound of discarded food falling on the ground. Such close feeding points were located on the canopy of the same tree or overlapping canopy of the nearby trees. These close points were clubbed and combined to one occurrence point from the field during the next day time. This was attempted only in cases where the activity of the animals was not clearly observable. The points where feeding activity was identified were named as feeding points and the movement paths also were located and marked.

3.3.3. Result

Food species

Twenty-five plant species including four commercial crops were identified as the food species of Malabar Spiny Dormouse (Table 17). Twelve food species including two commercial crops were identified using location telemetry and four species identified by direct sighting and the remaining species were identified by indirect evidences (Table 18). Common food items of the species in the intensive study area were *Terminalia bellerica, Persia macrantha, Tamarindus indica, Melia dubia* and Pepper (Plate 12). The animal consumed aril, seeds, flower and rhizome of plants and there was no evidence to show that the animal consumed tender leaves, but chances for such a feeding habit cannot be ruled out. Seeds or fruits were consumed from twenty one species; flower was consumed from five species and rhizome from one species. Cotyledons of seeds of seven plant species, mesocarp from two species and aril from one species were fed by the animal. The fleshy basal portion of the flowers was consumed. The fruits of three species and seeds of five species even though fed by the species, the exact portion of the fruit and seed consumed were not clear. During summer *Artocarpus heterophylla and Theobima cacao* species were used for obtaining food and during monsoon *Ficus*, *Knema attenuata,* and *Theobinima cacao* were consumed.

Animals passed over the fruits of *Theobroma cacao* but consumed only the matured fruits before ripening. Preference of food was mostly according to the availability but the species showed preference for the seeds of *Terminalia bellerica* in wild and *Theobroma cacao* in the case of commercial crops. *Piper sp.* was fed in wild and commensal areas. The animals were considered as a pest in the plantations (Rajagopalan, 1968) at the forest fringes and settlements inside the forest especially on *Anacardium occidentale*, *Piper nigrum* and *Theobroma cacao*. Three cases of controlling the species by poisoning were recorded between September 2002 and March 2005. The animals were feeding from the plants, which have canopy continuity with the forest area. Tribals used to remove all the canopy continuity to the commercial crops from the forest area in order to protect the crop from the Malabar Spiny Dormouse.

Table 17. Food species of Malabar Spiny Dormouse and feeding parts

Sl. No.	Plant species	Plant group	Feeding part
1.	*Anacardium occidentale*	Commercial crop	Cotyledons
2.	*Aporosa lindleyana*	Tree	Mesocarp
3.	*Artocarpus heterophylla*	Commercial/Wild tree	Cotyledons
4.	*Bombax ceiba*	Tree	Flower
5.	*Careya arborea*	Tree	Fruit/ Flower
6.	*Ficus* sp.	Tree	Fruit
7.	*Garcinia cowa*	Tree	Mesocarp
8.	*Holigarna beddomei*	Tree	Cotyledons
9.	*Hydnocarpus pentandra*	Tree	Cotyledons
10.	*Knema attenuata*	Tree	Aril/ Flower
11.	KORANDI	Tree	Seed
12.	KURAVI	Tree	Seed
13.	*Macaranga indica*	Tree	Seed
14.	*Madhuca longifolia*	Tree	Seed
15.	*Melia dubia*	Tree	Seed
16.	*Persea macrantha*	Tree	Fruit
17.	*Piper* sp.	Commercial/Wild climber	Cotyledons
18.	*Sarcostigma klinii*	Liana	Cotyledons
19.	*Shumanianthus virgatus*	Shrub	Rhizome / Seeds
20.	*Symplocos anamallayana*	Tree	Flower
21.	*Syzygium caryophyllatum*	Tree	Flower
22.	*Tamrindus indica*	Commercial tree	Endocarp
23.	*Terminalia bellerica*	Tree	Endocarp
24.	*Theobroma cacao*	Commercial tree	Endocarp
25.	*Vitex altissimo*	Tree	Fruit

Feeding behaviour

The feeding remains were easily identified by the characteristic circular incisor marks on small seeds and circular opening with narrow gnawing marks on the wall in the case of big fruits (Plate 13). Seed hoarding behaviour was not common in the species but a sign of hoarding of the seeds of the species *Terminalia bellerica* was recorded from low elevation forests of Kasragod, in the northern part of the State. In the case of *Theobroma cacao* animal opened the mesocarp of the fruit mostly from the top portion (N=38) sitting on the fruit and the head is inserted into the fruit. The head was taken outside intermittently to throw away the discarded portions. The openings were more or less circular with a mean diameter of 3.6 cm (N=45). In the case of few fruits the openings were towards the basal portion of the seed (N=7). These fruits were on small branches and the animal could feed the contents by perching on the branches. In most of the cases, half of the seed inside the fruits were consumed. The *Hydnocarpus pentandra* fruits were consumed through a hole on the upper part of the fruit and half of the seeds were consumed (N=18). Animal handled the seeds for removing the epicarp and mesocarp and then made a hole in the endocarp to feed on the cotyledons in the case of small fruits like *Terminalia bellerica*. Half portion of the *Tamrindus indica* fruits were cut open and the cotyledons were consumed keeping the remaining half of the fruit including the epicarp intact in the plant. In this case also the species consumed only ripened fruits (Plate 14).

Table 18. Seasonal pattern of feeding in Malabar Spiny Dormouse

Sl. No	Species of trees	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.	*Anacardium occidentale*		X	X	X	X							
2.	*Aporosa lindleyana*						✓	✓					
3.	*Artocarpus heterophylla*		X ✓	X ✓	X ✓	X ✓							
4.	*Bombax ceiba*										*	*	*
5.	*Careya arborea*		*	*	*	*				*	*	*	*
6.	*Ficus Sp.*						X						
7.	*Garcinia cowa*							✓	✓				
8.	*Holigarna beddomei*		✓	✓	✓	✓							
9.	*Hydnocarpus pentandra*		✓	✓	✓	✓							
10.	*Knema attenuata*		✓	✓	✓	✓		✓	✓				
11.	Unidentified		*	*	*	*							
12.	Unidentified							✓	✓				
13.	*Macaranga indica*		*	*	*	*							
14.	*Madhuca longifolia*		*	*	*	*							
15.	*Melia dubia*									*	*	*	*
16.	*Persea*		✓	✓	✓	✓							

	macrantha												
17.	*Piper sp.*									*	*	*	*
18.	*Sarcostigma klinii*		*	*	*	*							
19.	*Shumaniant hus virgatus*		X	X	X	X				*	*	*	*
20.	*Symplocos anamallaya na*						✔	✔					
21.	*Syzygium caryophyllat um*						✔	✔					
22.	*Tamrindus indica*		✔	✔	✔	✔							
23.	*Terminalia bellerica*									*	*	*	*
24.	*Theobroma cacao*	X	X	X	X	X			X	X	X	X	X
25.	*Vitex altissima*						✔	✔		*	*	*	*

*** - Identified by location telemetry, X - Identified by direct observation, ✔ - Identified by indirect evidences.**

In the case of pepper the species opened up the pepper drupes and consumed the cotyledons. Half portion of the epicarp, mesocarp and endocarp were left in the drupelets after feeding. Fully and partially eaten drupelets were observed on the plants. All the fully eaten drupelets were observed initially attached to the plant and later dried and fallen (N=108) and most of the partially eaten droplets were fallen fresh (N=34) but some were seen attached to the plant (N=15). All the consumed drupelets were fully consumed in the case of wild species (N=8). Generally the animals were seen foraging individually but in the case of *Terminalia bellerica* considerably large number of animals were observed feeding at same time (n<12).

This type of feeding continued up to 4 to 7 days on a tree by which time the seeds will be completely finished.

Male: The male animal was foraging in an area of varying canopy cover. Out of the 14 points identified eight points were having food items. Remaining six points were not having any food items but these points were at an area were relatively high vertical thickness for the tree canopy due to high lower and mid story cover. The animal spent a considerably long period of 815 m on reeds at two points (P5 and P6) (Fig. 11). Daytime observations recorded fresh holes on the tender tips of the reeds as if the animal had eaten the tender base of the growing stem by making holes on the sheath covering the basal region. But attempts using searchlights to observe the feeding failed. It was also not possible to conclude whether the animal was feeding on the tender shoot or some insects inside the sheath.

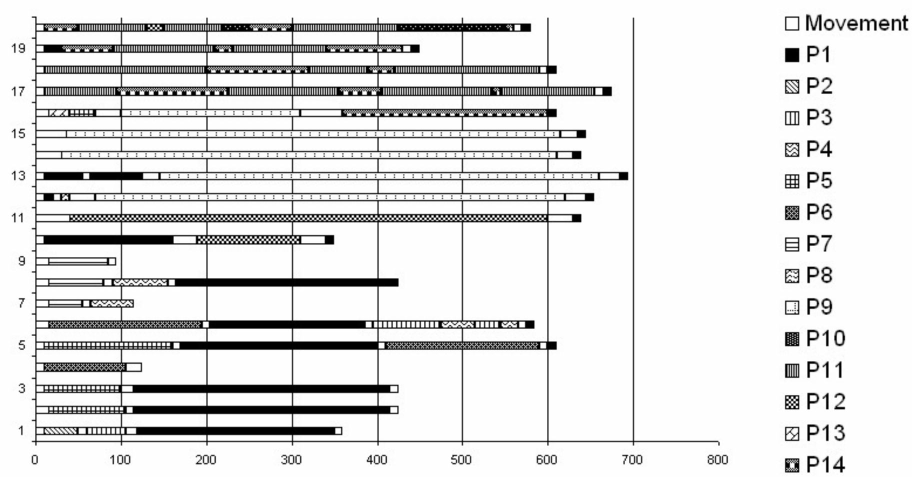


Fig. 11 Activity pattern of the male Malabar Spiny Dormouse

The adult male showed two types of foraging movements. Short feeding bouts were common in short distance foraging but in the long feeding bouts were recorded in long distance foraging. This type of long feeding bouts was for less number of days. Solitary foraging. *Coco* and *Terminalia bellerica* most preferred food. Dare to come down for *Shumanianthus* sp. The animal utilised considerably short periods (10 to 180 m) on feeding at a feeding point and then either moved to another feeding point, nest or to the thick canopy area, in the case of foraging with in thirty five meter from the nest. The animal spent long periods at a feeding point (210 m to 560 m) in case the feeding point was more than 800 m away from the nest. Two feeding points were identified which were more than 700 m from the nest (P9 and P12) (Fig. 11). P9 was an isolated *Terminalia bellerica* tree of 47 m height with light canopy and the point also covered an adjacent *Melia dubia* tree. The seeds of the tree were fed by the species and the animal utilised less than 10 m on this tree. P12 was a *Theobroma cacao* tree 1.2 km away from the nest inside a commercial plantation where the canopy was light. Feeding at these areas continued for long time periods with out changing the position from one tree to another. Mass feeding was observed on *Terminalia bellerica*, with more than 12 animals at a time on a single tree. When the male Malabar Spiny Dormouse was followed during the movement to the *Terminalia bellerica* tree other members of the colony were also observed moving in the same route. The mail stopped foraging on this *Terminalia bellerica* tree often three nights but other members of the colony continued feeding until the seeds finished.

Two feeding points were identified which were more than 900 meter from the nest on was an isolated *Terminalia bellerica* tree of 47 m height with light canopy during the period of observation time and the other was a *Theobroma cacao* plantation 1.2 km away from the nest, here also the canopy was light. Feeding in these areas continued for long time with out changing the position from one tree to another. In the case of *Terminalia bellerica* there were mass feeding when the seeds are matured. More than 12 animals were sighted at a time on a single tree. The mail stopped foraging in this *Terminalia bellerica* tree after three nights but other members of the colony continued moving to the tree until the seeds were finished. Even though the activity of the animal on the thick canopy area was not able to observe, no feeding remains were found falling from the spot it was located, so it was concluded that the animal was not carrying out feeding activity. No seasonal variation of feeding was observed between different habitats. The feeding activity of the species was started at 1900 hours and the animal returned to the nest by 4.00 hours.

The *Hydnocarpus pentandra* fruits were eaten with a hole in the upper part of the fruit but half of the seeds were consumed (N=18). The animal handled the seed for removing the epicarp and mesocarp and then made a hole in the endocarp to feed the whole cotyledons in the case of small fruits like *Terminalia bellerica*. Half portion of the *Tamrindus indica* fruits were cut open and the cotyledons were eaten keeping the remaining half of the fruit including the epicarp intact with the plant. In this case also only ripened fruits were consumed. Animals were seen foraging individually and different animals were feeding on adjacent tree species same time (N=5). In the case of *Terminalia bellerica* large number of individuals were observed feeding at same time (n<12). These mass feeding proceeds to 4-7 days by which the seeds more or less finish.

Female: The female was pregnant when trapped. Long feeding bouts were observed in females. Solitary foraging was observed and they never came down during tracking from trees. Malabar Spiny Dormouse was feeding on a variety of food items available in its habitat. The seed predating nature of this species is adept at harvesting seeds and other food items directly from the canopy. The species is capable of long distance foraging movements up to 1.25 km when the favorite food items were available. The animal is endemic to the region and the favorite food items include the endemic genus like *piper* and the exotic species like *Theobroma cacao* and *Anacardium occidentale*. *Anacardium occidentale* nuts are fed by only few animals' species. The feeding of the Malabar Spiny Dormouse on this exotic species is unique. The openings made on the seeds or fruits were of different size but they were of similar circular shape. The feeding remains of the species were recognizable by the shape of the hole made in the nuts. The openings made by the *Rattus rattus*, *Theobroma cacao* was of irregular shape and with narrow gnawing mark. The *Terminalia bellerica* and *Piper nigrum* were not fed by two species of rodents namely the *Rattus rattus* and *Cremnomys blanfordi*, in captivity even after starving for three days.

Malabar Spiny Dormouse is highly selective of the status of the fruits or seeds. The animal consumed the mature *Theobroma cacao* fruits before it ripen but only the presence of movement marks were recorded on the fruits, which were not matured. Malabar Spiny Dormouse also had different mode of feeding according to the size of edible portion of the food species. More studies will be needed to correlate the nutritive value of the food items and the quantity of consumption. The seed holding behaviour recorded from the northern part of the State also showed high diversity in the feeding behaviour of the species. This also supported the general assumption that the degree of autecology of small mammals varies greatly with change in demography and climatic pattern (Meserve *et al.,* 2003) the probability of folivory can not be ruled out in the case of Malabar Spiny Dormouse. The absolute similarity of feeding by the species on one of the favorite food species, *Terminalia bellerica* to that of the Hazel Nut Dormouse in Europe on its favourite food species Hazel nuts is worth mentioning.

Pest of cash crops

The species was doing damage to five species of cash crops in the forest fringes. The animal came out of the nest hole and foraged only during night. Three cases of control by poisoning were observed between September 2002 and March 2005. In most cases the food items were consumed after maturation but before the ripening. This species also observed as moving up to 1.25 km in search of favorite food items. The animal is endemic to the region, but the most favorite food items include the endemic plant genus *piper* and the exotic species like *Theobroma cacao* and *Anacardium occidentale*. This proves that the feeding of small mammals is always changing according to the availability of the food. *Anacardium occidentale* seeds have been observed as fed by limited number of animals. The development of dentine features to break the extremely corrosive seed coat of the species should by an evolutionary change attained by Malabar Spiny Dormouse after the introduction of the tree into the region. The animal is highly selective against the status of food items and the observation of movement marks on the fruits of *Theobroma coca* and their feeding only on the mature fruits before ripening supports the selection. Dormouse also has different mode of feeding according to the size of edible portion of the food species. The observation of food holding behaviour in the northern part of the Kerala part of Western Ghats also showed the existence of high diversity in the feeding behaviour of the species. This also supports the general assumption that the degree of autecology of small mammals varies greatly with change in demography and climatic pattern (Meserve *et al.,* 2003). The chance of flavor also to be suspected in case of Malabar Spiny Dormouse. Close similarity in feeding favorite food species *Terminalia bellerica* to that of Hazel Nut Dormouse in Europe on its favorite food species Hazel nuts is interesting since both the species fall in different taxonomic orders and biogeographic regions. The conventional methods of avoiding this animal by removing all the canopy connection to the cultivating plants are now being replaced to the modern chemical rodenticide applications. This is a critical problem, which may intensify the bioaccumulation of pesticide in the forest ecosystem. The animal is a pest in the plantations, situated at the edge of the forest areas and having canopy continuity with the forest. The conventional method of avoiding the animal, by removing all the canopy connection to the cultivated plants is now being replaced by the modern chemical rodenticide applications. This is a critical problem, which destroys the population of Malabar Spiny Dormouse. The conventional solution practiced by the tribals *i*.e. the clearing the canopy connection with the plantation is an excellent practical solution.

3.3. Discussion

Yunger *et al.* (2002) reported that predation, competition and the interaction of these two factors influence the foraging decision of the small mammals. By manipulating the number of predators and the competitor species, they proved that the behavioural response towards the temporary adjustments of these factors is species specific. The present study also brought out enough evidence to show the influence of risk of predation in the foraging behaviour of Malabar Spiny Dormouse. The animals changed the feeding points during foraging, if they were feeding with in a small distance from the nests (80 m maximum). The foraging movements were susceptible to predation risks. But the animals dared to ignore the risk, and moved through the canopy with mild mid story cover and fed on a single tree for considerably long time (560 minutes_{max}) in order to feed on the most favourite food items. Male have been carrying out the small distance movements for consecutive nights (3_{max}) where as the females continued feeding until the seeds finished. The male was intermittently moving through the area with more mid story from the feeding tree if the feeding tree is at an area with less mid story. These movements can be attributed for avoiding the risk of predation while in a high risky location for more and time, especially when the potent predators are the aerially flying birds of prey.

The sexual dimorphism in behaviour was also supported by the fact that the biased trapping of Malabar Spiny Dormouse by fixing the traps nears the identified nests. Males were trapped only when the traps were kept for more nights, proving that the males are more neophobic than females and so less exploratory too. Nichols *et al*. (2004) reported that the males of *Mus spicilegus* and *Mus musculus musculus* are more exploratory than females. Fine scale foraging experiments within well replicated long term biotic manipulations are necessary to ascertain the biotic and abiotic factors influencing foraging decisions (Kelt *et al.*, 2004). A study with fine scale experiments can be designed only based on the basic data and hypotheses brought out by base line studies like the present one, especially on a non-studied species like Malabar Spiny Dormouse. The practical difficulties in carrying out the foraging behaviour observations on a nocturnal rodent, especially in a tropical rain forest, which are frequented by large mammals and torrential rain, also hamper the study in many ways.

In the case of Malabar Spiny Dormouse the recorded predation (N=1) using location telemetry was by nocturnal birds of prey on a sub adult Dormouse. More than fifty percent of the attempts in location telemetry observations during the present study were partially or fully restricted due to the above reasons. Malabar Spiny Dormouse is a selective feeder and is adept in seed predation. This endemic rodent fed on a variety of food items and its preferred food species included exotic cash crops introduced only the last three centuries. The trophic relationship of this species in the forest ecosystem is crucial because it act as an important pray base in the canopy and as a potential seed predator. The foraging decisions of the species are depending on the predator pressure and food availability. Sexual dimorphism exists in the foraging behaviour of Malabar Spiny Dormouse. Males are found less exploratory than the females. The animals are capable of carrying out foraging trips up to 1.25 km, occasionally in search of selected food species.

3.4. Behavioural observations on Malabar Spiny Dormouse

3.4.1 Introduction

The impact of small mammals on rain forest ecosystems is poorly understood (Wells *et al.*, 2004), but various studies in the tropical forests indicated small mammal communities as major ecological force due to their seed predation and of consumption (Struhsaker, 1997; Adler and Kestell, 1998; Guariguata *et al*., 2000). Behavioural patterns of a species is evolved by different ecological factors existed during different time periods in the life history of the species. It is crucial to study the behaviour patterns of an endemic rodent species of the Western Ghats. The present chapter deals with the behavioral characteristics of Malabar Spiny Dormouse.

3.4.2. Methods

Estimation of home range and activity pattern: Four animals were studied using radio telemetry. Details of the methodology are described in Chapter 3.3. The position of the radio tagged animal was recorded in every ten minutes. Initially the animals were located and sighted, but later the sighting of the animals was not insisted as this was interfering with the natural movement of the animals. The position of each sighting location was not able to mark using GPS, as these animals foraged in areas where satisfactory GPS signals were not available. As these animals made only small distance movements, it was not possible to mark the points using GPS. So the positions of the animals were recorded in relation to the nearest trees.

The occurrence points and feeding points were well marked in the plot and the movement routes tracked at night was marked with temporary marks on the trees along the route. These marks were located and plotted in next day morning. In the case of long distance movements the path way was followed by tracking the animal and the trees through which the animal moved were marked. This route also was plotted on next day morning using GPS. The sighting of other individuals of the same species was also recorded. It was not possible to study many behaviour patterns in the wild due to the lack of visibility during night. The artificial light disturbed the natural movement of the animals and the thick canopy prevented the spotting of animals directly. Due to the small size of the organism and the nocturnal habit it was difficult to observe the activity of the animals in the canopy. Observations were made at daytime where the animals were located during night.

Peppara forest, which is a part of the peninsular forest, received rains in all months of the year. Out of the 41 days of field work tracking, 14 days were fully interfered by rain, 3 days by elephants, 10 days due to the problems of the telemetry equipment and 3 days due to other reasons. Out of the remaining 11 days, the animal was tracked for the whole night on five nights and remaining days were partially interfered by rain. Altogether 1027 locations of the animal movement were identified out of these eight points were having food plants. At one point the animal was located on the forest floor while feeding. Home range of the species was estimated using the movement data collected using the radio telemetry. Minimum convex polygon (MCP) method (Southwood, 1966) and Fixed kernel estimator was employed using the data as such and also after standardising the data with multivariate normal scores. Least Squire Cross Validation (LSCV) was used to estimate an optimal value of *h* (Seaman and Powell 1996). Swihart and Slades auto correlation index was estimated to confirm the independence of data (Swihart and Slades, 1985). The data set is considered as independent for an index value less than 2. Software CALHOME version 1.0 was utilised for the home range estimations using Minimum convex polygon method and the HOME RANGER version 1.5 (Ursus Software, Canada) was used to estimate home range using adaptive kernel and fixed kernel estimators. The home range estimations of male and female were carried out using different estimators. In the case of male Malabar Spiny Dormouse at location III, there were two outlier points, which were up to 800 to 1100 m away from the nest. So to treat these outliers in better way home range for male Malabar Spiny Dormouse was estimated based on the Fixed Kernel Method using the non standardised data.

The Minimum Convex Polygon method at 95 and 95 percentage contour estimates exaggerated home range including more areas, which were not frequently visited by the animal. The fixed kernel estimator treats the outlier's comparatively better way so that the home range estimation was carried out using this method at 95 percent contour at location III ignoring the less number of fixes. Along with the telemetry assisted observations direct observations were also made for identifying the activity pattern, the details of this method is already presented. The observers reached the study locations 30 minutes before the sunset and the nests were observed by sitting near the nest, before the animal emerged out of the nest.

Nesting Behaviour: Nineteen identified nest of Malabar Spiny Dormouse were regularly observed in the intensive study area at Peppara Wildlife Sanctuary between August 2002 and July 2005. The nests were identified primarily based on the characteristic circular shape of the opening and observing the oozing from the nest. The suspected nests were identified after examining the nest contents. The nests were confirmed by the presence of spines in the nest contents and were examined once in a month for the liveliness. The liveliness of the nests was confirmed by the presence of fresh leaves in the nests in every month. The direction of nest opening angles were recorded and the entrance hole diameter of the nests were measured in every month. The height at which the nests were situated was measured using a measuring tape. One nest was cut open to study the nest structure, as the number of nests available for the study was limited. Three nests were observed for three days between 18.00 h and 19.30 h for assessing the number of animals in the nest. Each nest was examined with out disturbing the animals inhabiting it.

3.4.3 Result

Activity pattern

At location I, one adult female Malabar Spiny Dormouse with 70 g weight was fitted with telemetry transmitter, but it was possible to observe the animal only for 20 hours during the four days (Table 19). Elephants frequently visited the area and on the fourth day the transmitter was detached and located on the ground. At location II an adult pregnant female Malabar Spiny Dormouse was the study animal. 4670 hours of observations were carried out on this animal, between March 2003 and May 2003. The transmitter stopped giving signals due to some unknown reasons for 20 days during the study. At location III a sub adult and an adult male Malabar Spiny Dormouse were studied. 10270 minutes of observations were carried out on the adult male but the sub adult was predated on the very same day when the telemetry transmitter was attached to it. The process of tracking was frequently interfered due to rains and by the intervention of other large mammals especially the elephants.

Table.19 Details of telemetry observations carried out in the Peppara Wildlife Sanctuary.

Location	Sex	Morphology			Duration of observation	Remarks
		Hbl (mm)	Tail (mm)	Weight (gm)	(min)	
Location I	Female	110	105	70	1200	
Location II	Female	108	105	70	4670	Pregnant
Location III	Female	80	85	50	60	
Location IV	Male	110	105	90	10270	

At location I, before the second night of tracking the animal was located hiding in the epiphytic growth on a nearby tree 28 m away from the original nest. On the third night the animal created a new nest in a slit of a near by old tree which had canopy connections with adjacent trees. A nest of one day old contained dry and fresh leaves. The animal was found resting at the bottom of the nest hollow during daytime but moved up when disturbed by knocking on the tree. After each disturbance the animal came down to the bottom exactly after 12 minutes, but again went up if disturbed again. The animal was having wounds on its body, which was not recorded when it was released after attaching the transmitter. The cable attaching the transmitter was found gnawed on the third night and the transmitter was recovered from the ground after the third night. The animal was observed for a total of 1200 minutes, but all the observations were partially or fully interfered due to the movements of wild elephants.

Telemetry observations on another female and male carried out at Location II and III brought out considerable information regarding the behaviour patterns of the Malabar Spiny Dormouse. Adult female Malabar Spiny Dormouse trapped for telemetry studies at Location II was pregnant. The animal was of 90 g weight and was trapped from a riverine habitat. A total of 4670 minutes of observations were carried out and 467 locations of the animals identified. In seven points the animal used to be during its activity at night. The female Malabar Spiny Dormouse did not showed any consistency in time for emerging from the nest. The animal came out of the nest between 18. 50 h and 19.30 h. Longest distance movements recorded was for foraging was 85 m from the nest. The animal never came down to the forest floor during the period of observation. The animal was recorded as spending 520 minutes in a canopy marked as a point (P6) of occurrence of the animal (Fig. 12). The animal was making frequent movements in the canopy, which was not able to pinpoint using the location telemetry. The animal could be located using searchlights but the attempts failed as it was found disturbing the natural foraging movements of the animal. In general the female Malabar Spiny Dormouse was spending short periods at one point in the canopy. At location III a sub adult on which transmitter was attached were predated on the first night of observation, when the observation was being carried out. The animal was predated 17 minutes after it came out of the nest. At location III, out of the 60 days of tracking, 34 days were full and 9 days were partially affected by rain. 1027 locations were identified from which 14 potential points were marked in the field. The point P9 was 820 m away from the nest and another point P12 was 1.2 km away from the nest (Fig. 13 and Fig. 14). All other points were with in 35 m distance from the nests. The animal showed consistency in the time of emerging from the nest for foraging for some of the consecutive days but frequently changed the timing. For the initial six days of observation, the animal spends considerable time (180 min to 230 min) in the nest after a first feeding bout of 45 min to 150 min duration. The animal gnawed the nest hole entrance intermittently when they went into the nest. The animal was sighted 13 times but direct sighting was avoided as it interfered with the natural foraging movement.

These observations revealed that the locations were having trees with seeds, fruits and flowers, but this was not the case in all occasions. A total of seven points were identified during the study, which the animal visited regularly or spent considerable time at occasional or even single visits. Out of these seven points identified, only five were having potential food items. The point P7 and P6 were devoid of any flower fruit or seed (Fig. 15), but the animal spent one night full at these points. Eight to ten days after the trapping of the pregnant female, the animal was found intermittently visiting the nest during the foraging movements. This particular behaviour was not recorded in detail as the transmitter gave bad signals during that period. But after 20 days when the signal was clear, the animal was not seen making such intermittent visits. From the limited observation it was presumed that these visits were for feeding the young ones.

Fig. 12 Activity pattern of the female Malabar Spiny Dormouse

Home range

Home range was estimated using the data from telemetry study locations II and III. Minimum Convex Polygon gave the highest estimates for the male Malabar Spiny Dormouse (Figs. 16 and 17). At the 95 percent contour the minimum value was estimated by Fixed Kernel estimator using non standardised data (Fig. 18). In the case of female Malabar Spiny Dormouse at location II the Minimum Convex Polygon gives the highest estimates of the home range (Fig. 19) and Fixed Kernel estimator using the non-standardised data estimated lowest value. As the 50 percent contour under the Fixed Kernel method using the non-standardised data enclosed the whole marked points, in order to reduce the exaggeration in estimation, the home range was estimated at 50 percent contour at this location. For the female Malabar Spiny Dormouse at location II the MCP method estimated highest value of home range. The Swihart and Slades auto correlation index was with in the allowed limit for all the datasets (Table 20 and 21).

Table 20. Home range of the Malabar Spiny Dormouse (Location II, female)

Method	Contour (%)	Home range (ha)
Minimum Convex Polygon	95	1.1
Minimum Convex Polygon	90	1.1
Minimum Convex Polygon	85	0.66
FK un standardised	95	0.24
FK un standardised	75	0.47
FK un standardised	50	1
FK standardised	95	19.87
FK standardised	75	9.56
FK standardised	50	4.91

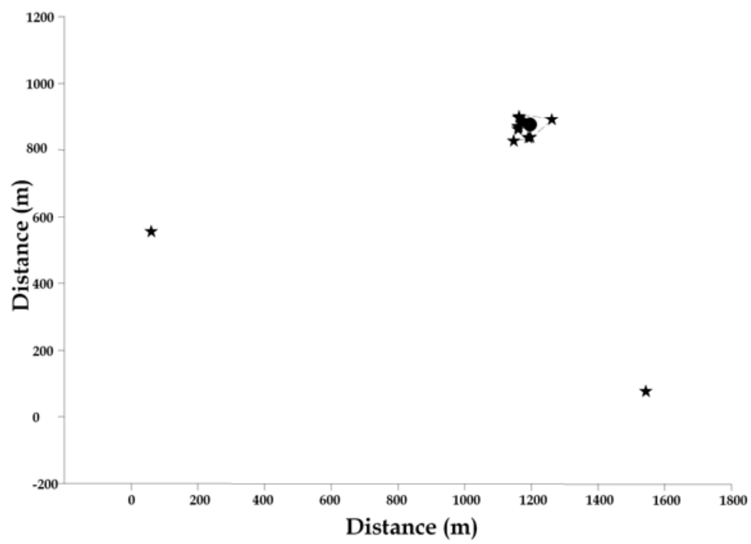


Fig. 16 Home range of the male Malabar Spiny Dormouse (80% Minimum Convex Polygon method)

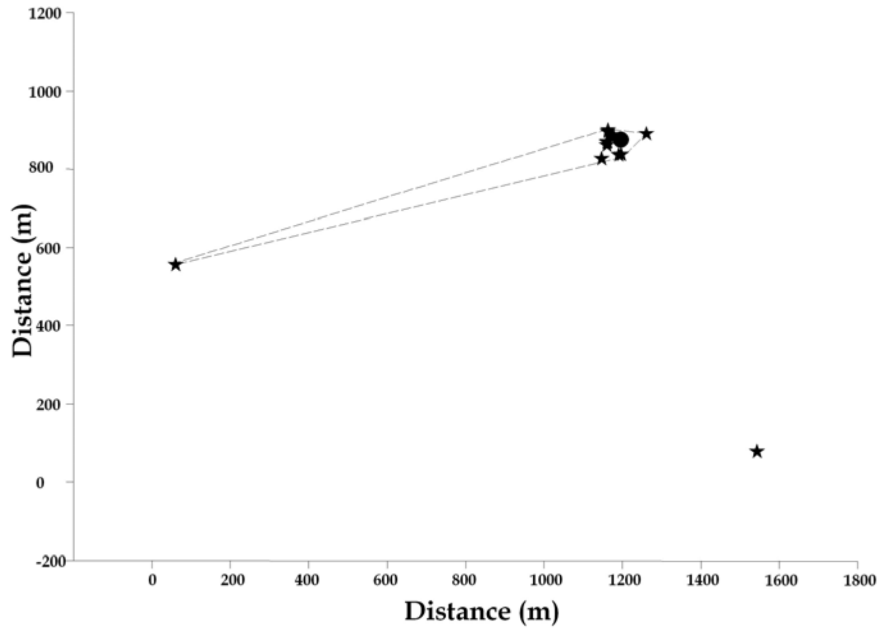


Fig. 17 Home range of the male Malabar Spiny Dormouse

(90 % Minimum Convex Polygon method).

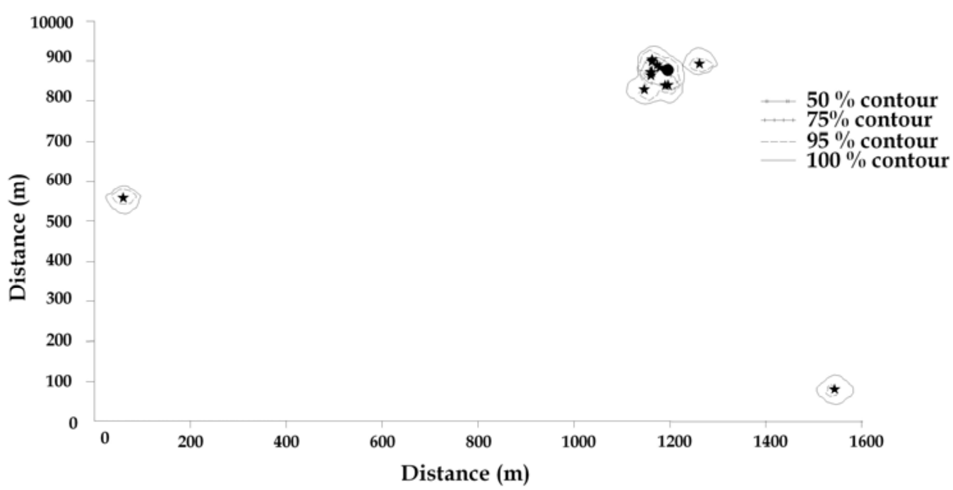


Fig. 18 Home range of the male Malabar Spiny Dormouse

(Fixed Kernel Method using nonstandardised data).

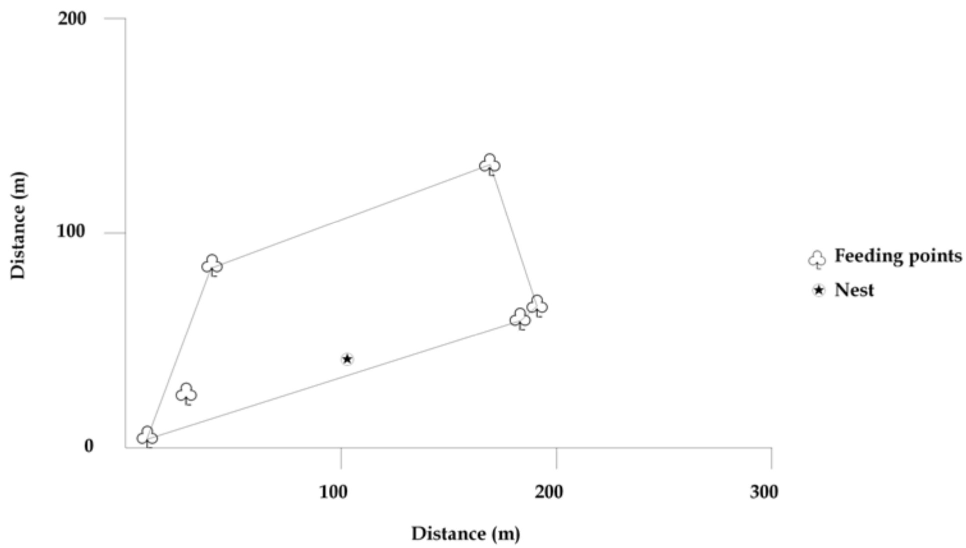


Fig. 19 Home range of the female Malabar Spiny Dormouse (90% Minimum Convex Polygon).

Table 21. Home range of the Malabar Spiny Dormouse (Location III, male)

Method	Contour %	Home range (ha)
Minimum Convex Polygon	95	55.89
Minimum Convex Polygon	90	4.3
Minimum Convex Polygon	85	0.45
FK un standardised	95	0.97
FK un standardised	75	0.48
FK un standardised	50	0.16
FK standardised	95	4.82
FK standardised	75	1.92
FK standardised	50	0.75

Nesting behaviour

All the recorded nests were vertical hollows with opening at the bottom. The details of the nests observed are given in Table 22. It was not possible to measure the length of the hollow through non-invasive techniques. Two of the nests were abandoned by the dormouse colony, which inhabited it. One nest was abandoned when the tree (*Persea macrantha*) was dried and the canopy connection with the other trees was lost. Second nest in a *Vateria indica* tree, which was regularly monitored, was abandoned when it was filled with rainwater. The nest height varied from 3 m to 32 m (Fig. 20). The 23 nests identified were made on 11 species of trees and 30 percent of the identified nests were made on *Lagerstroemia microcarpa*. The nests were seen opening into different directions (Fig. 21) but 61 percent of the nests were opening towards the West. GBH of the trees in which Malabar Spiny Dormouse nests were located ranged between 0.48 m to 4.8 m. All the nests were containing dry and fresh leaves. The characteristic oozing was observed from the nest beginning from the initial south-west monsoon showers, maximum up to the month of September in Peppara Wildlife Sanctuary. Presence of urea was confirmed from all the nest contents. Using the location telemetry it was confirmed that the animal was entering into the nest only through the bottom of the nest. These regular movements of the colony members created a dark shade at the bottom of the nest, which prevailed after the oozing was another characteristic (Plates 15 & 16).

Most of the nests were with circular opening and the mean diameter of the nest opening was 50.1 mm (N = 19). This was so because three high values existed so the mode 48 mm with mode frequency 7 was taken as the measure of central tendency. Out of the 19 nests measured 15 falls in the range of 47 mm to 49 mm (Fig. 22). The nest hole was maintained by the colony with in this narrow range. The male animal studied at location II was observed gnawing the nest entrance for maintaining the size (N = 3) and the entrance of the nest, abandoned by the Malabar Spiny Dormouse colony near the location III was later closed due to the growth of bark. Another nest located on 8th September 2002 was cut open by local people on 22nd December 2002 for capturing the animals and after this incident, the nest hole started shrinking and finally closed with in six months. The local people widened one nest opening in an attempt to capture the animal and the colony abandoned the nest after the disturbance. After three months when the nest hole reduced to the normal size the nest was again occupied. One tribal report from Idukki Wildlife Sanctuary states that a snake was found in the nest of a Malabar Spiny Dormouse, which consumed its prey but trapped inside the nest as the snake could not come out of the nest after the feeding. This happened, as the nest hole was much small to wriggle out with a dormouse.

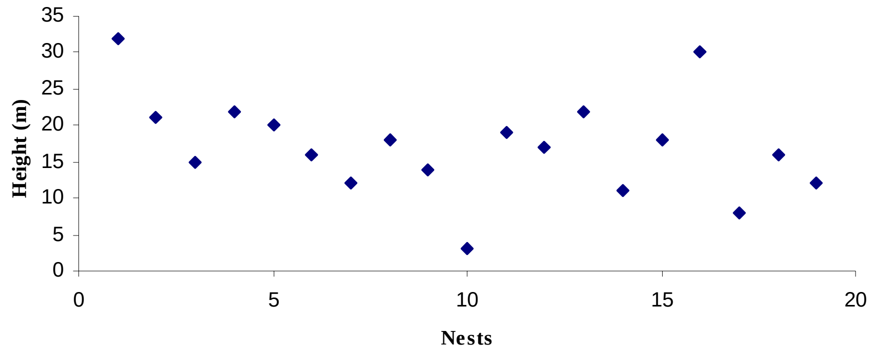


Fig. 20 Height of the Malabar Spiny Dormouse nests from ground

Table. 22 Characteristics of Malabar Spiny Dormouse nest

Sl No.	Species of trees	Nest characters			gbh of trees (m)
		Height (m)	Opening Diameter (mm)	Opening directions	
1.	*Artocarpus hirsutus*	32	48	SE	2.3
2.	*Carallia brachiata*	21	48	SW	0.74
3.	*Bombax malabarica*	15	48	SW	0.48
4.	*Hopea parviflora*	22	50	NW	1.6
5.	*Lagerstroemia microcarpa*	20	47	NE	0.78
6.	*Lagerstroemia microcarpa*	16	48	NE	1.05
7.	*Lagerstroemia microcarpa*	12	49	SW	0.65
8.	*Lagerstroemia microcarpa*	18	49	W	0.64
9.	*Persea macrantha*	14	47	SW	0.72
10.	*Lophopetalum wightianum*	3	70	NE	2.1
11.	*Bridelia crenulata*	19	48	SW	0.82
12.	*Artocarpus hetrophyllus*	17	48	NW	0.85
13.	*Lagerstroemia microcarpa*	22	50	NW	0.90
14.	*Vateria indica*	11	48	SW	0.76
15.	*Lophopetalum wightianum*	18	49	NE	1.3
16.	*Artocarpus hirsutus*	30	47	SE	0.75
17.	*Lophopetalum wightianum*	8	62	N	1.9

18.	*Lagerstroemia microcarpa*	16	49	NW	4.8
19.	*Carallia brachiata*	12	47	SW	2.4
20.	*Vateria indica*	**	**	NW	1.4
21.	*Vitex altissima*	**	**	E	1.2
22.	*Vateria indica*	**	**	SW	0.90
23.	*Lagerstroemia microcarpa*	**	**	NE	1.2

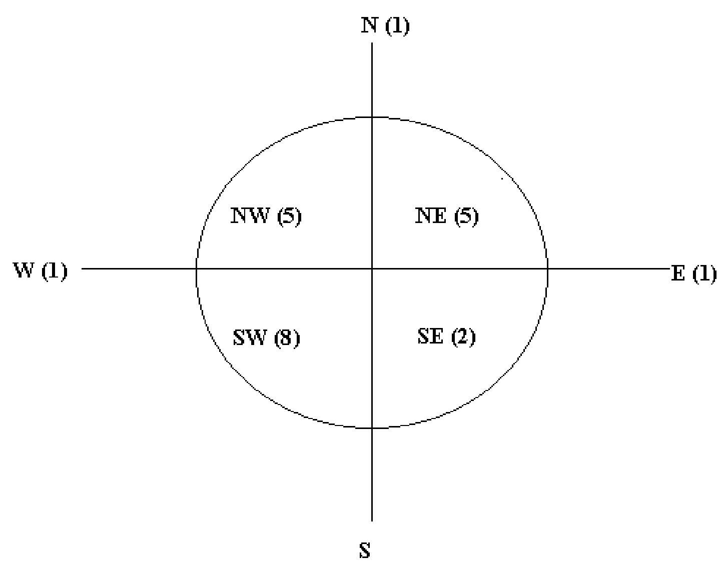


Fig. 21 Orientation of the Malabar Spiny Dormouse nest openings

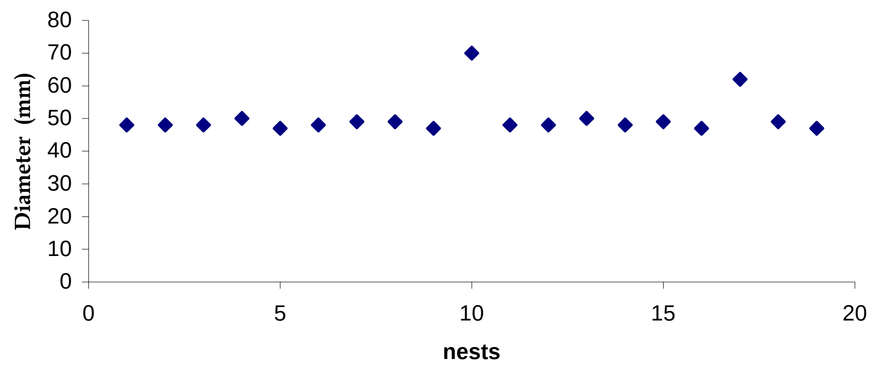


Fig. 22 Diameter of Malabar Spiny Dormouse nest openings

Social life and breeding

An adult male, two adult females and three sub adults were recorded from a single nest. Two out of the three nests observed for recording the number of animals emerging out were having more than one animal but one nest was having only one male. A total of thirteen animals were captured using Sherman traps from five nests in 11 occasions out of which two were sub adults. Most of the females were trapped with in the first night attempt, but males were trapped only when the traps were kept for more than two days. Pregnant females were recorded during March (N=2) and sub adults were observed during November and December (N= 4).

3.4.4 Discussion

More than fifty percent of the attempts to observe the behaviour were partially or fully disturbed due to various reasons. The available results showed that the foraging decisions of the species were influenced by the availability of food items and the predator pressure. Sexual dimorphism has a role in balancing these factors. Males gave relatively more weightage to the predation risks where as females were bolder to ignore the risk of predation for the availability of food. Juveniles are more prone to predation and availability of the food species also influenced the foraging decisions but more studies are necessary.

Tribal people were experts in identifying the nests of Malabar Spiny Dormouse. They use the characteristics of the nests like clear round opening, presence of leaves inside, oozing from the nest for the identification of the nests. *Lagerstroemia microcarpa* was identified as the preferred nesting tree of Malabar Spiny Dormouse (Plate 17). Sixty five percent of the nests were opening towards the West (N=23). This may be for easily monitoring the setting of sun to begin foraging. As the intensive study area was receiving heavy northeast monsoon the preference of West direction may be to avoid the direct showers into the nest. A colony abandoned a nest after it was filled with rainwater.

There was a clear pattern in the nest hole diameter, which was more or less related to the body size of adult animals. Maintenance of nest hole diameter prevents the entry of the predators like snakes. The incidence of abandoning the nest when the nest entrance was widened and the reoccupation of the nest after the hole regained the normal size is indicating to this behaviour. Another incidence reported by the tribals about a snake, which was trapped inside the nest after swallowing a dormouse, also supports this conclusion. Nest visibility to the predators has been reported as a major factor in the nesting behaviour of birds (Rangen *et. al.*, 1999). It was clear that the nests were constantly gnawed and the entrance size was maintained by the colony. Females were not carrying out the nest maintenance activity, but the male was spending considerable time in gnawing the nests during night. The nest maintenance was carried out on the cost of foraging time. Home range is a more or less restricted area where an animal moves during its normal activity (Harris *et al.*, 1990). A variety of methods have been developed for estimating the home range, based on the probabilistic notion of the utilization distribution (UD). Minimum convex polygon (MCP) method (Southwood, 1966) using outliers may greatly overestimate home range size, including parts never visited by the individuals (White and Garrot, 1990). Even though the home range estimation using MCP method is exaggerated by including the areas never visited by the animal. This method is the most robust method especially when the number of fixes is very low (Harris *et al.*, 1990). Kernel density estimators are the most dependable method when the number of fixes is sufficient in number (Powell *et al.*, 1997).

The fixed kernel estimator estimates the home range of the male Malabar Spiny Dormouse as 4.82 ha at 95 percent contour. In the case of female Malabar

Spiny Dormouse the home range was estimated at 50 percent contour produced by the fixed kernel estimator using the standardized data as 4.9 ha. The estimation is affected by the low sample size but with the available data the home range of the species can be estimated as 4.85 ± 0.05 ha. Such a wide home range along with the existence of several nests in an area clearly showed that the home range of the colonies overlaps. The colony was having more than one female but as no colony without males was observed and at the same time solitary males existed which indicates to a male dominated social structure. The observation of pregnant females and sub adults in the same habitat during March and November respectively indicates that at least two breeding seasons exist in the case of the species. The species is an important seed predator in the Western Ghats tropical forest especially on the species *Terminalia bellerica*.

3.5 Modelling the habitat of Malabar Spiny Dormouse

3.5.1 Introduction

An understanding of the habitat selection of organisms is necessary to solve many issues in population biology. Development of appropriate habitat selection theories can in many way address different problems in conservation biology (Morris, 2005). A clear knowledge on the mode of habitat selection will reveal the components governing ecological systems in a better way (Orrock *et al.,* 2000). This will also help in the identification and protection of high-profile habitats (Law *et al*., 1998) and will predict changes in the community structure that might follow natural or anthropogenic alterations of ecosystems (Dunning *et al*., 1995). Habitat selection influences the distribution of the organisms across landscapes (Pulliam and Danielson, 1991).

Malabar Spiny Dormouse, an arboreal rodent has been considered as a species inhabiting the evergreen forests. The animal was reported from the moist deciduous forest of Peppara Wildlife Sanctuary (Jayson and Christopher, 1995). Information on the habitat selection of this species is limited (Mudappa *et al*., 2001). The presence of arboreal rodents in the canopy provides a prey base for many vertebrate predators (Carey, 1991). While selecting the habitat, prey species prefer maximum level of protection from the predators. Diversity of tree species and well developed under stories will increase the canopy volume, interconnections of crown, abundance and dependability of which food is the essential habitat requirement of rodents (Carey, 1996). Even though this study has identified major food items of Malabar Spiny Dormouse, the chances of folivory exist. Considering this, analysis was carried out to study the influence of habitat parameters like the vegetation and other characteristics of the habitat. The major objective of this chapter is to describe the microhabitat selection of the Malabar Spiny Dormouse in the tropical moist deciduous forests of Western Ghats.

3.5.2 Methods

All the possible nests were located and recorded in the intensive study area. The aliveness of the nests was confirmed by the presence of fresh leaves in the nest, wetness of the nest hole and markings of nest maintenance at the entrance of the nest hole. The details of the methodology are already described in an earlier chapter. One hectare vegetation plots were marked in rectangle shape surrounding the 12 identified nests and 13 control plots were also surveyed for measuring the following parameters.

1. Tree density- Total number of trees was counted and their Girth at Breast Height (GBH) was measured in one-hectare plots. The trees were categorized into four groups based on their Girth at Breast height (10 cm to 20 cm - Class I, 20 cm to 50 cm - Class II, 50 cm to 1 m - class III and above 1 m - class IV).
2. Tree diversity – Alpha diversity was calculated using the equation $\alpha = \frac{N(1-x)}{x}$ (Taylor *et al.*, 1976). Alpha diversity index was selected due to its high discriminantability and low sample sensitivity (Magurran, 1988).
3. Leaf bead thickness (fallen leaves) was measured using an engine divided scale.
4. Canopy cover (%) – canopy cover was estimated in percentage using a grinded plain mirror.
5. Under growth was estimated by counting the number of herbs in one m^2 area from five points of the plot and the mean was calculated. The data from all the plots were pooled and rated in 1 – 4 scale.
6. Slope of land was arbitrarily measured from field and later confirmed using the three dimensional topo sheets.
7. Distance to the nearest water body was measured by GPS or using measuring tapes in the case of short distances.
8. Distance to the nearest human habitation was measured using GPS.
9. The altitude of the plots was measured using the GPS.

Statistical analysis

The data was analysed using a non-parametric test for comparison based on the presence and absence of the Malabar Spiny Dormouse nests. Mann Whitney U test was conducted for differentiating the parameters of the selected and control plots using the statistical package STATISTICA Version 6. The data was then submitted for a forward and reverse stepwise discriminant analysis using the same package to identify the variables, which best separate the selected plots from the control plots.

GIS analysis

The satellite image from IRS ID with LISS sensors were used for the GIS analysis (Plate 18). The image was georectified using the software ERDAS 8.6 version using the ground controllable points. Since the image pixel size was 23 m X 23 m and the plot size was 100 m X 100 m the image was resampled and the pixel size was converted to the sample plot size using the nearest neighbor method available in the software ARCGIS 90 version. The Geocordates of the center points of the plots were imported to the image and the pixel values of four bands of the image from the pixel of the plots were estimated. The ranges of the pixel values of the plots with the nests of the Malabar Spiny Dormouse were estimated for all the four bands. The four bands of the image were then reclassified using the pixel value range of the respective bands using the spatial analyst tool of ARCGIS 9.0. The possible habitats of Malabar Spiny Dormouse were modeled by combining the resampled layers using the Raster calculator tool of the software.

3.5.3 Results

Thirteen out of twenty five plots sampled were in the habitats preferred by the Malabar Spiny Dormouse (Table 23 and 24). One plot (PEP_X) was situated outside the limits of the protected area. Mann Whitney U test showed that thirteen microhabitats of Malabar Spiny Dormouse differed significantly from the control plots in having more canopy cover, species diversity of trees, slope, fallen leaf thickness, trees in GBH class I and II and proximity to water body (Table 25). The GHB class 1 increased the lower story of the canopy and Class II increased lower and middle story. The Class II and IV were providing the Malabar Spiny Dormouse food and nest holes other than increasing the upper and middle stories of the canopy. Among these variables canopy cover, litter thickness, distance to water body, number of trees in GBH class I and diversity index (α) were highly significant ($p<0.01$) (Fig. 23). Canopy cover, number of trees in the GBH Class IV and species diversity of trees discriminated best between the preferred habitats and control habitats of the species using forward stepwise method (Table 26) and among these canopy cover discriminated best when backward stepwise method was used (Table 27).

Table 23. Habitat parameters recorded from the preferred nest sites and control plots

Plot No.	α Diversity index	Altitude (m)	Litter Thickness (cm)	Canopy cover (%)	Under Growth (Scaled)	Slope (Angle)	Distance to water body (km)	Distance to human habitation (km)	Nest	No. of trees in different GBH class			
										I	II	III	IV
PEP_A	8.9270	162	8	100	2	15	0	4	P	113	89	55	22
PEP_B	7.0030	178	9	90	2	70	0	3	P	65	100	69	15
PEP_C	7.8870	175	7	70	2	45	0.4	1	P	31	65	72	12
PEP_D	8.9620	126	5	90	2	45	0.3	1	P	65	70	46	14
PEP_E	1.7020	192	0	50	0	2	1	0.5	A	6	76	98	8
PEP_F	5.2270	186	2	60	4	10	1	0.5	A	14	25	32	64
PEP_G	10.8980	173	7	90	2	30	0	0.5	P	39	52	34	20
PEP_H	10.7270	241	5	100	2	0	0	1	P	10	82	67	7
PEP_I	7.2480	650	10	100	3	40	0	5	P	38	66	52	12
PEP_K	9.4460	256	12	100	3	70	0	4	P	68	104	172	31
PEP_L	10.7060	675	8	100	3	60	0	1.5	P	65	72	50	36
PEP_M	1.4630	625	1	25	2	10	3	3	A	9	48	28	3
PEP_N	2.9250	725	1	20	1	0	2	6	A	20	59	43	4
PEP_O	11.9100	642	11	90	4	45	0	9	P	17	49	39	19
PEP_P	4.2410	425	1	20	4	20	2	6	A	22	42	30	26
PEP_Q	18.3540	430	6	70	4	15	0	3	P	7	29	25	21
PEP_R	3.1000	364	4	30	4	70	0.4	2	A	5	25	28	17
PEP_S	2.8690	325	2	50	3	15	1	3	A	14	42	44	41
PEP_T	9.6690	337	6	50	3	45	0	1	A	4	25	39	39
PEP_U	3.9950	196	3	40	2	30	1.5	1.5	A	4	44	63	21
PEP_V	1.6450	135	6	60	3	0	1	3	A	9	55	139	11
PEP_X	3.9160	175	2	40	3	20	1	2.5	A	4	39	73	23
PEP_Y	3.8740	192	6	70	3	0	0.5	1.5	A	4	42	73	24

Table 24. Habitat parameters recorded from the preferred and control plots (N=25).

Sl. No.	Habitat parameters	Mean	Minimum	Maximum	Standard deviation
1.	α diversity index of trees	6.4120	1.4630	18.3540	4.2727
2.	Altitude	316.2000	126.0000	725.0000	196.8722
3.	Fallen leaf	5.4000	0.0000	12.0000	3.3040
4.	Canopy	67.0000	20.0000	100.0000	27.4621
5.	Under Growth	2.7200	0.0000	4.0000	1.0214
6.	Slope	28.2800	0.0000	70.0000	23.2155

7.	D_W (km)	0.6480	0.0000	3.0000	0.7943
8.	D_H (km)	2.5720	0.3000	9.0000	2.1575
9.	G1	27.0400	4.0000	113.0000	28.1402
10.	G2	54.5600	25.0000	104.0000	23.2810
11.	G3	60.8800	25.0000	172.0000	35.9401
12.	G4	21.7200	3.0000	64.0000	13.4335

α – alpha diversity index; D_W – Distance to Water body; D_H - distance to human habitation; G1 – No. of trees in GBH class I ; G2 – No. of trees in GBH GBH Class II; G3 - No. of trees in GBH GBH Class II; G4 – No. of trees in GBH GBH Class IV

Table 25. Comparison of the habitat parameters of the preferred and control plots (Mann-Whitney U Test).

Sl.No	Habitat parameters	Mann-Whitney U	Z	p-level	Z adjusted	p-level
1.	α *	26	2.82843	0.004678	2.82843	0.004678
2.	Altitude	63	-0.81589	0.414562	-0.81636	0.414293
3.	Fallen leaf *	9	3.75311	0.000175	3.77789	0.000158
4.	Canopy *	1.5	4.16105	0.000032	4.20743	0.000026
5.	Under Growth	75.5	-0.13598	0.891836	-0.1427	0.886528
6.	Slope *	40	2.06693	0.038742	2.08179	0.037362
7.	D_W *	11	-3.64432	0.000268	-3.78368	0.000155
8.	D_H	72.5	-0.29916	0.764818	-0.30184	0.762772
9.	G1 *	18	3.26357	0.0011	3.27366	0.001062
10.	G2 *	38	2.17571	0.029577	2.18202	0.029109
11.	G3	67.5	0.57112	0.567916	0.57145	0.567692
12.	G4	75	-0.16318	0.870378	-0.16327	0.870304

α – alpha diversity index; D_W – Distance to water body; D_H - Distance to human habitation; G1 – GBH class I ; G2 – GBH Class II; G3- GBH Class II; G4 – GBH Class IV; * p< 0.05 (significant)

Table 26. Discriminant analysis between the preferred and control plots of Malabar Spiny Dormouse (Forward Stepwise, tolerance = 0.01).

Sl. No.	Habitat parameters	Wilks' Lambda	Partial Lambda	F-remove (1-17)	p-level
1.	Canopy cover	0.310019	0.440304	21.60971	0.000230
2.	G4	0.191975	0.711041	6.90860	0.017612
3.	Diversity index	0.171665	0.795168	4.37914	0.051691
4.	Slope	0.159803	0.854192	2.90185	0.106688
5.	D_H	0.153270	0.890599	2.08827	0.166615
6.	G2	0.161727	0.844028	3.14152	0.094242
7.	G1	0.145458	0.938429	1.11538	0.305695

D_H - Distance to human habitation; G1 – GBH class I ; G2 – GBH Class II; G3 GBH Class II; G4 – GBH Class IV; * p< 0.05 (significant)

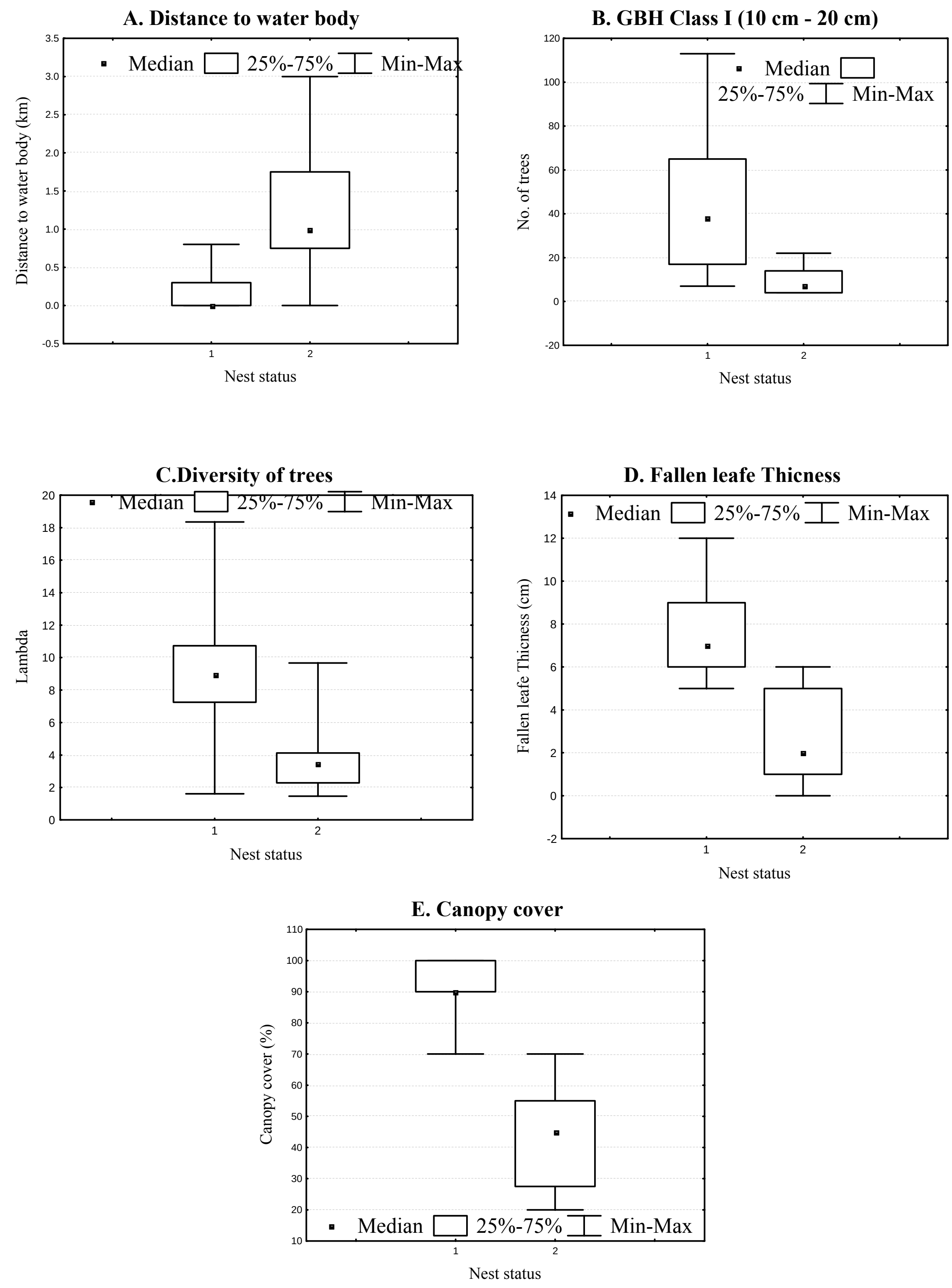


Fig. 23 Box plots of the variables showing significant difference between the preferred and control plots (Mann-Whitney U test (P<0.01)).

Table. 27 Discriminant analysis between the preferred and control plots of Malabar Spiny Dormouse (Backward Stepwise, tolerance = 0.01)

Variable	Wilks' Lambda	Partial Lambda	F-remove (1-23)	p-level
Canopy cover	1.000000	0.260510	65.28848	0.000000

The variance of the pixel values of the pixels of four bands of the IRS image of the area was specific for the selected habitats of Malabar Spiny Dormouse. Much difference were observed in the standard deviation and variance of the pixel values of the sample plots from the preferred plots of Malabar Spiny Dormouse was lower than that of the control plots in all cases other than green band (Table 28, Table 29 and Fig. 24). Non parametric tests to compare the pixel values also showed significant difference between these two groups of plots in pixel values for all the four bands of the image (Table 30 and Fig. 25).

Table 28. Pixel values of the four bands of the satellite image of sample plots in the preferred habitats of Malabar Spiny Dormouse (N=13).

Sl. No.	Band	Mean	Lower values	Upper values	Variance	Standard deviation.
1.	Green	75.2500	69.00000	84.0000	22.38636	4.731423
2.	Red	38.0833	33.00000	46.0000	20.08333	4.481443
3.	Short Infrared	105.6667	84.00000	119.0000	79.15152	8.896714
4.	Far Infrared	106.0000	94.00000	116.0000	50.54545	7.109533

Table 29. Pixel values of the four bands of the satellite image of control plots (N=12)

Sl. No.	Bands	Mean	Lower values	Upper values	Variance	Standard deviation.
1	Green	79.7500	74	88	16.9318	4.11483
2	Red	45.7500	36	53	33.1136	5.75444
3	Short Infrared	96.6667	70	113	165.3333	12.85820
4	Far Infrared	122.6667	106	133	78.0606	8.83519

Table 30. Comparison of the pixel values of the preferred and control plots (Mann-Whitney U Test).

Sl. No.	Bands	**U**	**Z**	**p-level**	**Z adjusted**	**p-level**	**2*1 sided exact p**
1.	Green	34.5	-2.16506	0.030384	-2.16979	0.030024	0.028421
2.	Red	19	-3.05996	0.002214	-3.06931	0.002146	0.001433
3.	Short Infrared	35	2.13620	0.032664	2.13992	0.032362	0.033241
4.	Far Infrared	9	-3.63731	0.000276	-3.64524	0.000267	0.000072

Fig. 24 Mean and variation of pixel values of the preferred and control plots

The pixels of the bands of the image, which have a pixel values in the identified range of pixel values of the preferred habitats of the species, were reclassified and then superimposed to map the possible habitats of Malabar Spiny Dormouse. The modelled areas were evidently the riparian multilayer forests of the intensive study area and adjacent areas (Plate 19).

Fig. 25 Box plots comparing the variance of the pixel values of the preferred and control plots

3.4 Discussion

Habitat selection of rodents is highly influenced by the habitat structure and the risk of predation (Wywialowski, 1987). In the case of large herbivores with high risk of predation the habitat structure have been influencing more on the population structure and density than the predation risk including the hunting risk from humans (Gude, 2004). The canopy structure and vertical thickness of foliage in tropical forest is highly correlated to the tree species diversity. Many features of the tropical forest, like the high degree of variations in the canopy structure and resources for foraging proved to be enhancing the community diversity and specialization, predator avoidance and nesting behaviour (Mac Arthur *et al*., 1966).

The study indicated that Malabar Spiny Dormouse is highly selective in choosing the microhabitat. High degree of preference is shown to the canopy cover and the number of trees in the girth class 10 to 50 cm. The trees in this girth class support the development of lower and middle stories of the canopy rather than food or nest. The selection of microhabitats with dense vegetation is an antipredator strategy against aerial predators (Longland and Price 1991). This in turn showed that the antipredator strategy of the species is strong. Various earlier studies showed that many communities of small mammals prefer habitats with high amount of vegetation cover (Kotler and Brown, 1988). The avoidance of predation risk was well proved in the arid rodents (Bowers, 1988), neotropical rodents (Lagos *et al*,. 1995) and rodent pests in crop areas of Europe (Díaz, 1992).

Dense canopy provides food resources for small mammals, as leaves, fruits, seeds and insects but studies showed that the preference is for avoiding predation risk. Similarly, Malabar Spiny Dormouse showed significant preference to the tree diversity and number of trees in the Girth class IV (>1 m). This indicates that, the species gives high importance to the availability of trees for nesting and diverse food. As stated by MacArthur *et al*. (1966) diversity cannot be correlated to the food supply alone but these features also supplement the canopy structure in the tropical forests. Habitat selection of this species is obvious at microhabitat level and relatively high preference is attached to the predator avoidance followed by the availability of food and shelter. Many earlier studies reported that significant relationships between small mammal distribution, abundance and habitat structure at microhabitat scale. Small mammal responses to such scales rely on the degree of habitat specialization of every species: A sharp relationship with microhabitat structure exists in case of generalist species of rodents (Seamon and Adler, 1996). Analysis of habitat parameters in a Geographic Information System (GIS) is the best way to understand the habitat structure and distribution of a species. The potential areas identified using GIS were not covering the moist deciduous forest areas with low canopy cover and the mono species plantations including the tea estates with thick vegetation cover. But the GIS analysis was able to mark the thick forest with diverse vegetation cover clearly.

The GIS assisted prediction, selected the riparian forests of the protected area as the probable habitat of Malabar Spiny Dormouse. This new and highly significant information will help in the conservation of the species. Peppara Wildlife Sanctuary is the type locality of the species. Earlier studies described the Malabar Spiny Dormouse as an evergreen species, but this study showed that the species inhabit in the riparian forests in the middle of the dry moist deciduous forest also. The present study has not attempted to evaluate the level of fragmentation between these populations inhabiting in these habitat patches. But it is clear from the rescaled satellite image that many of these habitats are fragmented. Most of the studies dealing with the climatic changes and its impact are restricted to large geographical scale (Karanth 2003; Sukumar, 2000; Kirsch Baum *et al.*, 1996; Peters and Lovejoy, 1992). The studies on the impact of climatic changes on the forest cover at microhabitat level are rare. The probability of this population of an evergreen species like Malabar Spiny Dormouse to be relict populations aggregated to these habitat refugiums during the process of forest transformations due to the post glaciation climatic changes also need validation. Molecular studies using fine scale markers only can check the hypothesis. Considering the endemic status of the species the hypothesis is significance even though there are no fine scale ecological studies on the impact of climatic changes on the forest ecosystems of the region for comparison.

Malabar Spiny Dormouse is not a fully evergreen species, but the species inhabits, in areas with high crown density in the moist deciduous forests, especially in the riparian habitats. In habitat selection, the species prefers dense canopy cover rather than any other ecological variable. This can be directly attributed to the antipredatior strategy of the species. The species has an altitude independent distribution. As the species is distributed in the habitat patches, and some of these patches are fragmented, the probability of isolation of the species in these isolated patches cannot be ruled out in future.

3.6. Conservation of Malabar Spiny Dormouse

The present status of the species is in Vulnerable (IUCN). This is mainly based on the assumption that the distribution of this species is from the south of Shimoga to Kanyakumari in the Western Ghats. But now it is clear from this study that even though the species is distributed all along the Western Ghats, the distribution is patchy and in the moist deciduous forests it is only found in the riverine patches. Further in the evergreen forest the species is mainly found in association with lianas (Mudappa *et al.,* 2001). Further the species is low in density in all the areas and with the continuing destruction of large trees the availability of nest holes may be a limiting factor.

The main problem faced by the animal is the poaching. Kani tribals extensively use the species for preparing medicines which is believed to be a cure for Asthma. For catching the animal, tribals either destroy the nest hole or smoke out the animals after making them unconscious (Plate 20). Another problem is the indiscriminate poisoning practiced by the tribals and locals for getting rid of the Malabar Spiny Dormouse from their crop fields. Tribals are attempting large scale poisoning using rodenticide to remove the species from their agricultural areas (Plate 21). Habitat loss due to the drying of rivulets in the moist deciduous forest is a big threat to the population depending on the riverine forests. As the species needs thick vertical foliage *i.e.* undisturbed forest as preferred microhabitat, cattle grazing and fire wood collection will deteriorate the habitat of the species. Lack of regeneration in the moist deciduous forest is also harmful to the species. Before this study was initiated not much information was available on the species (Plate 22).

Management

Maintaining the continuity of the moist deciduous forest and canopy is crucial for conserving the species. The species can be considered as a indicator species of the undisturbed riverine forest in the moist deciduous areas. Dormouse is strictly protected by law and may not be intentionally killed, injured or disturbed in their nests, collected, trapped or sold. The species principally require diverse habitat having several different trees and shrubs to provide food throughout the seasons. But lopping of trees can create such conditions as cleared areas and wide gaps which may interfere with the movements of dormouse, because the species live almost exclusively in the trees. The study has indicated that sub adults are more prone to predation. Birds of prey are the only recorded predator. It can be summarised that protection of riverine patches in the moist deciduous forests and protection of evergreen forests with lianas are crucial for the survival of Malabar Spiny Dormouse.

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Table16. Vegetation data and habitat parameters recorded from the trapping sites in the protected areas.

Sl. No.	Protected areas	Tree species	Total no. of trees	Altitude (m from msl)	Canopy cover (%)	Under growth (Scaling)	Litter thickness (cm)	Distance to Water body (km)	Distance to human habitations (km)
1.	Neyyar	28	92	720	4	1	4	0	12
2.	Periyar Tiger Reserve	13	122	1560	8	3	8	5	2
3.	Aralam	32	271	250	8	3	6	0	2
4.	Shendurney	22	360	250	9	1	9	1	4
5.	Peppara	24	107	220	6	2	8	3	1
6.	Chinnar	12	120	1710	10	4	11	3	8
7.	Silent Valley	16	210	1050	9	3	8	5	2
8.	Idukki	14	160	1070	8	3	9	5	5
9.	Wayanad	24	180	950	7	2	8	3	8
10.	Thattekkad	34	402	100	9	3	9	2	4
11.	Eravikulam	12	240	1650	10	3	10	1	1
12.	Parambikulam	26	212	495	10	3	11	1	7
13.	Peechi I	18	113	550	7	1	5	4	2
14.	Peechi II	22	210	780	8	1	5	3	1
15.	Chimmony I	26	224	450	9	1	7	1	3
16.	Chimmony II	12	143	450	7	0	5	1	3

3.2.3 Discussion

The protected areas of Kerala have only low density of rodents. Fifty six per cent of the 16 sampled plots were only having sufficient capture data needed for necessary analysis for the estimation of density. The increase of new captures on the fourth day in three of the sessions was significant as it may be due to the immigration of the rodents from the near by areas to the plot where plenty of food was available. The study indicated that in the Western Ghats tropical forest, four days of trapping is optimum. In such circumstances, where a most robust method like Schnabel method (Schnabel, 1938; Schumacher and Eschmeyer, 1943) fail to produce reliable population size estimator, the MNA should be taken as the population size. In tropical conditions increasing the sampling period for more than four days causes high trap death (Shanker, 2000). Another problem of increasing the sampling period for more than four days was the immigration, which will break the demographic closure assumption necessary for CMR operations other than for open population models (Shanker, 2000; Vieira, 2004). No study has been reported from the tropical areas using CMR in considerably large area as the Kerala part of the Western Ghats with uniform methodology so that the heterogeneity in trapability over similar large-scale demographic changes could be assessed.

***Sex ratio*:** Low density was a problem in interpreting the sex ratio of the animals trapped except *Rattus rattus* in some protected areas. The available sex ratio of the animals trapped was highly biased towards male or female. In the case of *Rattus rattus* considerably few percentage of males were trapped on the first day, which showed that males are more neophobic than females. Since reliable information about the behaviour of the species is lacking, it is difficult to propose a sex specific change in trap responses, including exploratory behaviour, which causes a decrease in number of males trapped at least in certain sessions. Majority of the protected areas showed highly female biased sex ratio in the case of most abundant species. As the number of individuals trapped were less in the case of other species, it was difficult to interpret their sex ratios. The habitat use of two species - *Rattus rattus* and *Cremnomys blanfordi* was similar and the niche of the species *Platacanthomys lasiurus* was found overlapping to *Rattus rattus*.

Role of habitat in species composition

The study established a strong positive correlation between the rodent species richness and the tree species richness. The criteria of habitat selection of each species were not clearly studied. Multi dimensional scaling of the protected areas based on the habitat parameters of the sampled plots have shown a pattern of habitat influence in species assemblage, but with low resolution. The protected area, where the *Rattus rattus* was dominating has comparatively high positive values for their second stimulus coordinates dimension in the analysis. In the protected areas which had a negative value for this axis (less than 0.002) either species other than *Rattus rattus*, which has similar habitat use, was trapped or they were trapped along with *Rattus rattus* with out a clear dominancy for *Rattus rattus*. A clear pattern of species assemblage was not revealed from this, other than the fact that habitat characteristics have some influence in habitat selection.

Meena (1997) had reported a strong negative correlation in the distribution of *Rattus rattus* and *Cremnmys blanfordi.* She also reported that *Rattus rattus* was dominant in semi evergreen forest and *Cremnomys blanfordi* was dominant in deciduous forest. Multi Dimensional Scaling of the protected areas revealed a trend in the habitat characteristics for the co-existence of these species. *Rattus rattus* was found absent in semi evergreen forest at Aralam Wildlife Sanctuary and in moist deciduous forest at Neyyar Wildlife Sanctuary. In Wayanad Wildlife Sanctuary were the sample plot was in semi evergreen forest *Rattus rattus* was the most abundant species and *Cremnomys blanfordi* the second abundant one. The present study also revealed that the diversity of tree species is positively correlated to the diversity of rodents. This is a strong evidence to believe that, more than competition; the diversity of the habitat influences the coexistence of rodent species. This is in accordance to the generally accepted principle that the intensity of the competition depends on the carrying capacity of the ecosystem.

Since there is no evidence of competition in these circumstances, the species composition should be attributed to the habitat selection criteria of the individual species. These criteria may vary over the demography and climate (Meserve *et al.,* 2003). A behavioural change according to the presence and absence of a resource sharing species was clear in trapping, but weak to be attributed to competition.

Rodent species richness is positively correlated to the tree species richness. Diversity in tree species nurtures the diversity in an important component of the ecosystem. In general this shows the necessity and importance of plant diversity. A pattern of species assemblage exists with regard to the vegetation characteristics of the habitat. There exist little evidences of competition but strong behavioural responses against the presence of competitive species at least in case of the most abundant rodent species *Rattus rattus*. *Mus platythrix,* a burrowing rodent species so far not reported from Kerala part of the Western Ghats was newly recorded from the Kerala part of the Western Ghats in this study. The study also indicated that House Rat invaded the most of the forest areas in Kerala.

Cremnomys blanfordi was newly reported from Wyanad, Neyyar and Aralam Wildlife Sanctuaries. The result is of special interest in formulating wildlife management and biodiversity conservation strategies for the protected areas of Kerala and standardising methodology for rodent studies in tropical forest habitat. The predominance of the species *Ratts rattus* in all the protected areas among the rodent community is an important observation. The trap response of *Rattus rattus* which is a broad niche species is totally diverse and highly individual. The diverse trap response of the species and low capture success of the other less dense rodent species make it impossible to apply conventional Capture Mark Recapture density estimation models in the study.