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**DIVERSITY OF SMALL MAMMALS IN THE
PARAMBIKULAM WILDLIFE SANCTUARY**

**By
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THESIS

**Submitted in partial fulfilment of the
requirement for the degree of**

Master of Science in Forestry

**Faculty of Agriculture
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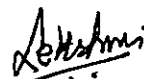
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I hereby declare that the thesis entitled “**Diversity of small mammals in the Prambikulam Wildlife Sanctuary**” is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or any other similar title, of any other University or Society.

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Certified that the thesis entitled “Diversity of small mammals in the Prambikulam Wildlife Sanctuary” is a record of research work done independently by Miss. Lekshmi, R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.


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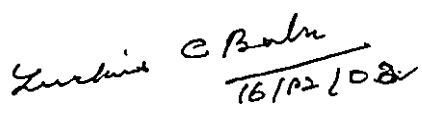



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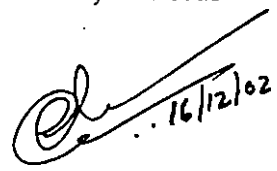
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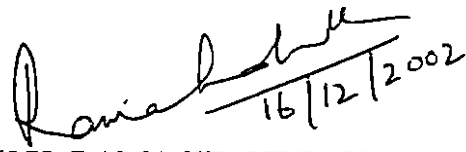
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***Dedicated to my
Mother Nature***

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Introduction

INTRODUCTION

Biodiversity comprises the whole life on earth. It denotes the nature's variety and variability and is recognized at three levels viz., genetic, species and ecosystem. Genetic diversity is the sum total of the genetic information comprised in the genes of individual organisms. Species diversity refers to the variety of living organisms on earth. Ecosystem diversity relates to the variety of habitats, bio-communities and ecological process in the biosphere and the diversity within the ecosystem.

The present study has relevance to the mammalian diversity. The class Mammalia comprises highly adapted group of animals and some among these represent excellent examples of adaptive radiation and divergent evolution. Four hundred and five species of mammals are known to exist in India and are spread over 186 genera, 43 families and 13 orders (Nameer, 2000). Chiroptera is the largest order with 112 species in 7 families followed by Rodentia (102 species in 4 families), Carnivora (62 species in 7 families), Artiodactyla (39 species in 6 families), Cetaceae (30 species in 7 families), Insectivora (31 species in 3 families), Primates (15 species in 3 families), Perissodactyla (7 species in 2 families), Scandentia (3 species in 1 family), Pholidota (2 species in 1 family) and Sirennia and Proboscidae each with one species in one family each.

Forty species of mammals are known to be endemic to India, out of which sixteen are endemic to Western Ghats, ten to Andaman and Nicobar islands and the rest fourteen species to different regions within India. Order Rodentia has the maximum number of endemic species of Indian mammals followed by Chiroptera and

Insectivora. These three groups together account for 75 per cent of the endemic mammals of the country and form the major part of the small mammal fauna of the country. It is very difficult to define a small mammal. Delany (1974) used the term to include only the insectivore and rodent species weighing less than 120 gms. Bourliere (1975) considered any mammalian species up to 5 kilogram in weight as small mammals. Chew (1978) suggested that small mammals be defined as the size range within which the majority of species have diets at least partly dependant on seeds or insects and/or require a burrow for protection from extreme environmental temperatures and predators. Some researchers consider the members of the mammalian orders of Insectivora, Rodentia, Carnivora and Chiroptera as small mammals. However, in general, the definition proposed by Bourliere (1975) is accepted by most researchers on small mammals.

The small mammals form an important component of the forest animal community. In addition to contributing to energy flow and nutrient cycling, small mammals play an important role as predators and seed dispersal agents in tropical forest ecosystem. They also form part of the food chain and is predated by medium size carnivores and birds of prey.

The present study was undertaken with the following objectives:

- to prepare an inventory on the small mammal fauna in the Parambikulam Wildlife Sanctuary
- to estimate the abundance and diversity of rodents in different habitats such as plantation, natural forest and vayal
- to generate information on the floral diversity of different habitats and to correlate the rodent species richness with the vegetation.

Review of Literature

REVIEW OF LITERATURE

2.1 Small mammals of the world

Wu Delin *et al.* (1996) made a comparison of ground dwelling small mammal communities in primary and secondary tropical rainforest and found twelve species from primary forest and eleven species from secondary forest. A study on the distribution of small mammals among successional and mature forest types was made by Simon *et al.* (1998) and found that the abundance of small mammals on plots increased with the successional age of the plot.

Paritschniak and Messier (1998) conducted a study on the effect of edges and habitats on small mammals in a prairie ecosystem and found that edge effect across all habitats was dependant on season. The relative abundance of small mammals was significantly higher along edge in spring. Bykov (1998) studied the distribution of small mammals grouping in Taiga forest. Gomez and Anthony (1998) found that riparian system and adjacent upland areas provide important habitat for small mammals. Decher and Bahian (1999) studied the diversity and structure of terrestrial small mammal communities in different vegetation types. Four species of shrew and nine species of rodents were caught and showed that abundance, diversity and composition of small mammals varied greatly between sites.

Getz *et al.* (1999) studied the diversity and stability of small mammals in tall grass prairie habitat. Kirkland *et al.* (1999) made a transcontinental comparison of forest small mammal assemblage and found that despite of marked difference in forest type small mammal assemblage from the conifer dominated and deciduous forest were similar in structure. Habitat gradient analysis among small mammals was studied by

Menzel *et al.* (1999) and found that the shrews respond favourably to microhabitat heterogeneity.

2.2 Small mammals of India

Early exploration on mammals began after Linnaeus, which Chakraborty (1986) referred to as Pre-Hodgson period. Belanger, Jacquemont, Lechenault, Duvaucel, Geoffroy and Blainville were the pioneer mammalogists and many Indian species were named by them. Pallas and Erxleben also contributed by describing new species during the Pre-Hodgson period. Hodgson (1844, 1845) made extensive collection from India and Nepal and described several new species. Blyth, the curator of Museum of Asiatic Society of Bengal published detailed accounts on small mammals, rodents and bats. Blandford and Anderson (1888, 1891) made elaborate studies on mammals of India and wrote the Fauna Volumes.

The mammalian survey became active when the Bombay Natural History Society (BNHS), the pioneering conservation agency in India came into being. The society made extensive surveys during 1911 to 1929 and about 25,000 specimens were collected with adequate field data. These surveys threw much light on the faunal diversity of India (Hinton, 1918 a, b, c, d; Thomas and Wroughton, 1915; Thomas, 1919, 1922, 1923 and Wroughton, 1920 a, b). Based on these surveys Pocock (1923, 1939 and 1941) published Fauna of India covering the primates and carnivora. Finn (1929) revised Sterndale's (1884) popular work and published the Mammalia of India. The Post independent period witnessed a series of publications based on surveys in various parts of India. Prater (1948), and Ellerman and Morrison-Scott (1951) made extensive studies on mammals. Ellerman and Morrison-Scott (1961) made elaborate studies on small mammals, especially with reference to rodents.

2.2.1 Rodents and bats

Robinson (1917) described two new species of squirrels from south India. The bats of Central India were documented by Brosset (1962 a, b, c). A series of publications on small mammals were available during this period (Roonwal, 1948; Moore and Tate, 1965; Ghosh, 1964; Kurup, 1965; Biswas and Tiwari, 1969; Mandal and Ghosh, 1981; Walker, 1983 and Corbett and Hill, 1991). The revisionary work by Sinha (1973) on the *Rhinolophus* and by Chakraborty (1981) on *Sciuropterus* was more noteworthy. A genus of flying squirrel was described by Saha (1982).

Ramachandran (1988) studied the ecology and behaviour of Malabar giant squirrel and found that they construct several dreys in its home range during the lactating period. Information on the endangered grizzled giant squirrel and about seventy five individuals were listed as part of a survey by Ramachandran (1989). According to the status survey and distribution of endangered grizzled giant squirrel, about fifty one squirrels were sighted and revealed that the population was found only in the riverine forest in Chinnar Wildlife Sanctuary (Ramachandran, 1993).

Borges (1993) found that the low density and clumped distribution of fig trees and the small number of fig species at the sites limited the importance of figs to squirrel which have access to the trees. Conservation measures for the grizzled giant squirrel population were proposed by Joshua and Johnsingh (1996) which include planting of desired species to promote canopy continuity and availability of food plants, nesting site and cover.

Pradhan (1994) showed that glue-trap can be used as an alternate method for rodent collection from different ecosystem. The vegetation structure, rodent

density and seed loss rate were compared between protected and disturbed sites in Thar Desert (Wada *et al.*, 1995). They found that the density of rodent burrows and the frequency of rodent captures were higher in the protected sites. Neelananarayan *et al.* (1995) found that live burrow counts of field rodents can be used as a method of population estimate of *Bandicota bengalensis* and *Mus booduga*. Chakravarthy (1996) studied the foraging behaviour of squirrels in the cardamom ecosystem and concluded that the animals were active in field on slopes. Solanke (1996) showed that there was no restriction in the breeding season of *Rattus rattus* and female rats attained sexual maturity at 49.13 gm and males at 60.2 gm body weight.

Raman (1996) studied the impact of shifting cultivation on diurnal squirrel and emphasized that shifting cultivation decreased the species density of the squirrel. Prakash (1996) conducted a study on the desert adapted rodent species and found that *Tatera indica* is more common in sand dune ecosystem whereas *Millardia meltada* and *Golunda ellioti* inhabit semi-arid zone. The study also revealed that with increasing aridity the body size of gerbil decreases, tail and ear length increases. Aparajitha (1996) made an assessment of the forest structure and the use of feeding and nest trees of *Ratufa indica* and found that larger trees were preferred for nesting and also there was preferential use of full mature trees and dependence on canopy continuity.

Chandrasekar and Sunquist (1999) reported that density of small mammals were more in natural forest. They also reported that *Rattus rattus* and *Mus platythrix* were the two most common species and *Golunda ellioti*, the least common species and found only in moist deciduous forest. Shankar and Sukumar (1999) found that *Rattus*

rattus was most abundant in montane forest patches. Umapathy and Ajithkumar (2000) while studying the occurrence and abundance of five species of arboreal mammals in the Anamalai hills reported that the densities of the Giant squirrel, the Large brown flying squirrel and the Travancore flying squirrel increased with decreasing area and increasing disturbance level.

2.2.2 Mustelids

The members of the Mustelidae are the most diverse group and may be paraphyletic (Wozencraft, 1989). They are mainly solitary, with males and females getting together only for the purpose of reproduction (Kuruska, 1990). In south India, otters are represented by three species namely, the eurasian otter, the small-clawed otter and the smooth-coated otter (Nagulu, 1996).

The otters show preference for rocky stretches in all seasons since these stretches provide sites for den and resting (Hussain and Choudhary, 1995). Fish is the major prey of otters and exceeds more than 80 per cent of the diet.

Studies on the Nilgiri marten are scant. There are reports of Nilgiri marten preying on crows in the High Ranges of Kerala by Gouldsbury (1949) and on Malabar giant squirrel in the high wavy mountains of Kerala by Hutton (1994). Yoganand and Kumar (1995) reported Niligiri marten from Nilgiri Biosphere and Madhusudan (1995) from Eravikulam National Park. Christopher and Jayson (1996) also reported it from Peppara Wildlife Sanctuary. Recent sighting was by Mudappa (1998) from Kalakkad-Mundamthurai Tiger Reserve. Very little is known about the behaviour and ecology of Nilgiri marten.

2.2.3 Viverrids

The members of the family viverridae are characterized by the presence of scent glands and perineal gland (Pocock, 1941 and Wozencraft, 1989). Most of the members have spots or stripes on the body and the tail has ring like marks (Pocock, 1939). The common palm civet is an omnivore and feeds on birds, rodents, insects and fruits such as tendu, banana, pineapple, coffee and berries (Pocock, 1939; Medway, 1978 and Singh, 1982). Malabar civet is endemic to Western Ghats (Pocock, 1933; 1939 and Corbet and Hill, 1992). There are only two reports of its occurrence in the higher elevation of Western Ghats (Hutton, 1949 and Karanth, 1986). Recently there was a report on its occurrence at Elayur (Kurup, 1989). Ashraf *et al.* (1993) reported its presence in the thickets in cashew plantation and highly degraded lowland forest. Mudappa (1998) found that it mainly feeds on nearly forty rainforest trees and lianas species.

2.2.4 Herpestids

The members of the family Herpestidae are characterized by the presence of anal sac and auditory bulla (Wozencraft, 1989). Pocock (1939) reported a well developed baculum and the absence of penial gland. Chowdhary (1981) reported that grey mongoose predate on gharial eggs. Brown mongoose and stripe-necked mongoose are found in the forests of Southern India (Pocock, 1939; Prater, 1971; Corbet and Hill, 1992 and Mudappa, 1998).

2.2.5 Primates

Ramachandran (1996) made a status survey of primates in the Shendurney Wildlife Sanctuary and four species of primates including slender loris were sighted in

the area. Khajuria (1956) described a new species of primate from Assam. A survey was also undertaken on the endangered slender loris by Singh *et al.* (1999).

2.2.6 Lesser cats

Gogate (1997) studied lesser cats of Maharashtra and five species of wild cats were found and the need for specific conservation efforts indicated.

2.3 Small mammals of Kerala

Studies on mammalian fauna in Kerala could be traced back to the British period and thereafter. In spite of these efforts, a comprehensive account on the small mammals of Kerala is yet to be published. The available information is mostly on larger mammals like elephant, tiger, gaur, tahr etc. (Rice, 1984; Vairavel, 1998 and Balasubramanian, 1998). Nair and Easa (1997) briefly summarised and reviewed the mammalian studies done so far in Kerala. Nameer (2000) compiled a list of mammals in the Indian region. But for the new description of the field rat by Agrawal and Ghosal (1969) and the survey of bats in Silent Valley (Das, 1986), most works pertaining to the small mammals were on the captive ones (Xavier, 1993 a, b; Xavier and Balakrishnan, 1993). A recent survey conducted by Easa *et al.* (2001) recorded about fifty seven species of small mammals from Kerala.

The review of literature indicates that there is dearth of information on the diversity and abundance of small mammals in Kerala. One major reason could be the smaller size of the animals. Also the specific microhabitats are not easily accessible and the nocturnal habits of rodents and bats in general make it difficult to document them unlike larger mammals.

Materials and Methods

MATERIALS AND METHODS

3.1 Study area

The present study was carried out in the Parambikulam Wildlife Sanctuary (WLS). This sanctuary is located in the Palghat district of Kerala State and lies between 76°35' and 76°50' E and 10°20' and 10°26' N (Fig.1) at an elevation of 600 m above sea level. An overview of the Parambikulam Wildlife Sanctuary is given in Plate 1. The sanctuary came into existence in 1962 when an area of 69.8 km² of Sungam range of Nenmara Forest Division was declared as a sanctuary and later, in 1973 the Parambikulam range was added to this. The sanctuary as of now is formed in 1985, and has an area of 270 km². The boundaries include the Indira Gandhi Wildlife Sanctuary of Tamil Nadu on the east, the Nelliampathy Reserve Forests on the northwest as well as the Vazhachal and Sholayar forests on the south. Many streams originate from this region, which later merge to form the Karappara-Kuriarkutti river systems, which finally drains into the Chalakudi river at Orukombankutty.

3.1.1 Topography

The sanctuary exhibits hilly terrain with characteristic distribution of undulating plains interspersed with marshy fields in the valleys. The altitude varies between 300 m and 1400 m, and the highest peak is Karimalagopuram which has an elevation of 1438 m. The mountain slopes are non-symmetrical and non-uniform spread throughout the area in different directions. The mountain ridges, which have well defined valleys, slope down straightly to streams, which permit denser growth of vegetation in those regions. The ridges of the sanctuary are of sheet rock and are exposed at the top. Some of the hilltops have a thin crust of soil favouring stretches of grasslands.

Fig. 1. Map showing the Parambikulam Wildlife Sanctuary

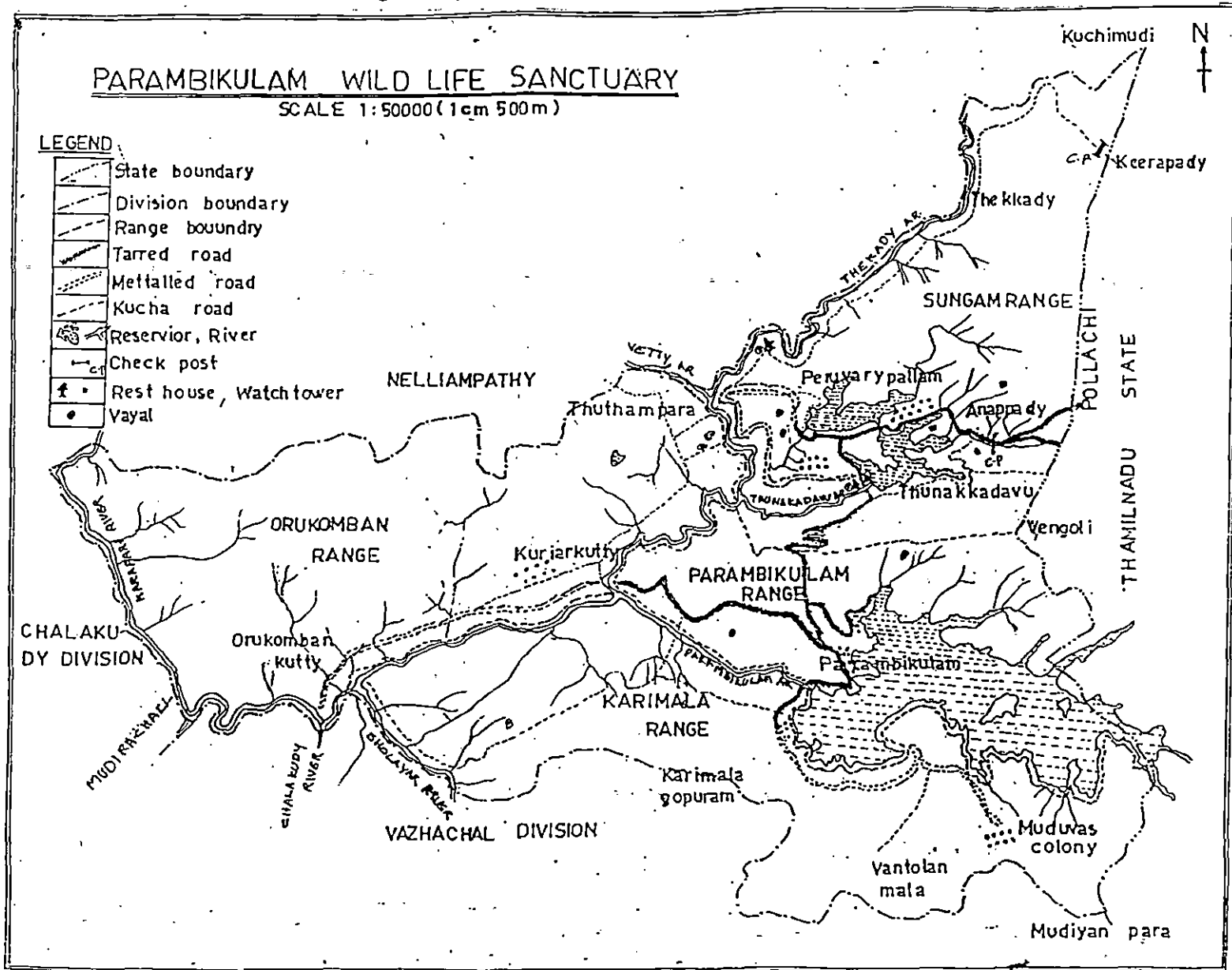


Plate 1. View of the Parambikulam Wildlife Sanctuary



Inside the sanctuary, three dams were constructed in the year 1960 - Parambikulam, Thunacadavu and Peruvairippalam as part of the Parambikulam-Aliyar project. The total water-spread area of these three dams comes around 29 km² of which Parambikulam is the largest (21.22 km²).

3.1.2 Climate

The maximum temperature ranges between 24°C to 33°C and minimum 20°C to 25°C. The average annual precipitation is 1800 mm varying between 1200 mm to 2300 mm. The area gets both the south-west and north-east monsoons, the south-west being more active monsoon which last from June to December and as such two seasons could be distinguished in the area-dry and wet. January to May with low or no rainfall is considered as dry and the remaining months of the year as wet. February to April is the hottest months and the sanctuary becomes dry and fire prone during this period.

3.1.3 Habitats and vegetation

The sanctuary has a variety of habitats, both natural and man-made. Natural habitats include moist deciduous forests to tropical wet evergreen rain forests. Semi-evergreen forests appear in areas where moist deciduous forests merge into evergreen forests. Grasslands are seen on the upper reaches of Karimalagapuram and Vengoli hills above 1000 m.

Based on Champion and Seth (1968), the natural vegetation is classified broadly as west-coast tropical evergreen (55 km²), west-coast semi evergreen (20 km²), the South Indian moist deciduous (65 km²) and the South Indian dry deciduous forests (15 km²). Besides these, small patches of bamboo and reed are also

present in certain areas. The man-made habitats are chiefly teak plantations, with an area of about 90 km² and were first introduced in the year 1912. In addition to this, a small area of the sanctuary bordering Tamil Nadu is planted with eucalyptus.

3.2 Vegetation type of the study area

3.2.1 Moist Deciduous Forest (MDF)

In the sanctuary, MDF covers 65 km² (Plate 2). They are mostly encountered along the ridges and lower slopes. Trees such as *Terminalia* sp., *Lagerstroemia microcarpa*, *Xylia xylocarpa* and *Tectona grandis* dominate the habitat. The understorey is a combination of shrubs like *Sida* sp., *Hibiscus* sp., *Helicteres isora*, *Glycosmis pentaphylla* and herbs like *Synedrella nodiflora*, *Smithia geminiflora*, *Centella asiatica* and *Globba maratiana*.

3.2.2 Evergreen forests

Evergreen forests are distributed in higher slopes above 800 m MSL. They exhibit luxuriant vegetation and are mostly found in Karianshola, Vengolimalai and Karimalagapuram. Most of the streams and rivers that drain the Parambikulam Valley originate from these forests. The total extent of these forests in the sanctuary is about 55 km². Upper canopy species include *Palaquium ellipticum*, *Cullenia exarillata*, *Mesua ferrea*, *Calophyllum tomentosum*, *Hopea parviflora*, *Polyalthia fragrans*, *Dipterocarpus indicus*, *Disoxylum malabaricum*, *Myristica malabaricum*, *Vateria indica* and *Syzygium cumini*. Lower canopy species include *Aporosa lindleyana*, *Canarium strictum*, *Elaeocarpus serratus*, *Evodia roxburghiana*, *Hydnocarpus wightiana*, *Mallotus philippensis* and *Holigarna arnottiana*. The under growth species are *Antidesma* sp., *Calamus rotang*, *Glycosmis pentaphylla*, *Ixora* sp., *Laportea*

Plate 2. Moist deciduous forest



crenulata, *Murraya exotica*, *Ochlandra wightii*, *Curcuma* sp., *Strobilanthus* sp., *Elettaria cardamomum*.

3.2.3 Teak plantation

About 90 km² area within the sanctuary is under teak plantation (Plate 3). Deciduous species like *Cassia fistula*, *Cordia dichotoma*, *Butea monosperma*, *Grewia tilifolia* and *Randia* sp., are seen (mixed) with teak trees in the plantations. Since Parambikulam is a Wildlife Sanctuary, the teak plantations are left without weeding or extraction of miscellaneous tree species, as a result of which some areas have developed into mixed stand.

3.2.4 Vayals

Vayals are marshy lands (Plate 4), generally low lying depressions with a high content of clay in the soil. They accumulate running water during monsoon and this becomes stagnant as dry season approaches. Most of the vayals are so interspersed with the teak plantations that they create effective edges. *Tectona grandis*, *Lagerstroemia microcarpa*, *Randia* sp., *Ziziphus*, *Butea monosperma* etc., grow in the fringes. Polygonums, sedges, grasses etc., grow well in these marshy areas. These marshy lands are interspersed within the sanctuary in more than 30 places occupying 150 ha. Most of these vayals are now in a degraded condition.

3.3 Wildlife and its distribution

The sanctuary is blessed with a rich wildlife fauna. A total of 36 mammal species, 52 species of reptiles including lizards, turtles, crocodiles and snakes, 268 species of birds, 16 species of amphibians, 47 species of fishes and 1049 species of insects are reported in the sanctuary. A list of the mammals of the sanctuary is given in Appendix I.

Plate 3. Teak plantation



Plate 4. Vayal



In order to prepare an inventory on small mammals, both direct and indirect methods were employed.

3.4 Direct methods

This method involved direct sighting of the animals. However, most of the small mammals are nocturnal in habits and therefore direct sighting cannot be relied upon to make a realistic assessment of their distribution and abundance. During the survey, the various habitats in the sanctuary were extensively covered by foot to get direct sighting of the species envisaged under the project. Vehicular transects were done, mostly at night, wherever possible. Stationary observations for a long period of time were made at probable haunts of the various species such as water holes, reservoirs, fruiting trees etc. To identify bats, mist nets were placed within the sanctuary at different locations. Traps were also set up at different habitats to capture other small mammals.

3.5 Indirect method

This included indirect evidences to identify the animal. Transects were laid in habitats in the study area to quantify indirect evidences of small mammals present in the sanctuary. The main indication of the presence of animals were scats, either excreted or marked for intra and inter specific communications. The animals usually use bridle paths for scat making. Therefore, mostly the roads and footpath were taken as transects for sampling. Scats found on the transect were collected to identify the species. In the field, scats were classified to various groups such as cats (Felidae), civets (Viverridae), mongoose (Herpestidae), otters (Mustelidae) depending on the characteristics such as size, shape and scent marking sites. Other signs such as

footprints were recorded and traced for later identification by comparing with already identified markings or prints.

3.6 Estimation of the abundance and diversity of rodents

To estimate the abundance and diversity of rodents, live trapping was carried out in the sanctuary for a period of six months (November 2000 to May 2001) for a total of 3600 trap nights.

The habitats chosen for the study included teak plantation, natural forest and vayal. The rodents were studied by placing modified versions of Sherman traps in different habitat. The traps were systematically laid out in the transect at 25 m apart. A total of 20 traps were placed in each of the habitat in 10 rows and in 2 columns. The traps were set up and were observed for five consecutive nights. This procedure was repeated thrice in every habitat. The traps were baited with grated coconut and dry fish. Traps were checked between 7.00-10.00 am and were re-baited regularly. However, considering the diurnal habits of certain rodents, traps were also set in the morning and checked in the evening.

3.7 Collection of Data

For each trapped mammals the following data were recorded in the prescribed proforma.

1. Trap number
2. Tentative identification, the identity was confirmed later based on authentic records.(Prater,1948 and Corbet and Hill,1991)
3. Body measurement such as head and body length and tail length

The above data was used to arrive at the following indices such as diversity index, dominance index and species richness.

3.8 Diversity indices

3.8.1 Simpson's diversity index, λ

Simpson (1949) proposed the first diversity index used in Ecology as

$$\lambda = \sum_{i=1}^s P_i^2$$

Where P_i is the proportional abundance of the species, given by $P_i = n_i/N$ where $i = 1, 2, 3, 4, \dots, s$. Where n_i is the number of individuals of the i^{th} species and N is the known total number of individuals for all S species in the population. Simpson's diversity index which varies from 0-1, gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated if the probability is high that both individual belong to the same species, then the diversity of the community sample is low (Ludwig and Reynolds, 1988).

3.8.2 Shannon – Wiener diversity index , H'

The Shannon–Wiener diversity index (Shannon and Wiener, 1963) is a measure of the average degree of uncertainty in predicting to what species, as individual chosen at random from a collection of species and N individual will belong. This average uncertainty increases as a number of species increases and as the distribution of individual among the species become even. Thus, H' has two properties that have made it a popular measure of species diversity; 1) $H' = 0$ if and only if there is one species in the sample, and 2) H' is maximum only when all s species are

represented by the same number of individuals, that is, a perfectly even distribution of abundances (Ludwig and Reynolds, 1988).

The equation for the Shannon function, which uses natural logarithm (ln), is

$$H' = -\sum_{i=1}^s (P_i \ln P_i)$$

Where H is the average uncertainty per species in the infinite community made up of species with known proportional abundance $P_1, P_2, P_3, \dots, P_s$

3.8.3 Dominance index

Patterns of relative abundance of species determine the dominance component of diversity. In the study, the relative dominance of each rodent species in a locality was determined by calculating the dominance index using the following formula.

$$\text{Relative dominance} = n_i \times 100/N$$

Where n_i is the number of rodents in the i^{th} species, and N the total number of rodents in all the species collected during the study period.

3.8.4 Species richness index

In the ecological literature the number of species at a site, in a region or in a collection is called species richness, richness is the simplest and most useful measure of species diversity. In this study, the total number of rodent species collected in each month from each locality was considered as species richness.

The index of species richness (d) was calculated using the formula given by

Menhinick (1964)

$$D = s/\sqrt{n}$$

Where “S” is the number of species recorded and “n” is the total number of individuals summed over all species.

3.9 Floral diversity and rodent species richness

Floral diversity of natural forests, plantation and vayal was enumerated and recorded. Richness of rodent species in each habitat with respect to the availability of plant species was also carried out.

Results

RESULTS

The results on inventory of small mammal fauna in the Parambikulam Wildlife Sanctuary obtained through direct and indirect methods are presented under separate heads.

4.1 Direct Methods

By this method, twenty seven species of small mammals were recorded from different habitats. The mammal species recorded include eight mammalian orders such as Primates, Carnivora, Rodentia, Insectivora, Chiroptera, Artiodactyla, Pholidota and Lagomorpha. Rodentia was the most highly represented order with eleven species followed by Carnivora with ten species. Insectivora, Chiroptera, Artiodactyla, Pholidota, Primates and Lagomorphs were represented by only one species. Table 1 provides a list of small mammals recorded during the present study and some of the salient characteristics of the species observed during the survey are described below.

1. Slender loris: *Loris tardigradus*

Slender loris was the only animal observed under primate and only one species was seen during the survey. It has longer and slender limbs, elongated snout, large rounded ears and large eyes. Its colour is dark grey to brown with silvery hairs and the lower part is paler. This animal was observed as solitary and seen at the fringes of an evergreen patch in Karianshola range in March 2001 (Plate 5).

2. Common palm civet/Toddy cat: *Paradoxurus hermaphroditus*

Six individuals of common palm civet were observed during the months of November, December, February and March 2001. Two individual numbers were

Plate 5. Slender loris



observed from natural forest during March and four from plantation; one each during November and December and two in February. Among these, four individuals were adults and two of them were sub-adults. All the animals sighted were blackish brown with long shaggy hairs, short limbs and long tail. Three dark brown longitudinal stripes are present on the back with white patch above the eyes and side of the nose. This was the commonest of the three viverrids (Plate 6a). A common palm civet caught in the trap is given in Plate 6b.

3. Brown palm civet: *Paradoxurus jerdoni*

A total of three numbers were sighted; two in the natural forest area near Thellickal vayal and one on the road side near the teak plantation during April and May 2001. They are glossy brown coloured animals with blackish face and dark coloured limbs. They have white tail tip with yellow colour at the base of the tail. These civets are similar to common palm civet in size (Plate 6c).

4. Small Indian civet: *Viverricula indica*

Two Indian civets were recorded during April 2001; one from the Orukombankutty range of the sanctuary and one in the den near Thunakkadavu area. They are sandy buff in colour and heavily spotted with blackish patches in parallel horizontal lines. The tail region is conspicuously marked with concentric black rings and two black semicircular bands are present on the upper throat (Plate 6d).

5. Ruddy mongoose: *Herpestes smithii*

Only one individual was located during the study period and it was from the dry forest area near the Thekkady region of the sanctuary during March 2001. This animal is darker in colour speckled with greyish white and reddish colour in the

Plate 6. Civet cats



6a. Common palm civet



6b. Common palm civet caught in the trap



6c. Brown palm civet



6d. Small Indian civet

hair of upper side of the head and on the neck, having a long tail with a curved tip (Plate 7a).

6. Brown mongoose: *Herpestes fuscus*

One individual was located near the evergreen patch of the forest near to Karimalagapuram hill area during May 2001. The colour of this mongoose is blackish brown with a relatively shorter tail (Plate 7b).

7. Stripe-necked mongoose: *Herpestes vitticollis*

One individual was observed at the stream bed area near Kannimara teak during May 2001. It is a stoutly built mongoose having short limbs with black stripe, starting from the back of the ear through the side of the neck up to the shoulder. Tail is very long, dark brown with yellowish grey in colour.

8. Eurasian otter/common otter: *Lutra lutra*

Two individuals of otter were located in the sanctuary near the rock and boulders along the side of the Thunakkadavu reservoir during January and February 2001. The colour of the animal is dusky brown on the upper side and greyish white on the ventral side of the abdomen. Hairy tail and paddle like feet are other characteristic features of this animal (Plate 8a).

9. Nilgiri marten: *Martes gwatkinsi*

Only one species of marten was located near the Karianshola range in February 2001. This animal is with deep brown colour from head to rump and the under part is yellowish and possessed a proportionately longer tail measuring three-fourth the length of head and body (Plate 8b).

Plate 7. Mongoose



7a. Ruddy mongoose



7b. Brown mongoose

Plate 8. Mustelids



8a. Eurasian otter



8b. Nilgiri marten

10. Jungle cat: *Felis chaos*

Three individuals were located at the deciduous forest area near Sungam colony and near Peruvairippallam dam during the months of February, March and April 2001. The colour of the animal is sandy grey to yellowish grey, tail is ringed with black towards the end and has a black tip. A dark band runs down the inner lower corner of each eye down to the nose on either side. Its long leg and short tail are other salient features (Plate 9a).

11. Leopard cat: *Prionailurus bengalensis*

A single individual was observed near the Kuriarkutty area of the sanctuary during May 2001. Its colour and marking are similar to that of leopard. The colour of the animal is yellowish above, white below and ornamented throughout with black spots. Four distinct bands are seen on the crown over the neck, which break up into short bars and also with elongated spots on the shoulders (Plate 9b).

12. The grey musk shrew: *Suncus murinus*

In total, seventeen individuals were trapped from the natural forest and teak plantation during November, January, February and March 2001. The peculiar feature observed is long pointed snout projecting beyond the lower lip. They are with small eyes and rounded ears and the body is covered with soft fur. The fur colour of the shrews are ashy brown (Plate 10).

13. Indian fulvous fruit bat: *Rousettus leschenaulti*

Seven individuals of this bat species were caught in the mist nest from the river side of the forest area near Thunakkadavu and Parambikulam. This species of bats are medium sized with large head and elongated dog like muzzle, large eyes and

Plate 9. Cats



9a. Jungle cat



9b. Leopard cat

Plate 10. Grey musk shrew



broad wings. The colour of the body is light brown and they possess well developed thumb.

14. Mouse deer: *Moschiola meminna*

Five individuals were located near Manchadippallam area of teak plantation, Anappady and Kuriarkutty region of the sanctuary. They are tiny creatures with very slender limbs and high hind quarters. The colour is olive brown speckled with yellow spots on the upper side and lower part is white and with three white stripes on the throat.

15. Indian pangolin: *Manis crassicaudata*

Two individuals were located in the natural forest near Thunakkadavu and Vengoli region of the sanctuary during November and April 2001. The upper part of the head, the back and side of the body, the tail and the outside of the limbs are covered with large overlapping scales. Feet are with long, somewhat covered and with blunted claws. This is the only toothless mammal represented in the State (Plate 11).

16. House rat: *Rattus rattus*

Seventy nine individuals of this rat species were trapped from the moist deciduous forest, teak plantation and vayal during November, December, January, February, March and April 2001. They are medium sized with darker and longer tail than the head to body length, the colour of the body is brown on the upper part and off white on the lower part. This was the most abundant rodent species trapped during the study period (Plate 12a).

Plate 11. Indian pangolin



17. Bandicoot rat: *Bandicota indica*

Forty two individuals of this species were trapped from the same region as that of the house rat. This was the biggest of the rats trapped. The general colour of the upper part is greyish brown and lower part pale (Plate 12b).

18. White tailed wood rat: *Rattus blanfordi*

Sixteen rats were trapped both from natural forest and teak plantation during November, February, March and April 2001. The colour is light brown on upper side and white on the lower side. The tail is brown for three quarters of its length, but the terminal portion is clothed with longer white hairs (Plate 12c).

19. Indian bush rat: *Golunda ellioti*

Nine individuals were trapped from the natural forest during January, February, March and April 2001. They are with short rounded heads, rounded ears and hairy tails. The coat colour is yellowish brown above and finely speckled with black. They were trapped only from the moist deciduous forest (Plate 12d).

20. Spiny field mouse: *Mus platythrix*

Thirty seven individuals were trapped from the natural forest, teak plantation and vayal of the sanctuary during December, January, February, March and April 2001. The coat colour is dark or sandy brown above and white below. The separation of the two colour is sharp and well defined and because of this the species is very easily distinguishable (Plate 12e).

21. Large brown flying squirrel: *Petaurista Philippensis*

Three individuals were sighted while feeding on the fruits of bombax near Sungam colony and Anappady region during April and May 2001. They are large

Plate 12. Rats



12a. House rat



12b. Bandicoot rat



12d. Indian bush rat



12c. White tailed wood rat



12e. Spiny field mouse

squirrels with brown colour on upper part and gray white colour below and with a long bushy tail. The flying membrane is light brown in colour (Plate 13a).

22. Small Travancore flying squirrel: *Petinomys fuscocapillus*

Two individuals were recorded from the Sungam range of the sanctuary during May 2001. They are reddish brown in colour on the back with white under surface. The hairs of the flying membrane are black, feet are pale yellowish brown and tail black (Plate 13b).

23. Malabar giant squirrel: *Ratufa indica*.

Twenty six individuals were located from the plantation and natural forest area of Thunakkadavu, Anappady and Vengoli region. This mammal species is beautifully coloured with reddish brown and black colour. Its ear, upper part of head and the body except fore limbs are coloured with reddish brown hairs and the upper part of the fore limbs, hind limbs and tail coloured with black hairs. The face, under part of the body and the limbs are with white hairs (Plate 13c).

24. Three-striped palm squirrel: *Funambulus palmarum*

Thirty one individuals were recorded from plantation, natural forest and vayal during November, December, January, February, March and April 2001. This species is with light colour having three white dorsal stripes on the back and greyish white under part and tail is interspersed with black and white hairs. This was the commonest of the squirrels found in the forest (Plate 13d).

25. Dusky striped squirrel: *Funambulus sublineatus*

Six individuals were sighted from the teak plantation and natural forest during December, January, March and April 2001 from Thellickal area and

Plate 13. Squirrels



13a. Large brown flying squirrel



13b. Small travancore flying squirrel



13c. Malabar giant squirrel



13d. Three-striped palm squirrel

Peruvarippallam region. This squirrel is with greenish grey colour with four dark brown longitudinal stripes. It was very difficult to locate this animal because of the dusky colour.

26. Indian porcupine: *Hystrix indica*

Twelve individuals were sighted from different habitats like plantation, natural forest vayal and along the road side during December, January, March and April 2001 during the night survey. The body is covered with quills. Each quill is ornamented with deep brown or black and white rings. They possess a short tail less than one-fifth of the head and body length (Plate 14).

27. Black naped hare: *Lepus nigricollis*

Sixteen individuals were observed during night inside the forest area near the road side during January, February, March and April 2001. They are dark brown in colour with black patch on the back of their neck from the ears to the shoulder. The other part of the body is having sandy-buff colouration and the upper surface of the small tail is black.

4.2 Indirect Methods

This method included indirect evidences generated on the animals as explained under materials and methods. The data generated on indirect evidences are grouped on the basis of the scat analysis and footprints.

4.2.1 Scat Analysis

A total of about 270 scats belonging to animal groups were collected and categorized. The scats belonged to civets, mongooses, cats and otters. Of the total scats, those of civets accounted 41.48 per cent followed by mongoose (27.04%), cats

Plate 14. Indian porcupine



Table 1. Number of animals sighted during the survey.

Sl.No.	Common name	Scientific name	No.of individuals	Location
1	Slender loris	<i>Loris tardigradus</i>	1	Natural forest
2	Common palm civet/toddy cat	<i>Paradoxurus hermaphroditus</i>	6	Natural forest, teak plantation
3	Brown palm civet	<i>Paradoxurus jerdoni</i>	3	Natural forest, teak plantation
4	Small Indian civet	<i>Viverricula indica</i>	2	Natural forest
5	Ruddy mongoose	<i>Herpestes smithii</i>	1	Natural forest
6	Brown mongoose	<i>Herpestes fuscus</i>	1	Natural forest
7	Stripe-necked mongoose	<i>Herpestes vitticollis</i>	1	Teak plantation
8	Eurasian otter/common otter	<i>Lutra lutra</i>	2	Thunakkadavu reservoir
9	Nilgiri Marten	<i>Martes gwatkinsi</i>	1	Natural forest
10	Jungle cat	<i>Felis chaus</i>	3	Natural forest
11	Leopard cat	<i>Prionailurus bengalensis</i>	1	Natural forest
12	Grey musk shrew	<i>Suncus murinus</i>	17	Natural forest, teak plantation
13	Indian fulvous fruit bat	<i>Rousettus leschenaulti</i>	7	Natural forest
14	Mouse deer	<i>Moschiola memina</i>	5	Natural forest

15	Indian pangolin	<i>Manis crassicaudata</i>	2	Natural forest
16	House rat	<i>Rattus rattus</i>	79	Natural forest, teak plantation and vayal
17	Bandicoot rat	<i>Bandicota indica</i>	42	Natural forest, teak plantation and vayal
18	White tailed wood rat	<i>Rattus blanfordi</i>	16	Natural forest and teak plantation
19	Spiny field mouse	<i>Mus platythrix</i>	37	Natural forest, teak plantation and vayal
20	Indian bush rat	<i>Gohunda ellioti</i>	9	Natural forest
21	Large brown flying squirrel	<i>Petaurista philippensis</i>	3	Natural forest
22	Small Travancore flying squirrel	<i>Petinomys fuscocapillus</i>	2	Natural forest
23	Malabar giant squirrel	<i>Ratufa indica</i>	26	Teak plantation and natural forest
24	Three-striped palm squirrel	<i>Funambulus palmarum</i>	31	Teak plantation, natural forest and vayal
25	Dusky-striped squirrel	<i>Funambulus sublineatus</i>	5	Teak plantation and natural forest
26	Indian porcupine	<i>Hystrix indica</i>	12	Teak plantation, natural forest and vayal
27	Black naped hare	<i>Lepus nigricollis</i>	16	Natural forest
	Total		331	

(24.07%) and otters (7.41%). The scats were collected from all the habitats such as teak plantation, natural forest and vayal. The scats of small mammal like civet, mongoose, cats and otter were more in natural forest than plantation and vayal. The abundance of scat of various small mammals in different habitats is given in Table 2. The data shows that the natural forest had the maximum scat abundance (Fig.2). The relative scat abundance of each mammal species is given in Fig. 3. The scat of otter was collected only from the stream near river bed area of plantation and natural forest.

The analysis of the scat showed that the diet of civet included rats, mice and fruits. Majority of the scat contained fruits and seeds of different plant species. This was confirmed by collecting the body parts, especially the hairs from the scat. The mongoose scat contained small pieces of bone and fish skeleton. The scats of cats were full of small hairs and small bones which indicated that they mainly feed on small mammals. The scat of otter was observed near the river bed area and near their den and consisted of fish bones, shell of mussels etc.

4.2.2 Foot Prints

The foot prints of small mammals observed in different parts of the sanctuary was taken and identified later using diagrams provided in the literature. The results showed that the footprints represented animal groups such as mouse deer, otters, civets and mongooses in the sanctuary. The footprints of mongooses and civets were very difficult to identify. Most of footprints of otters were obtained from the river bed area of the Thunkkadavu reservoirs.

By pooling the data obtained from direct sighting and indirect sighting, a list of small mammals observed at Parambikulam WLS is provided as Appendix II.

Table 2. Scat abundance of selected small mammals in different habitats

Sl No	Animal group	Set of Scats (Total)	% of Scats	Habitat					
				Plantation		Natural forest		Vayal	
				Set of scats	% of scats	Set of scats	% of scats	Set of scats	% of scats
1	Civets	112	41.48	23	20.54	61	54.46	28	25.00
2	Mongoose	73	27.04	12	16.44	48	65.75	13	17.81
3	Cats	65	24.07	11	16.92	38	58.46	16	24.62
4	Otters	20	7.41	8	40.00	12	60.00	-	-

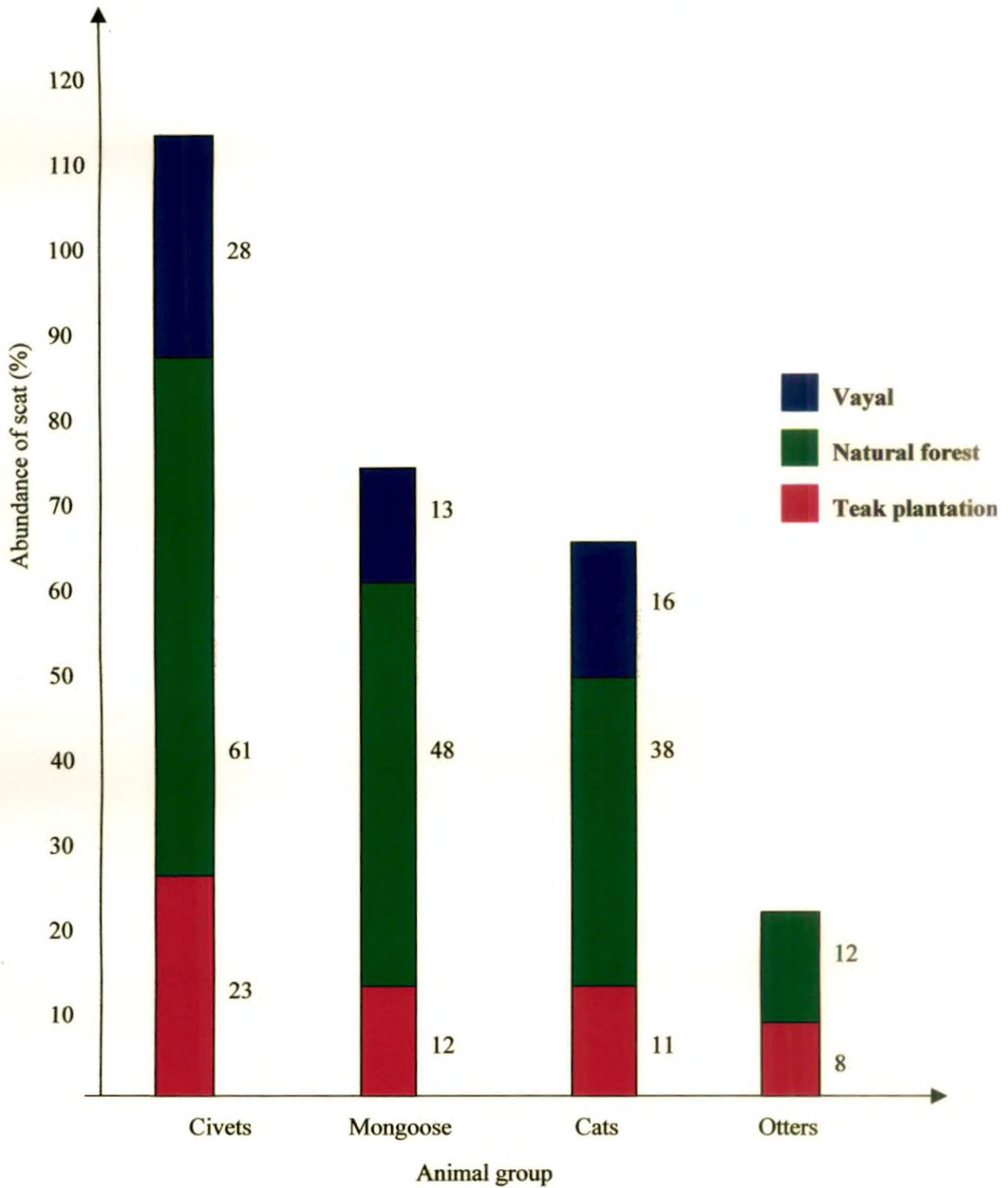
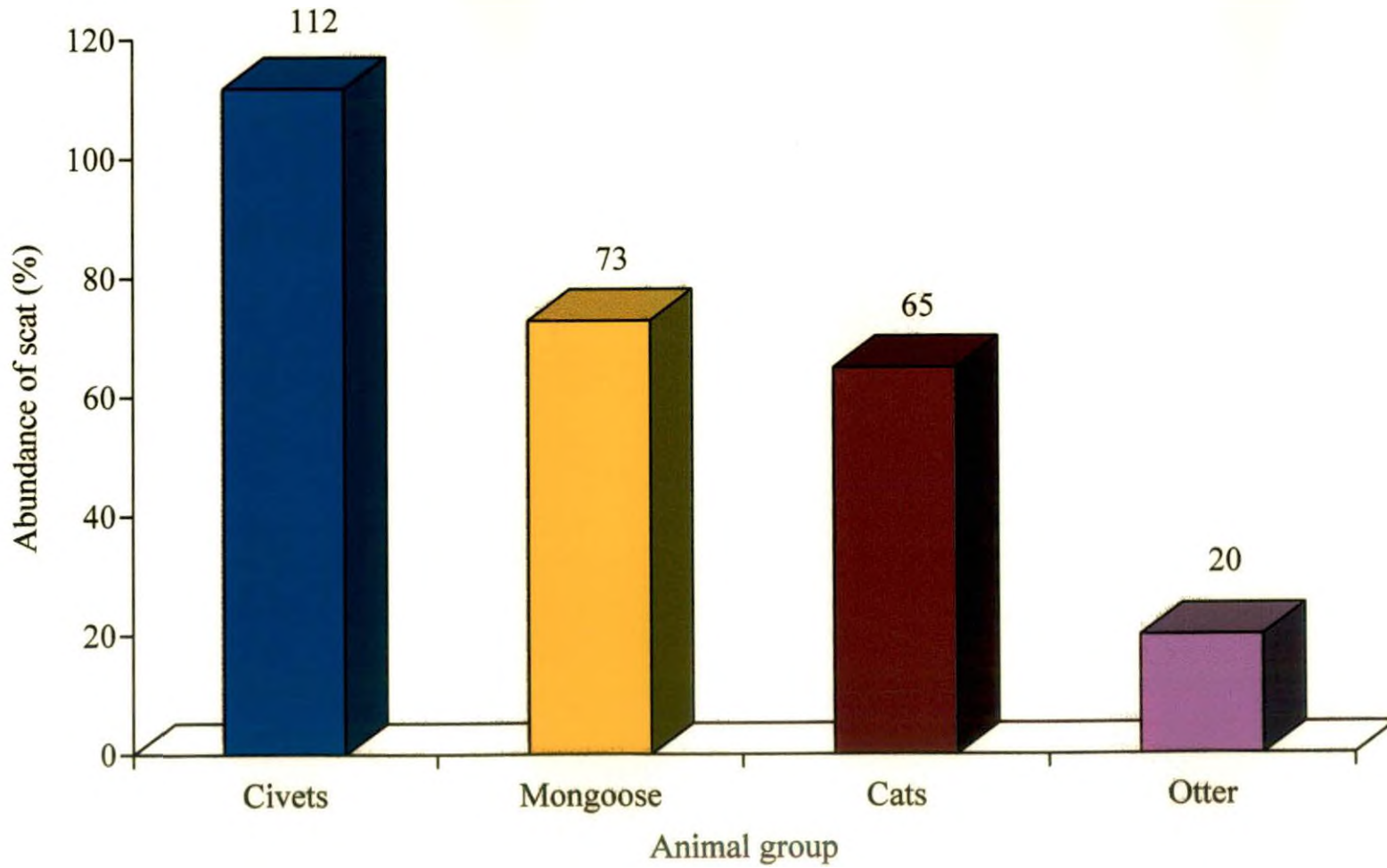
Fig. 2. Scat abundance in different habitats

Fig. 3. Relative scat abundance of animal species



4.3 Abundance and diversity of rodents

To estimate the abundance and diversity of rodents in different habitats such as plantation, natural forest and vayal, traps were maintained in each site and the trap data showed the occurrence of five rodent species from a total of 193 individuals. The trapping schedule is given in Table 3. The animals trapped were released after making observations on salient characters to get the identity, sex of animal etc. The systematic position and composition of rodent species caught in the trap is provided in Tables 4 and 5.

In the teak plantation, four species viz., *Rattus rattus*, *Bandicota indica*, *Mus platythrrix* *Rattus blanfordi* were caught in the traps. Of the 4 species, *Rattus rattus* was the most abundant species representing 33.71 per cent of the total species captured. *Bandicota indica* represented 30.95 per cent followed by *Mus platythrrix* (27.03 %) followed by *Rattus blanfordi* (31.25 %).

In the natural forest, five species were trapped viz., *Rattus rattus*, *B. indica*, *M. platythrrix*, *R. blanfordi* and *Golunda ellioti*. The percentage of rats caught in the traps was as follows. *Rattus rattus* 53.93 per cent; *B. indica* 54.76 per cent; *M. Platythrrix* 62.16 per cent; *R. blanfordi* 68.75 per cent; *G. ellioti* 100 per cent. Here also, *Rattus rattus* was the most abundant species. The Indian bush rat (*G. ellioti*) was trapped only from moist deciduous forest.

In the vayal, the rats caught were not as abundant as seen in the case of plantation or natural forest. Only three species were trapped viz., *R. rattus*, *B. indica* and *M. platythrrix* and the proportion of catches was as follows. *R. rattus* 12.36 per cent, *B. indica* 14.29 per cent, *M. platythrrix* 10.81 per cent. However, the most

Table 3. Trapping schedule

Habitat	Traps installed per month	Total trap nights
Teak plantation	20 X 10 = 200	200 X 6 months = 1200
Natural forest	20 X 10 = 200	200 X 6 months = 1200
Vayal	20 X 10 = 200	200 X 6 months = 1200
		Total = 3600

Table 4. Systematic position of rodent species caught in the trap

Sl. No	Family	Common Name	Scientific Name
1	Muridae	House rat	<i>Rattus rattus</i>
2	"	Bandicot rat	<i>Bandicota indica</i>
3	"	White tailed wood rat	<i>Rattus blanfordi</i>
4	"	Indian bush rat	<i>Golunda ellioti</i>
5	"	Spiny field Mouse	<i>Mus playthrix</i>

Table 5. Species composition of rodents in different habitats

Species	No. of individuals	Overall Species Composition in %	Teak Plantation		Natural Forest		Vayal	
			No. of individuals	%	No. of individuals	%	No. of individuals	%
<i>Rattus rattus</i>	89	46.11	30	33.71	48	53.93	11	12.36
<i>Bandicot indica</i>	42	21.76	13	30.95	23	54.76	6	14.29
<i>Mus playthrix</i>	37	19.17	10	27.03	23	62.16	4	10.81
<i>Rattus blanfordi</i>	16	8.29	5	31.25	11	68.75	-	-
<i>Gollunda ellioti</i>	9	4.66	-	-	9	100	-	-
Total	193	-	-	-	-	-	-	-

abundant species in the vayal was found to be *R. rattus*. Rodent species recorded in different months are given in Table 6.

4.4 Diversity indices

4.4.1 Simpson's diversity index

Using the proportion of individuals captured, Simpson's diversity index was calculated for each month and for each site (Table 7). The total Simpson's diversity index was more for natural forest (1.22) followed by plantation (1.04) and vayal (0.87). Figure 4 depicts the diversity based on Simpson's index.

Diversity index increased from November to March, but during April it showed a decrease for every site. The maximum diversity was obtained during the month of February in the teak plantation (0.40), whereas natural forest showed the maximum diversity during March (0.56) and vayal also during March (0.31).

4.4.2 Shanon-Weiner diversity index

The Shanon-Weiner diversity index was calculated for each month (Table 8). Monthly diversity index for each site was compared and the trend is shown in Figure 5. Diversity index increased from November to March, but during April it showed a decrease for every site. The maximum diversity was obtained during the month of February in teak plantation (0.62) whereas natural forest showed the maximum diversity during March (0.77) and vayal during February (0.46).

The Shanon-Weiner diversity index for all the six months was calculated. It was found that the natural forest shows a greater Shanon-Weiner diversity index (1.52) followed by teak plantation (0.63) and vayal (0.31).

Table 6. Rodent species recorded in different months

1) November

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	3	10	5	10.42	1	9.09
<i>Bandicota indica</i>	-	-	2	8.70	-	-
<i>Rattus blanfordi</i>	-	-	1	9.09	-	-

2) December

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	4	13.33	3	6.25	-	-
<i>Bandicota indica</i>	1	7.69	2	8.70	-	-
<i>Mus platythrix</i>	1	10.00	2	8.70	1	25.0

3) January

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	5	16.57	7	14.58	2	18.18
<i>Bandicota indica</i>	2	15.38	4	17.39	1	16.67
<i>Mus platythrix</i>	1	10.00	2	8.70	-	-
<i>Golunda elioti</i>	-	-	1	11.11	-	-

4) February

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	7	23.33	11	22.92	3	27.27
<i>Bandicota indica</i>	4	30.77	5	21.74	2	33.33
<i>Mus platythrix</i>	3	30.77	5	21.74	1	25.00
<i>Rattus blanfordi</i>	2	40.00	3	27.27	-	-
<i>Golunda ellioti</i>	-	-	2	22.22	-	-

5) March

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	7	23.33	12	25.00	2	18.18
<i>Bandicota indica</i>	4	30.77	5	21.74	1	16.67
<i>Mus platythrix</i>	2	20.22	8	34.78	2	50.00
<i>Rattus blanfordi</i>	1	20.00	4	36.36	-	-
<i>Golunda ellioti</i>	-	-	4	44.44	-	-

6) April

Species captured	Teak plantation		Natural forest		Vayal	
	No.	%	No	%	No.	%
<i>Rattus rattus</i>	5	16.67	9	18.75	3	27.27
<i>Bandicota indica</i>	2	15.38	5	21.74	2	33.33
<i>Mus platythrix</i>	3	30.00	6	26.09	-	-
<i>Rattus blanfordi</i>	2	40.00	3	27.27	-	-
<i>Golunda ellioti</i>	-	-	2	22.22	-	-

Table 7. Simpson's diversity index for each month

Month	Teak plantation	Natural Forest	Vayal
November	0.01	0.03	0.008
December	0.03	0.02	0.060
January	0.06	0.07	0.060
February	0.40	0.27	0.250
March	0.23	0.56	0.310
April	0.30	0.27	0.190
Total	1.04	1.22	0.878

Table 8. Shanon-Wiener diversity index for each month

Month	Teak plantation	Natural Forest	Vayal
November	0.10	0.299	0.10
December	0.30	0.260	0.15
January	0.35	0.450	0.26
February	0.62	0.730	0.46
March	0.58	0.770	0.41
April	0.57	0.730	0.23
Total	0.63	1.520	0.31

Fig. 4. Simpson's diversity index curve

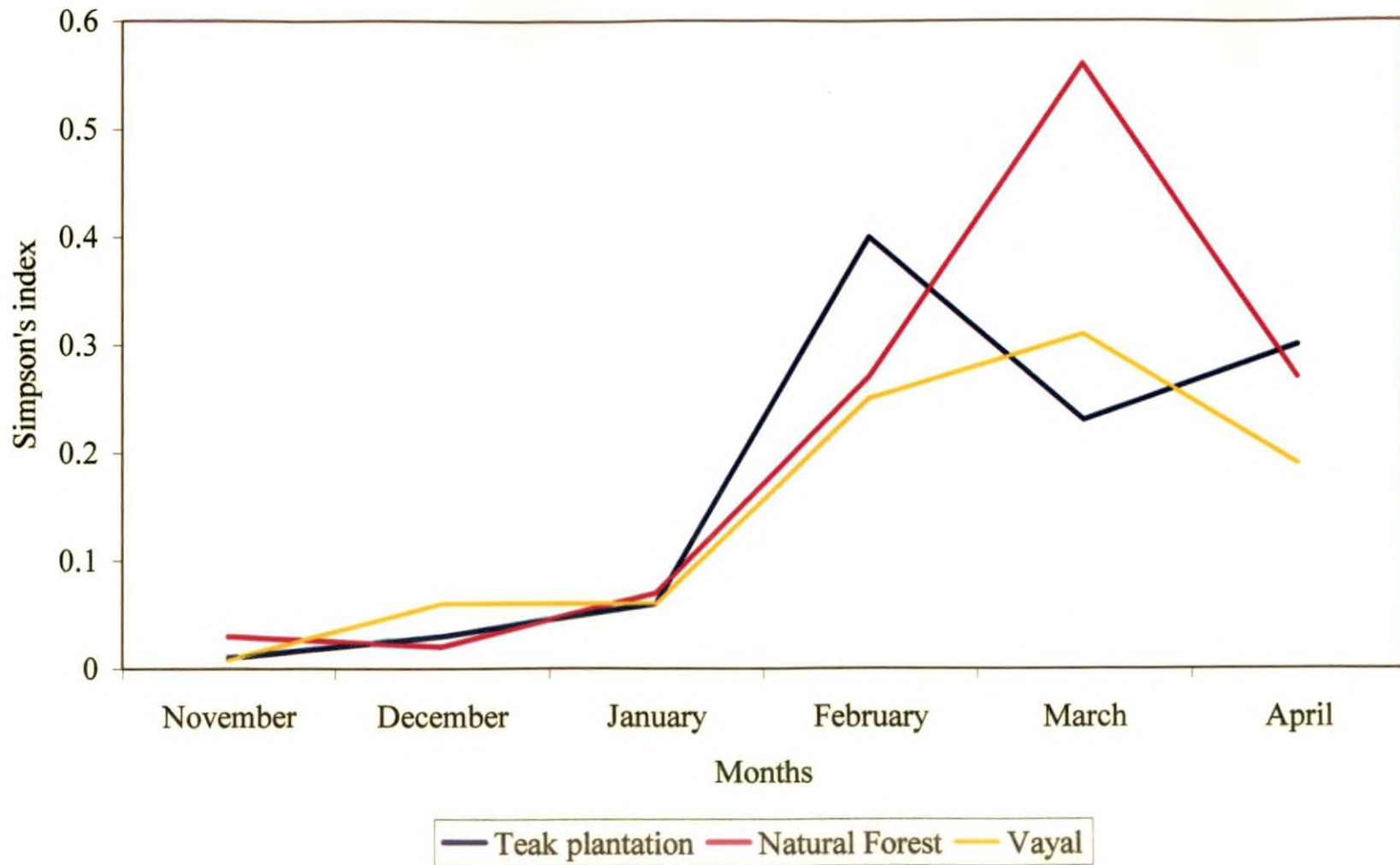
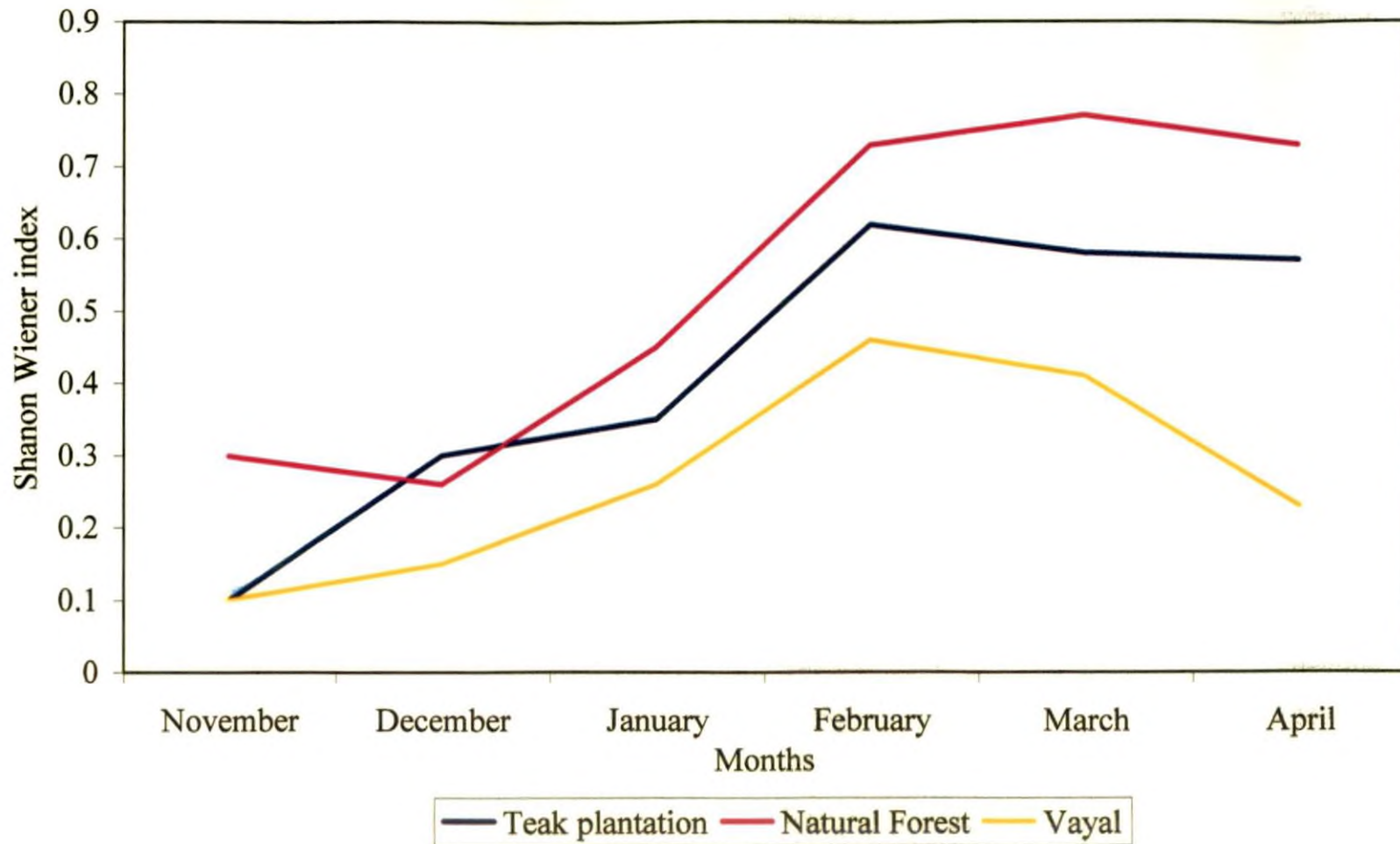


Fig. 5. Shanon –Wiener diversity index curve



4.5 Species richness

The species richness was also calculated for each month and compared. The values for species richness for each month and each habitat are given in Tables 9 and 10. Monthly species richness for each site was compared and is depicted in Figure 6.

In the teak plantation there was an increase initially, but then decreased during March and again increased till April, whereas in the natural forest there was a decrease initially and then gradually increased till April. In the case of vayal the species richness showed an increase from November to March and a decrease during April. Maximum species richness was observed both in natural forest (1.51) and teak plantation (1.2) during the month of April. Vayal showed maximum species richness during the month of February and March. The species richness was more in vayal (0.66) compared to teak plantation (0.53) and natural forest (0.47).

4.6 Relative dominance

The relative dominance was more in the natural forest for *Rattus rattus* (24.87) followed by *B. indica* and *M. platythrix* (11.92); *R. blanfordi* (5.7) and *Golunda ellioti* (4.6).

In the teak plantation *R. rattus* showed the maximum relative dominance (15.54) followed by *B. indica* (6.74) *M. platythrix* (5.18) and *R. blanfordi* (2.59).

In vayal also *R. rattus* showed the maximum relative dominance (5.7) followed by *B. indica* and *M. platythrix* (3.11) and (2.07). While comparing the relative dominance for each species in different sites, natural forest showed the maximum, followed by teak plantation and then vayal (Table 11).

Table 9. Species richness index for each month

Month	Teak plantation	Natural Forest	Vayal
November	0.45	1.34	0.45
December	1.13	1.13	0.38
January	1.00	1.33	0.67
February	1.16	1.45	0.87
March	1.16	1.45	0.87
April	1.20	1.51	0.60
Total	0.53	0.47	0.66

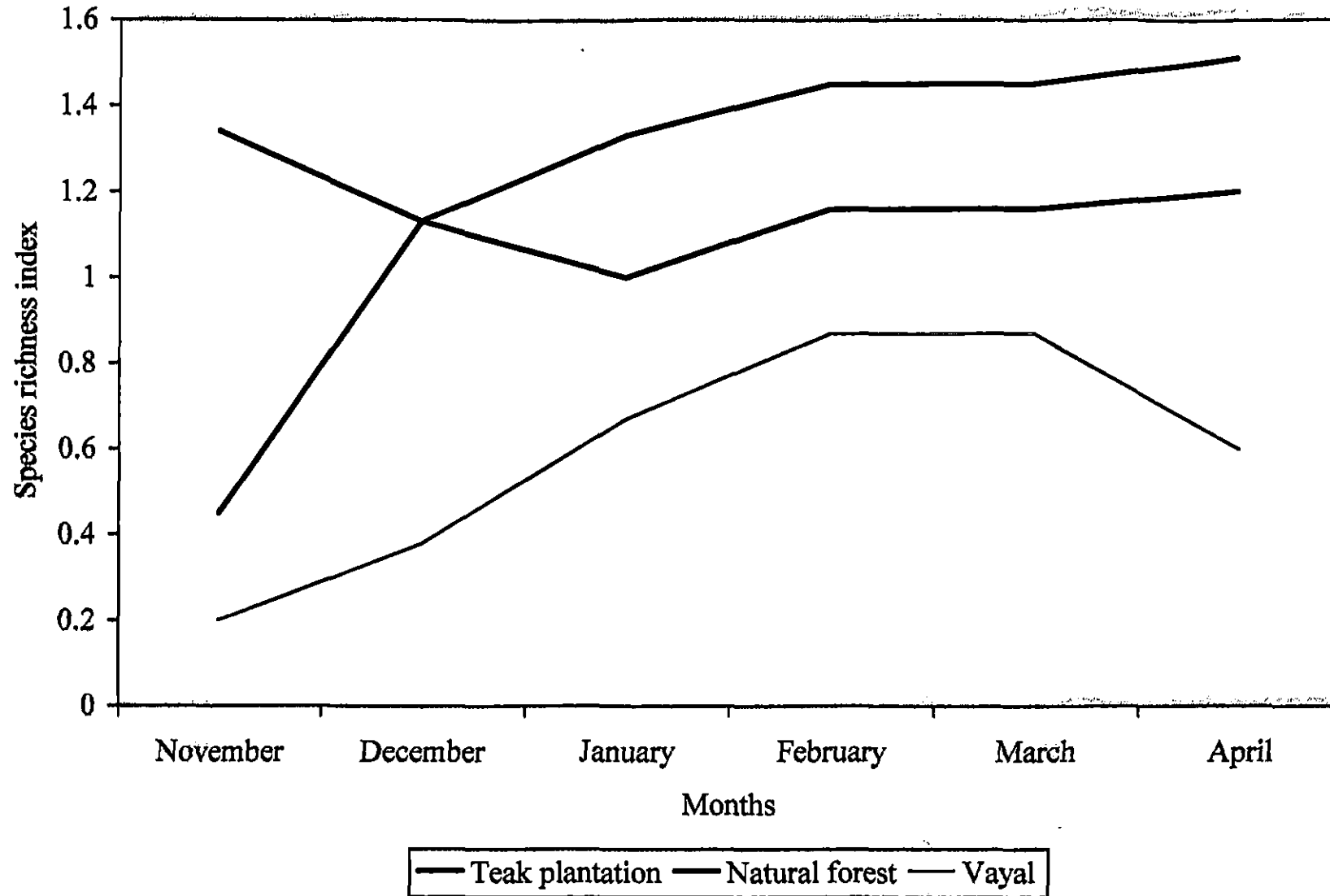
Table 10. Species richness for each habitat

Vegetation	No. of Species	No. of individuals	Species Richness
Teak Plantation	4	58	0.525
Natural forest	5	114	0.468
Vayal	3	21	0.655

Table 11. Relative dominance for each species in different habitats

Sl. No	Species	No. of Individuals			Relative dominance		
		Teak Plantation	Natural Forest	Vayal	Teak Plantation	Natural Forest	Vayal
1	<i>R. rattus</i>	30	48	11	15.54	24.87	5.70
2	<i>B. indica</i>	13	23	6	6.74	11.92	3.11
3	<i>M. platythrix</i>	10	23	4	5.18	11.92	2.07
4	<i>G. ellioti</i>	-	9	-	-	4.66	-
5	<i>R. blanfordi</i>	5	11	-	2.59	5.7	-

Fig. 6. Species richness index curve



In the case of trap catches, *G. ellioti* was trapped only from the moist deciduous forest along with other 4 species, whereas in the vayal *M. platythrix* and *Golunda ellioti* were not trapped at all. In teak plantation except *Golunda ellioti*, the other 4 species were trapped. Between the two baits used, i.e., dried fish and grated coconut, the animals preferred the latter.

4.7 Floral diversity and rodent species richness

The study conducted in the Parambikulam Wildlife Sanctuary showed that natural forest formed the major vegetation type with relatively higher diversity of plant species than in the other two habitats. It was characterized by higher diversity of deciduous species and the details of flora are provided as in Appendix III.

Plantation was dominated by *Tectona grandis* with a few other species as undergrowth like *Helicteris isora*, *Glycosmis pentaphylla*, *Eupatorium odoratum*, *Lantana camera*, *Centella asiatica* etc.

The data generated indicate that natural forest has the maximum species diversity in terms of both floral and rodents compared to plantation and vayal. The natural forest possessed fifty five species of plants and twelve species of rodents, whereas in plantation, teak was the major tree species with few other vegetation. Only eight species of rodents could be observed in this habitat. Vayal was with less number of plant species and five species of rodents were recorded from this area.

The possible interaction between rodent population with reference to the plant community in different habitats has been given in Tables 12, 13 and 14.

Table 12. Floral diversity and rodent species richness in natural forest

Sl. No.	Plant species	Sl. No.	Plant species	Sl. No.	Plant species	Sl. No.	Rodent species
1	<i>Holigarna arnottiana</i>	30	<i>Pterocarpus marsupium</i>	59	<i>Chrysopogan aciculatus</i>	1	<i>Rattus rattus</i>
2	<i>Lannea coromandelica</i>	31	<i>Lagerstroemia microcarpa</i>	60	<i>Dactyloctenium aegyptium</i>	2	<i>Bandicota indica</i>
3	<i>Semecarpus anacardium</i>	32	<i>Dysoxylum macrocarpum</i>	61	<i>Paspalidum</i> sp.	3	<i>Rattus blanfordi</i>
4	<i>Spondias indica</i>	33	<i>D. malabaricum</i>	62	<i>Cenchrus ciliaris</i>	4	<i>Mus platythrix</i>
5	<i>Milium velutina</i>	34	<i>Melia dubia</i> Cav.	63	<i>Digitalis purpurea</i>	5	<i>Golunda ellioti</i>
6	<i>Alstonia scholaris</i>	35	<i>Albizia lebeck</i>	64	<i>Echinochloa crusgalli</i>	6	<i>Petaurista philippensis</i>
7	<i>Alstonia venenata</i>	36	<i>A. odoratissima</i>	65	<i>Cyprus</i> sp.	7	<i>Petionomys fuscocapillus</i>
8	<i>Holarrhena antidysenterica</i> .	37	<i>Xylia xylocarpa</i>			8	<i>Ratufa indica</i>
9	<i>Tabernaemontana heyneana</i>	38	<i>Artocarpus hirsutus</i>			9	<i>Funambulus palmarum</i>
10	<i>Wrightia tinctoria</i>	39	<i>Ficus arnottiana</i>			10	<i>Funambulus sublineatus</i>
11	<i>Oroxylum indicum</i>	40	<i>F. dalhousiae</i>			11	<i>Hystrix indica</i>
12	<i>Stereospermum xylocarpum</i>	41	<i>F. asperrima</i> .			12	<i>Lepus nigricollis</i>
13	<i>S. chelonoides</i>	42	<i>F. microcarpa</i>				
14	<i>Bombax ceiba</i>	43	<i>F. racemosa</i>				
15	<i>Cordia dichotoma</i>	44	<i>F. tinctoria</i>				
16	<i>Garuga pinnata</i>	45	<i>Ziziphus glabrata</i>				
17	<i>Acrocarpus fraxinifolius</i>	46	<i>Z. mauritiana</i>				
18	<i>Bauhinia racemosa</i>	47	<i>Sapindus laurifolia</i>				
19	<i>Cassia fistula</i>	48	<i>Sterculia urens</i>				
20	<i>Anogeissus latifolia</i>	49	<i>S. villosa</i>				
21	<i>Terminalia arjuna</i>	50	<i>Grewia tiliifolia</i>				
22	<i>T. bellirica</i>	51	<i>Trema orientalis</i>				
23	<i>T. chebula</i>	52	<i>Clerodendrum viscosum</i>				
24	<i>T. tomentosa</i>	53	<i>Gmelina arborea</i>				
25	<i>T. paniculata</i> .	54	<i>Tectona grandis</i>				
26	<i>Dillenia pentagyana</i>	55	<i>Randia brandisii</i> Gamble				
27	<i>Butea monosperma</i> .	56	<i>Cynadon dactylon</i>				
28	<i>Dalbergia latifolia</i>	57	<i>Digitaria longiflora</i>				
29	<i>Dalbergia lanceolaria</i>	58	<i>Cenchrus setigerus</i>				

Table 13. Floral diversity and rodent species richness in plantation

Sl.No.	Plant species	Sl.No.	Rodent species
1	<i>Tectona grandis</i> (major)	1	<i>Rattus rattus</i>
2	<i>Cassia fistula</i>	2	<i>Bandicota indica</i>
3	<i>Cordia dichotoma</i>	3	<i>Mus platythrix</i>
4	<i>Butea monosperma</i>	4	<i>Rattus blanfordi</i>
5	<i>Grewia tilifolia</i>	5	<i>Ratufa indica</i>
6	<i>Randia</i> spp.	6	<i>Funambulus palmarum</i>
7	<i>Lantana camera</i>	7	<i>Funambulus sublineatus</i>
8	<i>Mimosa invisa</i>	8	<i>Hystrix indica</i>
9	<i>Glycosmis pentaphylla</i>		
10	<i>Helicteris isora</i>		
11	<i>Syndrella nodiflora</i>		
12	<i>Smithia geminiflora</i>		
13	<i>Centella asiatica</i>		
14	<i>Globba marantiana</i>		

Table 14. Floral diversity and rodent species richness in vayal

Sl.No.	Plant species	Sl.No.	Rodent species
1	<i>Terminalia arjuna</i>	1	<i>Rattus rattus</i>
2	<i>Terminalia tomentosa</i>	2	<i>Bandicota indica</i>
3	<i>T. paniculata</i>	3	<i>Mus platythrix</i>
4	<i>Dillenia pentagyna</i>	4	<i>Funambulus palmarum</i>
5	<i>Butea monosperma</i>	5	<i>Hystrix indica</i>
6	<i>Melia dubia</i>		
7	<i>Xylia xylocarpa</i>		
8	<i>Carria fistula</i>		
9	<i>Randia brandissi</i>		
10	<i>Ziziphus glabrata</i>		
11	Grasses		
12	<i>Cynadon dactylon</i>		
13	<i>Digitaria longiflora</i>		
14	<i>Cenchrus setigerus</i>		
15	<i>Chrysopogan aciculatus</i>		
16	<i>Dactyloctenium aegyptium</i>		
17	<i>Paspalidum</i> sp.		
18	<i>Cenchrus ciliaris</i>		
19	<i>Digitalis purpurea</i>		
20	<i>Echinocloa crusgalli</i>		
21	<i>Cyprus</i> sps.		

Discussion

DISCUSSION

In general, information on small mammals is less on account of their smaller size and nocturnal habits. Some of the recent studies made on small mammals include Chandrasekhar (1999), Sankar and Sukumar (1999) and Easa (2001). However, the available literature is not sufficient enough to prepare an inventory of small mammals. Moreover, there is a need to prepare inventories on specific protected areas on account of the importance given to biodiversity conservation. The opinion expressed by Robinson (1978) that the number of biologists is negatively correlated with the number of biological species in different parts of the globe is also relevant in this context.

In the present study, a total of twenty seven species of small mammals belonging to eight orders were recorded from the Parambikulam Wildlife Sanctuary. Among the eight orders, Rodentia was represented maximum with eleven species followed by Carnivora with ten species. Remaining orders were represented by only a single species.

Slender loris was the only primate species encountered under small mammal group. A survey conducted at Shendurney Wildlife Sanctuary also revealed the occurrence of this species (Ramachandran, 1996).

Under Carnivora, three species of civets, three species of mongoose, two species of cats, and one species each of otter and marten were recorded during the study period. Of the three species of civets, the common palm civet was frequently sighted followed by brown palm civet and small Indian civet. Mudappa (1998) reported the occurrence of the same from different parts of Western Ghats. They

preferred well wooded forest and mostly sighted in teak plantation during the present study and took shelter in the hollows of trees. The food consumed by them was fruits and berries. Earlier studies on the feeding habits of the species indicate the omnivorous nature of feeding (Pocock, 1939; Medway 1978 and Singh, 1982).

Mongoose such as ruddy mongoose, brown mongoose and stripe-necked mongoose were represented only by a single individual each. The occurrence of these species was also recorded from Western Ghats (Mudappa, 1998).

Eurasian otter was the only otter species recorded from the sanctuary which were diurnal in their habit. The preference of the species to remain in rocky stretches to make den and rest is reported (Hussain and Chaudhary, 1995).

Only one individual of Nilgiri marten was recorded during the survey. Earlier reports on the occurrence of this species were from Eravikulam National Park (Madhusudan, 1995) from Peppara Wildlife Sanctuary (Christopher and Jayson, 1996) and from Kalakkad-Mundanthurai (Mudappa, 1998). This is an endemic species to Western Ghats and very little is known about the behaviour and ecology of the animal.

The two flying squirrel species reported from the sanctuary were the large brown flying squirrel and small Travancore flying squirrel. Both these species were sighted from the sanctuary only during the flowering of bombax tree. They were seen feeding on the immature flowers and fruits of bombax which is considered to be the most preferred food of the species. The arboreal mammals in the Anamalai Hills were studied (Umapathy and Ajitkumar, 2000), and they reported that the density of Giant squirrel, large brown flying squirrel, small Travancore flying squirrel increased with decreasing area due to habitat destruction. The other squirrels sighted from the



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sanctuary were Malabar giant squirrel, three striped palm squirrel and dusky striped squirrel. Twenty six individuals of Malabar giant squirrel were recorded from different habitats of the sanctuary. A detailed study on the ecology and behaviour of Malabar giant squirrel was made by Ramachandran (1988). Thirty one individuals of three striped palm squirrel and six individuals of dusky striped squirrel were also recorded from various habitats of the sanctuary.

5.1 Scat analysis

Relaying on indirect evidences like scat of animals to get the correct identity of animals is a well known method. However, the reliability of this method may not hold good always. Even during the present study, there were cases, where in there was some difficulty in distinguishing between the scats of cats and mongoose. The civet scat was mostly found in natural forest with good canopy cover, and this could be due to the fact that civets to a large extent are frugivorous and also are arboreal. Ashraf *et al.* (1993) reported that the common palm civet is most likely to be confined to the dry forests whereas the brown palm civet is likely to be confined to the evergreen and moist deciduous forest.

The occurrence of scats of mongoose was abundant in natural forests compared to teak plantation and vayal. The abundance of scat obtained from the natural forest nearer to water bodies indicates their preference to habitats close to water bodies. The scat of jungle cat was also abundant in natural forest compared to plantation and vayal. Mukherjee (1998) while studying the behaviour of jungle cat found that it can tolerate the disturbances including presence of humans. Rodents form their major diet.

The scat of otter was found only in the river bed areas close to plantation and natural forests. Careful examination of the scat showed that fishes form the major food of otter. In addition to fish, a whole range of other prey items have been recorded in the diet at varying proportions.

5.2 Abundance of rodents

While comparing the rodents trapped from different habitats, natural forests account for more number of species than plantation and vayal. The most common species in the three habitats was *Rattus rattus*. The Indian bush rat was found only from the natural forests, especially from the moist deciduous forest. It is assumed that this species prefer moist deciduous forests than any other habitats because of the favourable ecological conditions prevailing for its survival. Sankar and Sukumar (1999) found that *Rattus rattus* was the most abundant species in montane forest patches. Chandrasekhar and Sunquist (1999) also reported the occurrence of the species from Anamalai hills.

5.3 Diversity indices

The Simpson's diversity index and Shanon-Weiner diversity index showed that the maximum diversity was in natural forest than in plantation and vayal. The diversity indices were low in wet season and increased during dry season. The exact reason for the increase in diversity index during dry season is not known. It is likely that the animal remains in its burrows during wet season and does not go out to collect feed and depends on food materials collected and stored during the dry season. The species richness was more in vayal followed by plantation and natural forest. The relative dominance was also high in natural forests followed by plantation and vayal.

Only three species were found in the vayal and the species richness was also high in vayal.

The correlation between the floral diversity and rodent species richness indicates that the natural forest with more number of plant species also possessed high rodent species richness. The natural habitat, with ideal conditions would have helped the survival of the twelve rodent species. The lack of ideal conditions as seen in the natural forests would have been the reason for lesser number of rodent species both in plantation and vayal. In the case of vayal, the marshyness of the area also would have contributed to the less number of species.

The data generated from the present study indicate that the species dominance, species density and species diversity are more in the natural forest than in the man-made forest or degraded forest or vayal. Since all the indices are more in the natural forest it is evident that the suitable place for the small mammal species is natural forest than the converted or degraded forest. It is very well appreciated that the tropics are rich in floral and faunal diversity with an incomparable multiplicity of ecosystems and species (Shiva, 1994). Just as in the case of many other studies related to biodiversity of animal groups, this present study also reveals that the natural forests possess the maximum in terms of diversity and richness of small mammals. It is evident that diversity and density of small mammals will also depend on the vegetation and thus protecting the natural ecosystems becomes more important. The ecological requirements of small mammals in terms of food and shelter would require further detailed studies.

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Summary

SUMMARY

Information on the diversity and abundance of small mammals of forests of Kerala in general and Parambikulam Wildlife Sanctuary in particular remains unexplored. This is partly because of the lack of interest to study this group because of inherent problems such as smaller size, moving nature and nocturnality. Though the rodents constitute the largest order of existing mammals, information on this group from the forest is scant. The ecological services rendered by the small mammals in maintaining the sustainability of forest ecosystem is seldom recognized and such values are difficult to be measured in terms of monetary values.

The present study was undertaken in the College of Forestry, Vellanikkara to prepare an inventory and to estimate the abundance of small mammal fauna in diverse ecological habitats of the Parambikulam Wildlife Sanctuary.

The salient findings of the studies are summarized as follows:

1. Twenty seven species of small mammals belonging to eight orders such as Primates, Carnivora, Rodentia, Insectivora, Chiroptera, Artiodactyla, Pholidota and Lagomorpha were recorded from Parambikulam Wildlife Sanctuary. Among the eight orders Rodentia was represented maximum with eleven species followed by Carnivora with ten species. Remaining orders were represented by only a single species.
2. Slender loris was the only primate species encountered under small mammal group. It was observed as solitary and seen at the fringes of an evergreen patch.

3. Ten species of carnivores were observed under four various families viz., Viverridae, Herpestidae, Mustelidae and Felidae. Among these three species of civets, three species of mongoose, two species of cats and one species each of otter and marten were included.
4. Grey musk shrew was the only insectivore species observed under small mammal group. It was trapped both from natural forest and teak plantation.
5. Fulvous fruit bat was the only chiropteran species recorded during the study period from the sanctuary.
6. One species of artiodactyla was observed under one family Tragulidae and that was mouse deer.
7. One species of Indian pangolin was represented under Order Pholidota.
8. Eleven species of rodents were observed under two families viz., Muridae and Scuridae of the eleven species, two species of flying squirrels, four species of rats, one species of mouse, three species of squirrels and one species of porcupine were present.
9. Natural forest account more number of species than plantation and vayal. Among the three habitats studied *Rattus rattus* was recorded as the most common species. The Indian bush rat was found only in the natural forest especially from the moist deciduous area, it is assumed that this species prefers moist deciduous forest than any other habitat because of the favourable ecological conditions prevailing there for its survival.
10. Maximum diversity of rodents was more in the natural forest than in plantation and vayal. The diversity indices were low in wet season and increased in the dry

season. It is likely that the rodents remain in the burrows during wet season and do not go out.

11. Species richness was more in vayal followed by plantation and natural forest and the relative dominance was high in natural forest followed by plantation and vayal.
12. With regard to floral diversity and rodent species natural forest possessed high rodent species richness since the habitat favoured with more number of plant species. So the natural habitat with this ideal condition would have helped the survival of twelve rodent species.

In the present study, species dominance, species density and species diversity were more in the natural forest than in the plantation and vayal. Since all the indices are more in the natural forest, the suitable habitat for the small mammal species is natural forest than the converted or degraded forest.

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Appendix I. List of mammals in Parambikulam Wildlife Sanctuary

Sl.No	Common Name	Scientific Name	Status
1	Bonnet macaque	<i>Macaca radiata</i>	LRlc
2	Nilgiri langur	<i>Presbytis johni</i>	VU
3	Lion tailed macaque	<i>Macaca silenus</i>	EN
4	Common langur	<i>Presbytis entellus</i>	LRlc
5	Slender loris	<i>Loris tardigradus</i>	EN
6	Tiger	<i>Panthera tigris</i>	EN
7	Leopard	<i>Panthera pardus</i>	LRnt
8	Leopard cat	<i>Felis bengalensis</i>	LRnt
9	Jungle cat	<i>Felis chaus</i>	LRnt
10	Small Indian civet	<i>Viverricula indica</i>	LRnt
11	Toddy cat (Common palm civet)	<i>Paradoxurus hermaphroditus</i>	LRlc
12	Ruddy mongoose	<i>Herpestes smithi</i>	LRlc
13	The dhole (Wild dog)	<i>Cuon alpinus</i>	VU
14	The sloth bear	<i>Melursus ursinus</i>	VU
15	Common otter	<i>Lutra lutra</i>	DD
16	Nilgiri marten	<i>Martes gwatkinsi</i>	VU
17	Fruit bat	<i>Rousettus leschenaulti</i>	LRlc
18	Indian giant squirrel	<i>Ratufa indica</i>	VU
19	Three striped palm squirrel	<i>Funambulus palmarum</i>	LRlc
20	Large brown flying squirrel	<i>Petaurista philippensis</i>	LRnt
21	Black naped hare	<i>Lepus nigricollis</i>	LRnt
22	Bandicoot rat	<i>Bandicota indica</i>	LRnt
23	Grey musk shrew	<i>Suncus murinus</i>	LRlc
24	Indian porcupine	<i>Hystrix indica</i>	LRnt
25	Common house rat	<i>Rattus rattus</i>	LRlc
26	Indian elephant	<i>Elephas maximus</i>	VU
27	The gaur	<i>Bos gaurus</i>	VU
28	Nilgiri tahr	<i>Hemitragus hylocrius</i>	EN
29	Spotted deer	<i>Axis axis</i>	LRlc
30	Sambar	<i>Cervus unicolor</i>	LRlc
31	Barking deer	<i>Muntiacus muntjak</i>	LRlc
32	Mouse deer	<i>Tragulus meminna</i>	LRnt
33	Indian wild boar	<i>Sus scrofa</i>	LRlc
34	Indian pangolin	<i>Manis crassicaudata</i>	LRnt

EN - Endangered
concerned

VU - Vulnerable

LRnt - Low Risk near threatened

LRlc - Low Risk least

DD - Data deficient

Appendix II. List of small mammals in the Parambikulam Wildlife Sanctuary

Sl.No	Order	Family	Common Name	Scientific Name
1	Primates	Loridae	Slender loris	<i>Loris tardigradus</i>
2	Carnivora	Viverridae	Common palm civet/toddy cat	<i>Paradoxurus hermaphroditus</i>
3	Carnivora	Viverridae	Brown palm civet	<i>Paradoxurus jerdoni</i>
4	Carnivora	Viverridae	Small Indian civet	<i>Viverricula indica</i>
5	Carnivora	Herpestidae	Ruddy mongoose	<i>Herpestes smithi</i>
6	Carnivora	Herpestidae	Brown mongoose	<i>Herpestes fuscus</i>
7	Carnivora	Herpestidae	Stripe-necked mongoose	<i>Herpestes vitticollis</i>
8	Carnivora	Mustelidae	Eurasian otter/common otter	<i>Lutra lutra</i>
9	Carnivora	Mustelidae	Nilgiri marten	<i>Martes gwatkinsi</i>
10	Carnivora	Felidae	Jungle cat	<i>Felis chaos</i>
11	Carnivora	Felidae	Leopard cat	<i>Prionailurus bengalensis</i>
12	Insectivora	Soricidae	Grey musk shrew	<i>Suncus murinus</i>
13	Chiroptera	Pteropodidae	Fulvous fruit bat	<i>Rousettus leschenaulti</i>
14	Artiodactyla	Tragulidae	Mouse deer	<i>Moschiola meninna</i>
15	Pholidata	Manidae	Indian pangolin	<i>Manis crassicaudata</i>
16	Rodentia	Muridae	House rat	<i>Rattus rattus</i>
17	Rodentia	Muridae	Bandicoot rat	<i>Bandicota indica</i>
18	Rodentia	Muridae	White tailed wood rat	<i>Rattus blanfordi</i>
19	Rodentia	Muridae	Indian bush rat	<i>Golunda ellioti</i>
20	Rodentia	Muridae	Spiny field mouse	<i>Mus platythrix</i>
21	Rodentia	Scuiridae	Large brown flying squirrel	<i>Petaurista philippensis</i>
22	Rodentia	Scuiridae	Small Travancore flying squirrel	<i>Petinomys fuscocapillus</i>
23	Rodentia	Scuiridae	Malabar giant squirrel	<i>Ratufa indica</i>
24	Rodentia	Scuiridae	Three striped palm squirrel	<i>Funambulus palmarum</i>
25	Rodentia	Scuiridae	Dusky striped squirrel	<i>Funambulus sublineatus</i>
26	Rodentia	Hystricidae	Indian porcupine	<i>Hystrix indica</i>
27	Lagomorpha	Leporidae	Black naped hare	<i>Lepus nigricollis</i>

Appendix III. List of plant species surveyed from natural forest

Sl. No.	Species	Family	Remarks
1	<i>Holigarna arnottiana</i> Hk.f.	Anacardiaceae	Large tree
2	<i>Lannea coromandelica</i> (Houtt.) Merr.	Anacardiaceae	Medium tree
3	<i>Semecarpus anacardium</i> L.	Anacardiaceae	Medium tree
4	<i>Spondias indica</i> (Wt & Ann.) Airy shaw & Forman	Anacardiaceae	Very large
5	<i>Milium velutina</i> (Dunal.) Hk.f. & Thoms	Annonaceae	Small tree
6	<i>Alstonia scholaris</i> (L.) R.Br.	Apocynaceae	Large tree
7	<i>Alstonia venenata</i> R.Br	Apocynaceae	Small tree
8	<i>Holarrhena antidysenterica</i> Wall.	Apocynaceae	Small tree
9	<i>Tabernaemontana heyneana</i> Wall.	Apocynaceae	Small tree
10	<i>Wrightia tinctoria</i> (Roxb.) R.Br	Apocynaceae	Small tree
11	<i>Oroxylum indicum</i> (L.) Vent	Bignoniaceae	Small to medium tree
12	<i>Stereospermum xylocarpum</i> (Roxb.) Benth	Bignoniaceae	Large tree
13	<i>S. chelonoides</i> (L.f.) DC	Bignoniaceae	Large tree
14	<i>Bombax ceiba</i> L.	Bombacaceae	Large to very large tree
15	<i>Cordia dichotoma</i> Forst.f	Boraginacea	Medium tree
16	<i>Garuga pinnata</i> Roxb.	Burseraceae	Medium tree
17	<i>Acrocarpus fraxinifolius</i> Wt.& Arn.	Caesalpinioideae	Large tree
18	<i>Bauhinia racemosa</i> Lamk.	Caesalpinioideae	Small tree

Sl. No.	Species	Family	Habit
19	<i>Cassia fistula</i> L.	Caesalpinioideae	Medium tree
20	<i>Anogeissus latifolia</i> (Roxb. exDc.) Wall. ex Guill. & Perr	Combretaceae	Medium tree
21	<i>Terminalia arjuna</i> Roxb.	Combretaceae	Large tree
22	<i>T. bellirica</i> Roxb.	Combretaceae	Large tree
23	<i>T. chebula</i> Retz.	Combretaceae	Large tree
24	<i>T. tomentosa</i> (Roxb. exDC) wt. & Arn	Combretaceae	Large tree
25	<i>T. paniculata</i> Roth.	Combretaceae	Large tree
26	<i>Dillenia pentagyana</i> Roxb.	Dilleniaceae	Medium tree
27	<i>Butea monosperma</i> Taub.	Fabaceae	Small tree
28	<i>Dalbergia latifolia</i> Roxb.	Fabaceae	Large tree
29	<i>Dalbergia lanceolaria</i> L.f	Fabaceae	Medium tree
30	<i>Pterocarpus marsupium</i> Roxb.	Fabaceae	Large tree
31	<i>Lagerstroemia microcarpa</i> Wt.	Lythraceae	Large tree
32	<i>Dysoxylum macrocarpum</i> Bedd.	Meliaceae	Large tree
33	<i>D. malabaricum</i> Bedd. exhiern	Meliaceae	Large tree
34	<i>Melia dubia</i> Cav.	Meliaceae	Large tree
35	<i>Albizia lebbek</i> (L.) Willd.	Mimosoidae	Large tree
36	<i>A. odoratissima</i> (L.f) Benth	Mimosoidae	Large tree
37	<i>Xylia xylocarpa</i> Roxb.	Mimosoidae	Large tree
38	<i>Artocarpus hirsutus</i> Lamk.	Moraceae	Large tree
39	<i>Ficus arnottiana</i> (Miq.) Miq.	Moraceae	Small tree

Sl. No.	Species	Family	Remarks--
40	<i>F. dalhousiae</i> Miq.	Moraceae	Small tree
41	<i>F. asperrima</i> Roxb.	Moraceae	Small tree
42	<i>F. microcarpa</i> L.f	Moraceae	Small tree
43	<i>F. racemosa</i> L.	Moraceae	Medium tree
44	<i>F. tinctoria</i>	Moraceae	Small to Medium
45	<i>Ziziphus glabrata</i> Heyne ex Roth	Rhamnaceae	Small tree
46	<i>Z. mauritiana</i> Lamk	Rhamnaceae	Small tree
47	<i>Sapindus laurifolia</i> Vahl.	Sapindaceae	Small tree
48	<i>Sterculia urens</i> Roxb.	Sterculiaceae	Small tree
49	<i>S. villosa</i> Roxb.	Sterculiaceae	Small tree
50	<i>Grewia tiliifolia</i> Vahl.	Tiliaceae	Medium to Large tree
51	<i>Trema orientalis</i> (L.) Bl.	Ulmaceae	Small tree
52	<i>Clerodendrum viscosum</i> vent.	Verbenaceae	Medium tree
53	<i>Gmelina arborea</i> Roxb.	Verbenaceae	Medium tree
54	<i>Tectona grandis</i> L.f.	Verbenaceae	Very large tree
55	<i>Randia brandisii</i> Gamble	Rubiaceae	Small tree
56	<i>Cynadon dactylon</i>	Poaceae	Grass
57	<i>Cenchrus setigerus</i>	Poaceae	Grass
58	<i>Chrysopogan aciculatus</i>	Poaceae	Grass
59	<i>Dactyloctenium aegyptium</i>	Poaceae	Grass
	<i>Paspalidium</i> sp.	Poaceae	Grass
	<i>Cenchrus ciliaris</i>	Poaceae	Grass
62	<i>Echinochloa crusgalli</i>	Poaceae	Grass
63	<i>Cyprus</i> sps.	Cyperacea	Grass

DIVERSITY OF SMALL MAMMALS IN THE PARAMBIKULAM WILDLIFE SANCTUARY

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A detailed study was conducted in the Parambikulam Wildlife Sanctuary during 1999-2001 to prepare an inventory and to estimate the abundance of small mammal fauna in diverse ecological habitats of the Parambikulam Wildlife Sanctuary.

In this study, a total of twenty seven species of small mammals belonging to eight orders were recorded from the Parambikulam Wildlife Sanctuary. Among the eight orders Rodentia was represented maximum with eleven species followed by Carnivora with ten species, remaining orders represented only by a single species.

While comparing the rodents trapped from different habitats, natural forest account for more number of species than plantation and vayal. The most common rodent species in the three habitats was *Rattus rattus*, whereas *Golunda ellioti* (Indian bush rat) was found only in the moist deciduous natural forest because of the favourable ecological conditions prevailing there.

Maximum diversity was more in the natural forest than in plantation and vayal whereas species richness was more in vayal followed by plantation and natural forest. The relative dominance was also high in natural forest than plantation and vayal.

Correlation between floral diversity and rodent species indicates that natural forest with more number of plant species possessed high rodent species richness. The ideal conditions prevailing in the natural forest would have helped the survival of rodent species. The lack of ideal conditions in the plantation and vayal would have been the reason for lesser number of rodent species.