TAXONOMIC INVENTORY AND ECOLOGY OF THE RODENTS AND INSECTIVORES OF SILENT VALLEY NATIONAL PARK, KERALA

By

DEVIPRIYA K S

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DECLARATION

I hereby declare that this thesis entitled "**Taxonomic inventory and ecology of the rodents and insectivores Silent Valley National Park, Kerala**" is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
Date: 18-08-2016

Devipriya K S
(2014-17-102)

Dr. P. O. Nameer
Professor and Head
Department of Wildlife Sciences
College of Forestry
Kerala Agricultural University
Vellanikkara, Thrissur, Kerala

Date: 18-08-16

CERTIFICATE

Certified that this thesis, entitled "**Taxonomic inventory and ecology of the rodents and insectivores Silent Valley National Park, Kerala**" is a record of research work done independently by **Miss. Devipriya K S (2014-17-102)** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara

Dr. P.O. Nameer
Chairman
Advisory Committee

CERTIFICATE

We, the undersigned members of the advisory Committee of **Miss. Devipriya K S (2014-17-102)** a candidate for the degree of **Master of Science in Forestry** agree that this thesis entitled "**Taxonomic inventory and ecology of the rodents and insectivores Silent Valley National Park, Kerala**" may be submitted by **Miss. Devipriya K S (2014-17-102)** in partial fulfillment of the requirement for the degree.

Dr. P.O. Nameer
Professor and Head
Dept. of Wildlife Sciences
College of Forestry,
Vellanikkara, Thrissur
(Chairman)

Dr. T.K. Kunhamu
Professor and Head,
Dept. of Silviculture and Agroforestry,
College of Forestry.
Vellanikkara, Thrissur
(Member)

Dr. E.V. Anoop
Professor and Head
Dept. of Wood Science
College of Forestry,
Vellanikkara, Thrissur
(Member)

Dr. Siby Philip
Assistant Professor
Dept. of Zoology
Nirmalagiri College, Kannur
(Member)

EXTERNAL EXAMINER

18/8/16

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Introduction

INTRODUCTION

The term non-volant small mammals is normally applicable to any non-flying mammal whose weight is less than 1kg when adult. In effect the term is generally restricted to rodents, marsupials, insectivores and elephant shrews even though there are a few ungulate small deer (e.g. water chevrotain, *Hyemoschus aquaticus*, and mouse deer, *Tragulus* spp.) that are smaller than some of the larger rodents. The number of small mammals is more small any other type of terrestrial mammal (63.2%) and nearly half (47.45%) of all the mammals is constituted by them.

Order Rodentia is the most species rich group of mammals in the world. Out of the 5416 species of mammals, there are 2277 species of rodents belonging to 33 families distributed throughout all the continents, except Antarctica (Wilson and Reeder, 2005; Carleton and Musser, 2005). Order Rodentia is the mammalian order with the highest number of species in South Asia also (Srinivasulu and Srinivasulu, 2012), while as far as India is concerned the Rodents are the second largest mammalian group after bats, with 102 species (Nameer, 2015).

India has typical rodent genera in all its biogeographic zones. Every bioclimatic zone of the region has some typical rodent taxon: marmots (*Marmota*) and hamsters (*Cricetulus*) in the Himalayas; bamboo rats (Cannomys, Rhizomys) in northern-eastern India to the Malayan archipelago; Bandicota, Rattus, and Mus in the plains; the Porcupine (*Hystrix*) in rocky habitats; and the gerbils (*Gerbillus, Tatera, Meriones*) in the northwestern desert. Two peculiar genera of Murinae (*Diomys* and *Hadromys*) are practically confined to Manipur in northeast India. The woolly flying squirrel, *Eupetaurus*, and a microtine genus *Hyperacrius* (a vole) are endemic to Kashmir.

The largest rodents of the subcontinent is Porcupine with modified dorsal hair that thick and stiff which are known as quills. Squirrels are medium to large sized rodents with long, bushy tail. Sciuridae family is divided into two subfamilies: Sciurinae and Petauristinae. Within sciurinae the Ratufini tribe

comprises of giant squirrels, the Funambulini tribe- striped squirrels and the Callosciurni tribe consists of the non-striped diurnal squirrels. The members of Petauristinae subfamily are nocturnal and include flying squirrels. Ground dwelling Marmots are also members of the Sciuridae family. The murids including rats, mice, hamsters, voles, lemmings and gerbils comprise 281 genera and 1326 species. They are mostly with short limbs and long tail. They live in a wide variety of habitat and have different feeding habits also. Most rodents are quadrupedal, but some including gerbils show bipedality, while others such as flying squirrels glides in air (Menon, 2014).

Order Insectivora is a relatively large order encompasses six families, 65 genera, and 420 species of extant mammals (Hutterer, 1993). Most species are found in the Palearctic, Ethiopian, and Oriental regions, but a few also occur in the New World. These mouse like animals which are generally small and inhabit terrestrial, often moist, habitats (Nowak, 1991). More than 70% of insectivores are shrews (Soricidae). Larger terrestrial members of this order includes the hedgehogs of Eurasia and Africa (Erinaceidae), the solenodons (Solenodontidae) of the West Indies, and the tenrecs (Tenreciade) of Madagascar and Africa. After many revisions and additions Hutterer (2005) separated insectivores into 2 orders: Erinaceomorpha consisting 1 family, 10 genera and 24 species and Soricomorpha comprising of 4 families, 45 genera and 428 species.

Land dwelling insectivores occupies a variety of habitats like grasslands, scrub, and forests and on cultivated lands which often shelter in and under logs, branches and leaf litters; among rocks and roots of trees; in burrows; and under dense vegetation (George, 1989). Some semiaquatic or aquatic, species like the desman (Talpidae) and the water or otter shrews (Tenreciade) lives in water or in burrows located in banks of streams, ponds and lakes. Other species, such as the moles (Talpidae) of the Palearctic and Nearctic (Hartman and Yates, 1985) and the golden moles (Chrysochloridae) of the Ethiopian region, are fossorial and spend most of their life underground. These species frequent areas where the soil is loose and often sandy.

Except some shrews and aquatic forms which are active day or night all other insectivores are nocturnal. They are generally solitary, but individuals of some species occurs in small groups and they generally feed on immature or adult insects, other invertebrates, and small vertebrates that they encounter while moving over the ground or through their burrows, or while digging or swimming (Nowak, 1991).

The current study is on the taxonomy and ecology of the rodents and insectivores of Silent Valley National Park, Kerala. The evolutionary age of the Silent Valley evergreen rain forest is believed to be more than 50 million years. This is a cliff of forest suddenly descends from the Nilgiri plateau to the plains of Kerala with a sudden drop in altitude from 2500m to 150 m across a distance of 3 to 4 km. It is not clear who named this area 'Silent Valley'. It is believed that the name owes to its origin to the relative absence of the Cicada insects which normally cause a distinctive sound in a forest environment.

The rodents and insectivores are one of the least studied groups of mammals of the country and is true with Silent Valley National Park too. Until now there have been no studies on the rodents and insectivores of Silent Valley. Thus the current study is of considerable relevance as it will be the first attempt to document the rodents and insectivores of Silent Valley. Such a documentation on the diversity as well as the basic ecological parameters of these lesser known small mammals will be useful for developing the conservation action plans for the management of the rodents and insectivores of Silent Valley.

Review of Literature

REVIEW OF LITERATURE

2.1 ORDER RODENTIA

Order Rodentia comprises of a group of mammals which possess a single pair of incisors in both jaws, which grow continuously throughout their entire life. This order is widely understood and referred as 'rats and mice'. However, only the members of the superfamily Muroidea comes under these broad classifications (Prakash *et al.*, 2015). All rodents possess constantly growing rootless incisors that have a hard enamel layer on the front of each tooth and softer dentine behind. The differential wear from gnawing creates perpetually sharp chisel edges. In Rodents the absence of other incisors and canine teeth results in a gap, or diastema, between incisors and cheek teeth, which number from 22 (5 on each side of the upper and lower jaws) to 4, may be rooted or rootless and ever-growing, and may be low- or high-crowned. The nature of the jaw articulation ensures that incisors do not meet when food is chewed and that upper and lower cheek teeth (premolars and molars) do not make contact while the animal gnaws. Powerful and intricately divided masseter muscles, attached to jaw and skull in different arrangements, provide most of the power for chewing and gnawing.

The body size of the rodents range between the mice which weighs 18 grams to the marmot which have a weight of 3,000 grams. Delany's swamp Mouse (*Delanymys brooksi*), associated with bamboo in the marshes and mountain forests in Africa weighs 5 to 7 grams, and the body is 5 to 6 cm long is the smallest while the largest is the Capybara (*Hydrochoerus hydrochaeris*) of Central and South America, which weighs 35 to 66 kg and with a body 100 to 135 cm long.

Although the incisors are probably adapted primarily to feeding on seeds which form the principal component of their diet, they enable many other kind of tough vegetable food to be utilized. Usually they have small body with long tail and short limb. Even though most of the rodents are quadrupedal, some members like Gerbils walk in two limbs, while others such as the flying squirrels glide in air.

Rodents have a wide range of diets but they are largely herbivores and they feed on grains, vegetables, fruits, seeds, invertebrates and small vertebrates. Most of them are nocturnal and fossorial in habit. There are ground dwellers as well as arboreal rodents. Polytocy or the production of several young per litter is characteristic of most of the rodents (Menon, 2014).

2.1.1 Status and distribution over the world

Nearly 46% of mammals in the world are rodents. Out of the 5416 species of mammals, there are 2277 species of rodents belonging to 33 families distributed throughout all the continents, except Antarctica (Wilson and Reeder, 2005; Carleton and Musser, 2005). By number Muridae is the largest mammalian family and it is the mammalian order in the Red List with 227 threatened and 20 extinct species (IUCN, 2015). The first mammal to go extinct because of human caused climate changes is also a tiny rodent, Melomys rubicola (Bramble Cay Melomys) of Queensland, Australia (The Hindu, 27 Jun. 16). In South Asia order Rodentia is the mammalian order with the highest number of species (Srinivasulu and Srinivasulu, 2012).

Table 1. List of rodents across the world

	World	South Asia	India	Kerala
No. of family	33	9	8	4
No. of genera	481	63	41	14
No. of species	2277	163	102	23

The described rodents of India constitute only 5.06% of the total species of rodents in the world. Among the total endemic mammals of India, 42.5% are rodents (Nameer *et al.*, 2001). Out of 66 known species of murid rodents occurring in India, 17 have been recorded in the Western Ghats (Kumar *et al.*, 2000). From

the political boundary of Kerala around 23 species of rodents and seven species of insectivores were reported (Nameer *et al.*, 2015).

In all its biogeographic zones, India has typical rodent genera. Some typical rodent taxa are present in every bioclimatic zone of the region: Himalayas have the marmots *(Marmota*) and hamsters (*Cricetulus*); in northern-eastern India to the Malayan archipelago the bamboo rats (*Cannomys, Rhizomys*); in the plains, *Bandicota, Rattus*, and *Mus*; the porcupine (*Hystrix*) in rocky habitats; and in the northwestern desert the gerbils (*Gerbillus, Tatera, Meriones*). Two peculiar genera of Murinae (*Diomys* and *Hadromys*) are practically confined to Manipur in northeast India. The Woolly Flying Squirrel, *Eupetaurus*, and a vole of the genus *Hyperacrius* are endemic to Kashmir (Menon, 2014).

There are 273 species of squirrels found in the world in 50 genera, 62 species of squirrels in Indo-Malayan region in 28 genera and 28 species of squirrels in 12 genera found in the Indian sub-continent. Ellerman (1940) reported that there are 16 genera and 56 species of tree and ground squirrels occurring in the Oriental region. Thirty-nine species of squirrels, in 15 genera are found in south Asia; this constitutes 13.82 per cent of the squirrel species of the world (Thorington and Hoffman 2005). Eleven species of squirrels are endemic to south Asia. Four species – *Ratufa indica*, *Biswamoyopterus biswasi*, *Funambulus tristriatus* and *F. sublineatus* – are confined to India. *Funambulus layardi* and *Funambulus obscurus* are two species of squirrels endemic to Sri Lanka. India has 3 species of giant squirrels and in which Malabar Giant Squirrel is endemic to the Indian sub-continent (Menon, 2014).

Muridae is the largest family of mammals with 150 genera and 730 species (Musser and Carleton 2005). Muroidea is composed of 1517 known species worldwide, 95 species in South Asia and 71 species in India (75 per cent), with the family Muridae being the most speciose (84 in South Asia, 70 in India). Twenty-nine species of murids are endemic to south Asia; 13 in India (*Cremnomys cutchicus, C. elvira, Hadromys humei, Millardia kondana, Mus famulus, M. phillipsi, M. platythrix, Rattus burrus, R. palmarum, R. ranjiniae, R. satarae, R.*

stoicus and *Vandeleuria nilagirica*), 5 in Sri Lanka (*Mus fernandoni, M. mayori, Rattus montanus, Srilankamys ohiensis* and *Vandeleuria nolthenii*), and one species each in Nepal (*Apodemus gurkha*) and Myanmar (*Millardia kathleenae*). *Rattus ranjiniae* is endemic to Kerala while *Mus famulus, Rattus satare* and *Vandeleuria nilagirica* are endemic to Western Ghats.

Other rodent families seen in India are Cricetidae (13 species), Spalacidae (2 species), Dipodidae (1 species), Spalacidae (2 species), Hystricidae (3 species) and the lone species of Platacanthomyidae family (Srinivasulu and Srinivasulu 2012). Dipodidae six out of the 51 species of jerboas in the world (holden and Musser 2005) occur in south Asia and one species is seen in India. In Platacanthomyidae family one out of the 2 species of tree mouse (Musser and Carleton 2005) occurs in south Asia. *Platacanthomyis lasiurus* incidentally, is endemic to the Western Ghats in south India.

2.2 INSECTIVORES

Insectivores are small mammals with long and narrow snout. Previously they were considered as a single order 'Insectivora' which comprises of the third largest order of mammals (Hutterer, 1993). Their body is usually covered either by soft, short fur in the case of shrews or sharp spines as in the case of hedgehogs. Insectivores are terrestrial, fossorial or semi-aquatic and some of them can climb trees and almost all of them are nocturnal. They live in a wide variety of habitat, mostly solitary. Gestation period as well as life span are short, with most species lives only for two years. The former order 'Insectivora' comprised of 7 families, 66 genera and 428 species. After many revisions and additions Hutterer (2005), separated insectivores into 2 orders: Erinaceomorpha consisting 1 family, 10 genera and 24 species and Soricomorpha comprising of 4 families, 45 genera and 428 species.

2.2.1 ORDER SORICOMORPHA

Order soricomorpha consist of shrews which are small, mouse-like mammals. They live in subleaf litter stratum, fallen logs, rock crevices and some are semi-aquatic also. Apart from rodents, they have long pointed snout and depressed conch shaped ears. Its characteristic front teeth are adapted to break the cuticle of arthropod prey. Territorial by nature they keep away from rats and mice. White-toothed Shrews have white, unpigmented teeth while Shrews of the genus Suncus have four upper uncuspid teeth compared to three of Crocidura. Red-toothed Shrews have reddish pigmentation in their teeth, due to iron deposition.

Moles are small, ancient mammalian forms that hunt voraciously, with the help of their higher sense of smell. They are mostly subterranean rarely come above ground. Moles have very small or vestigial eyes and powerful digging limbs. Members of this order are regarded as insectivores since their main diet is insects. They also eat earthworms, beetles, grubs, seeds and nuts.

2.2.2 ORDER ERINACEOMORPHA

Order Erinaceomorpha consist of hedgehogs and gymnures or moonrats. They have small body size and secretive nature. Their body is usually covered by sharp spines over the upper part of the body. They have short five-clawed limbs with non-opposable toes.

2.2.3 Status and distribution over the world

Insectivores are found worldwide except in Australia, Greenland and most of South America. Three families, six subfamilies, 20 genera and fifty three species occurs in South Asia. Of these, there are two subfamilies, four genera and seven species of Erinaceidae; two subfamilies, four genera and four species of Talpidae; and two subfamilies, 12 genera and 39 species of Soricidae. Three families, 11 genera and 34 species are seen in India while two families' three genera and six species are seen in Kerala.

Table 2. List of Soricomorphs across the world

	World	South Asia	India	Kerala
No. of family	4	3	3	1
No. of genera	45	16	11	2
No. of species	428	46	31	4

Table 3. List of Erinaceomorphs across the world

	World	South Asia	India	Kerala
No. of family	1	1	1	1
No. of genera	10	4	2	1
No. of species	24	7	3	1

2.3 TAXANOMICAL STUDIES

Work on Indian rodents was carried out since the time of Linnaeues. The chapters of taxonomical studies of rodents begins with Blanford (1888) who made a comprehensive account of rodents of the Indian region. He included 93 species and 14 varieties in Rodentia. Ellerman and Morrison-Scott (1951, 1966) listed mammal species reported till 1946 from India in their exhaustive account "Checklist of Palaearctic and Indian mammals". Ellerman (1961) contributed his taxonomic studies mainly on rodents in Fauna of India: Rodentia (in two parts), based on the material present in British Museum (Natural History), London. Later scientists of the Zoological Survey of India, such as Dr.S. Roonwal, Khajuria, K. K. Tiwari, V. C. Agrawal, Sujit Chakraborty, S.S. Saha, A. K. Mandal, M. S.

Pradhan, R. K. Ghose, T. P. Bhattacharya, Rina Chakraborty, Talmale contributed most of the work on diversity and distribution of Indian rodents. Chakraborty (1962) published a list of rodents of Jammu and Kashmir. In his well-illustrated field guide on Indian Mammals, Prater (1971), however, dealt rodents only very briefly. Corbett and Hill (1992) regrouped the rodent species in 4 families comprising 43 genera and 99 species.

Revisionary work on taxonomic studies of rodents of Indian region was carried out by Corbet and Hill (1992), Moore and Tate (1965), Mishra and Dhanda (1975), Marshal (1977), Pradhan *et al.* (1993, 2005) and Agrawal (2000). Wilson and Reeder (2005) published a taxonomic description of rodents of the world. In that they said that the Indian rodent fauna not only include the indigenous species but also the forms that have migrated to India from adjoining areas. Thus they represent a mixture of Indian, Indo-Chinese, Malayan, Ethiopian and Palaearctic elements. Agarwal (2000) studied the taxonomy of Indian Muridae and Hystricidae.

Nameer (2000) reported 102 species of rodents in India belonging to 4 families namely Muridae, Sciuridae, Dipodidae and Hysricidae respectively. Twenty eight species of scuirids belonging to 12 genera of 2 subfamilies were reported in a checklist of the Scuirids of South Asia was by Srinivasulu *et al* in 2003. They assessed the distribution, abundance and activity pattern of the species. Srinivasulu and Pradhan, 2003 (Murids); Srinivasulu and Jordan, 2004 (Dipodids, Myoxids and Hystricids); Srinivasulu *et al.*, 2004 (Sciuridae) reported a checklist of rodents species of South Asian countries with some comments on subspecies validity. Nameer (2008) revised and updated the checklist of Indian mammals up to the species level only. Twenty-two species of indigenous rodents occurs in Sri Lanka, which include 13 rats and mice, two bandicoots, four squirrels, two gliding squirrels and one porcupine. Six species *Srilankmys ohiensis* (Bi-colored Rat), *Rattus montanus* (Highland Rat), *Mus mayori* (Spiny Rat), *Mus fernandoni* (Spiny Mouse), *Vandeleuria nolthenii* (Long-tailed Tree Mouse) and *Funambulus layardi* (Flame-striped Jungle squirrel) are endemic to the island (Wijesinghe, 2006).

A detailed account on the South Asian mammals including order rodentia and soricomorpha was given in the 2 volumes of the book "Mammals of South Asia" by Johnsingh and Manjrekar (2015). The rodents and insectivores seen in the political boundary of Kerala was listed in the checklist of the vertebrates of Kerala State by Nameer *et al*, 2015.

2.4 STUDIES ACROSS THE WORLD

2.4.1 Diversity and Abundance

Eleven species of small rodents were collected and identified by a survey of small rodents in three sentinel farms in Costa Rican island conducted by Jimenez *et al.* (2000). Akonda and Khan in 2000 studied the diversity of rodents and insectivores of Bangladesh and they reported twenty one species of rodents and four species of insectivores with one species of Indian Crested Porcupine, which is endangered in Bangladesh.

Horvath *et al.* (2001) studied the rodent diversity and abundance in Mount Bello National Park in Mexico and they found that Rodent diversity in the forest area was significantly higher than the farmlands. In 2002 Batin *et al* studied the influence of elevational habitat changes on non-volant small mammal species distribution and diversity on Mount Nuang, Malaysia. They concluded based on the number of small malla species that were recorded from several elevational sites on this mountain, the number of species or diversity gradually decreases with increasing altitude and they also found that elevation significantly affect 33 out of 36 habitat variables. Species richness and rarity in European rodents were studied by Krystufek and Griffith (2002) and found out that saltatorial rodents appeared to have the largest median ranges and fossorial species the smallest. Kasangaki *et al* (2003) studied Diversity of rodents and shrews along an elevation gradient in Bwindi National Park, south-western Uganda and reached at a conclusion that species richness of the small mammals decrease with an increase in altitude.

Constantine *et al.* (2004) studied six pine plantations in coastal South Carolina to determine the influence of clear-cutting with corridor retention on small mammal abundance, richness, and diversity. They compared small mammal communities between harvested stands with corridors and non-harvested pine stands and they found that rodent abundance, richness, and diversity indices were greater in harvested stands with corridors than in non-harvested pine stands. The early successional habitat created by clearcutting was used by many small mammal species, including cotton rats (*Sigmodon hispidus*) and marsh rice rats (*Oryzomys palustris*). Species composition of small mammals within the corridor habitats was similar to that in the non-harvested pine stands. The inclusion of corridors in pine plantation management enhances habitat diversity and ecosystem maintenance and contributes to local diversity of the small mammal community.

Rickart *et al.* (2010) conducted a faunal survey along an elevational gradient in Balbalasang-Balbalan National Park in northern Luzon Island, Philippines, revealed 15 species of non-flying small mammals. Thirteen, including 1 shrew and12 murid rodents, are native species endemic to the Philippines, 7 of which are endemic to northern Luzon. Comparative data from sites elsewhere on Luzon reveal that total species richness is a function of local elevation, with more species present in areas with higher mountain peaks. These patterns reflect the fact that diversity of non-flying small mammals is concentrated in highland areas where local assemblages include species that differ in daily activity, spatial habitat use, and diet.

Amori *et al.* (2011) studied country based patterns of total species richness, endemism and threatened species richness in African rodents and insectivores. They found that both rodents and insectivores showed: (i) an uneven distribution richness across countries and geographic regions, (ii) highest species richness peaks were observed in Middle Africa and lowest peaks in Northern Africa, (iii) species richness increased with rainfall but was independent on the country size, (iv) in each country, the insectivore species richness increases were positively correlated with rodent species increases, (v) the number of endemic insectivores was positively correlated with the number of endemic rodents by

country.

In a survey of non-volant mammals in montane (1300 and 1400 m) and mossy forest (1500 and 1550 m) on Mount Cetaceo in the northern Sierra Madre of northeast Luzon it has been recorded that there was a total of 12 species of mammals, including one shrew (Soricidae), seven murid rodents (Muridae) was there and that was the first ecological data on two recently discovered species endemic to northeast Luzon, *Archboldomys musseri* and *Apomys sierra* (Duya *et al.*, 2011). Sullivan *et al.* (2012) investigated the influence of linear habitats, three types of hedgerows and two types of field margins, on the small mammal community within a semi-arid agricultural landscape in south-central British Columbia, Canada. Vegetation and total abundance of small mammal species among three types of hedgerows were similar and population changes followed those within nearby apple orchards. Species richness and diversity of small mammals, however, were significantly higher in hedgerows than orchards. Fewer mammals occupied hedgerows with high volumes of herb and shrub biomass, but richness and diversity of mammals did increase with shrub volume.

A survey of non-volant small mammals in four areas of the Bicol Peninsula of southern Luzon islands of Philippines by Balete *et al.* (2013), documented nine species of which six are native and three are exotic and also in some areas none of the previously recorded species were present in the new surveys. From a study on the pattern of species richness and turnover for the South American rodent fauna, Maestri and Patterson (2016), observed that richness and species turnover are better associated with elevational effects than with latitudinal effects. The South American rodent fauna is dominated by independent and temporally staggered radiations of caviomorph and sigmodontine groups. Elevation was the main predictor of sigmodontine richness, whereas temperature was the principal variable correlated with richness of caviomorphs.

2.4.2 Ecological studies

Small mammals which includes rodents and insectivores are highly adaptable animals and notably rodents are omnivores. In a study on herbivores lemmings in

the tundra ecosystem by Pitelka (1957), it has been shown that the activities of lemming such as girdling, trampling, burrowing and defecation not only affect the system variable such as vegetation and its associated transfer functions but also have an impavet on the system variable soil and its transfer functions. In the economy of nature, rodents, because of their large number play an important role. Being mainly herbivores they provide a potent control on plant life. They form the staple food of most of the smaller carnivores and reptiles. In this way rodents helps in maintaining the food chain and thereby ensure the existence of higher level organisms (Prater, 1971). Sciuridae (squirrels) and Muridae (rats and mice) which are non-volant small mammals (NVSM) play an important role as seed predators and dispersal agents in tropical forests, in addition to contributing to food chain and cycling of nutrients (Fleming, 1975).

Batzli (1975) has pointed out small mammals influence at least three major components of an ecosystem, the soil, the vegetation and the predators. Grazing by the desert rodent *Rhombomys opimus* can either destroy the surface vegetation or alter the species composition in favour of invading species which include a number of annual grasses and cruciferae (Naumov, 1975). Studies on jungle cats and golden jackal have shown rodents to occur in more than 60% of the scats analysed (Schaller, 1967, 1970; Johnsingh, 1983; McShane & Grettenberger, 1984; Sultana & Jaeger, 1989). Rodents play an active role in preventing the destruction of seeds of *Vouacapoua americana* and to enlarge the recruitment area of the parent tree (Forget, 1990). For the regeneration of *Virola nobilis,* secondary seed dispersal and seed burying by rodents is as important as primary seed dispersal (Forget and Milleron, 1991). Two species of Gerbils and two species of murids are found to be the pollinating agents of African lily, *Massonia depressa* (Johnson *et al.*, 2001). Entire carnivore food webs are almost totally supported by rodents in habitats such as American prairies and European steppes (Jordan, 1999). Stafford *et al.* (2002) studied the gliding behaviour of Japanese giant flying squirrels (*Petaurista leucogenys*) at Nara Park, Japan. From observed 150 glides they were able to calculate glide ratios on 57 glides and airspeeds on 29 glides. Community ecology of the terrestrial small mammals of Zakouma National Park, Chad was studied by

Granjon *et al.* (2004). The terrestrial small mammal community of the Zakouma National Park (Chad) was assessed and yielded 505 captures of nine rodent and two shrew species, making up a representative small mammal community for the Sudanian savanna biotic zone. Murine rodents of the genus *Mastomys* dominated, with *M. erythroleucus* and *M. spergeri* occuring at similar abundances.

According to Li and Zhang (2007) seed removal, seed hoarding and dispersal distance at yearly and seasonal levels in Apricot rodent abundance have noteworthy effect. A study on the habitat disturbance and ecology of small mammals in Philippines was carried out by Ricart *et al.* (2007). They concluded that in general, native Philippine mammals are closely associated with, and dependent upon, natural forest habitat. This is clearly reflected in distributions across local disturbance gradients in Luzon; native species are most diverse in relatively undisturbed habitat, and decline in diversity with increasing levels of disturbance. Species composition and habitat association of rodents and insectivores in Alatish National Park, North-western Ethiopia was studied by Habtamu and Bekele (2008). The work revealed the presence of 29 species of insectivores and rodents in the study area. Out of these, 23 were rodents (including four squirrels and a porcupine), six were insectivores. During the present study, it was also observed that 11 species of the small mammals in ANP have a highly restricted distribution since they were trapped from a single habitat, while the other six species from two habitats, four from three and three from all habitats.

Puttker *et al.* (2008) studied the response of 5 small mammal species to micro scale variations in vegetation structure in secondary Atlantic Forest remnants, Brazil and they found that microhabitat preferences may be an important factor influencing the capacity of small mammals to occupy altered habitats and consequently, their vulnerability to forest fragmentation at a larger spatial scale. Two species of Colchicum, *C. coloratum* and *C. scabromarginatum* seen in the Karoo region are found to be rodent pollinated (Kleizen *et al.*, 2008).

2.4.3 Phylogenetic Studies

Ruedi *et al.* 1996, done a study on the phylogenetic relationships of populations of the phenotypically variable Asian House Shrew *Suncus murinus*. The populations represent a sample of both commensal and wild forms which were compared to another taxon, *S. montanus*, which was formerly considered conspecific with *S. murinus*. The higher genetic diversity found within *S. murinus* from India, as well as previous mitochondrial and karyological results suggest that this area is the probable centre of origin for the species.

Meegaskumbura and Schneider (2008) studied the taxonomic evaluation of the shrew *Suncus montanus* of India and Sri Lanka. Due to their similarity in size and colour the Sri Lankan and Indian populations of the mountain shrew *Suncus montanus* have been recognized as a single species but in a study on the mitochondrial DNA sequence data from the cytochrome-b and 16S genes that suggest these populations represent distinct species. Phylogenetic analyses further reveal that the Sri Lankan and Indian populations are not sister taxa: *S. montanus sensu stricto* from Sri Lanka is the sister species of *S. murinus*, while '*S. montanus*' from India is the sister species of *S. stoliczkanus*.

Meegaskumbura *et al.* (2010), made a study on the systematic relationships and taxonomy of *Suncus montanus* and *S. murinus* from Sri Lanka and find out that subspecies of *S. murinus*, *Suncus murinus murinus* from Anuaradhapura and *S. m. caerulescens* from Colombo, show little or no genetic difference in the mitochondrial and nuclear genes, confirming their classification as a single species. Phylogenetic relationships of Malayan and Malagasy Pygmy Shrews on the basis of mitochondrial cytochrome b gene sequence was studied by Omar *et al.* in 2011. The study revealed that *S. malayanus* represents a distinct species from the geographically widespread *S. etruscus* species complex. *S. etruscus* from Sri Lanka and *S. madagascariensis* from Madagascar, which has been considered an island endemic, revealed a close sister-group relationship and suggests that these animals are not specifically distinct. It can be concluded that the Malagasy population of this shrew most probably was translocated to the island by human intervention, with

the lineage originating from Southeast Asia or the Indian subcontinent. Balete *et al.* (2012), reported a new genus and three new species of Shrew Mice were discovered from Luzon Island, Philippines. Dissanayakea and Oshida (2012) studied the systematics of the Nilgiri Palm Squirrel, *Funambulus sublineatus* (Rodentia:Sciuridae) and its relationships to Layard's Squirrel, *Funambulus layardi* and found that the mitochondrial DNA suggests that the Sri Lankan subspecies of *F. sublineatus* is the sister taxon of *F. layardi* despite its phenotypic similarity to the nominate species. The Sequencing and analysis of complete mitochondrial genome of *Apodemus draco* (Rodentia: Arvicolinae) was done in a study by Wei *et al.* in 2015.

2.5 STUDIES ACROSS INDIA

2.5.1 Diversity, distribution and abundance

In a study by Srinivasulu *et al.* (2004), on the non-volant small mammals of Kasu Brahmananda Reddy National Park, Andhra Pradesh a total of 11 species of non-volant small mammals were recorded. Kumara and Singh (2006), studied the distribution and relative abundance of giant squirrels and flying squirrels in Karnataka. They recorded two species of giant squirrels, *Ratufa indica* and *Ratufa macroura* and two species of flying squirrels, *Petaurista philippensis* and *Petinomys fuscocapillus*. They also found that the distributional range included the forests of Western as well as Eastern Ghats. In a study on the small mammals inhabiting the semi natural and agro-ecosystems around a rapidly growing Indian city of Banglore by Shenoy and Madhusudan (2006) accounted 14 species of small mammals including one shrew and 13 rodents. They also added that the species composition and abundance was higher in less disturbed areas.

Occurrence and abundance of mammals were compared in five large protected rainforest patches inside the Indira Gandhi Wildlife Sanctuary and in four smaller, unprotected rainforest fragments in a plantation matrix in the Anamalai hills, southern Western Ghats by Sridhar *et al.* (2008) found that, among the 28 mammal species found in contiguous protected rainforests, 24 persisted in

unprotected fragments. Srinivas *et al.* (2008) studied the site occupancy estimates for unstudied populations of the Malabar Giant Squirrel (*Ratufa indica*) within Kalakad–Mundanthurai Tiger Reserve (KMTR), Tamil Nadu. The occupancy rates estimated in this study show that the Malabar Giant Squirrel is widely distributed in KMTR and the high detection probability shows that they are easily sighted. This indicates that the species is common in this landscape both in terms of detectability as well as distribution. In a study on the mammals of Meghamalai, north-eastern side of Periyar Tiger Reserve by Babu *et al.* (2013), 63 species of mammals belonging to 24 families were recorded from the landscape. Eight species of murids and seven species of sciurids were observed there along with two species of Soricidae members.

Population density of Malabar Giant Squirrel (*Ratufa indica*) in Srivilliputhur Grizzled Giant Squirrel Wildlife Sanctuary, Tamil Nadu was studied by Naresh *et al.* (2014). The study results revealed that the present mean population density of Malabar Giant Squirrel 6.9 ± 2.9 individuals per sq. km. in Srivilliputtur Wildlife Sanctuary and this density estimates from this area will provide baseline data for future study.

2.5.2 Ecological studies

In the last one or two decade there has been a large increase in the interest on the ecological aspects of small mammals which focussed on the composition and ecology of Western Ghats small mammal (Molur, 2009). Five species of rodents were reported from three different habitat types in Anamalai (Chandrasekara-Rao and Sunquist, 1996). Occurrence and abundance of arboreal mammals in the rainforests in the Anamalai Hills was studied by Umapathy and Kumar (2000) studied the. In a study on the abundance and habitat selection of the Malabar Spiny Dormouse *Platacanthomys lasciurus* in the different altitudinal regions of Kalakkad-Mundanthurai Tiger Reserve and Anamalai Hills of southern Western Ghats by Mudappa *et al.* (2000), 20 individuals of dormouse were reported. It has been found that rodents and insectivores such as, *Suncus murinus*, *Mus* spp., *Rattus*

wroughtoni and *Millardia meltada* form an important prey base for Greater false vampire Bat, *Megaderma lyra* (Ramanujam and Verzhutukii, 2004).

Six species of rodents and one insectivore were reported in the four tropical habitats in Mudumalai Wildlife Sanctuary (Venkataraman *et al.*, 2005). They were represented by 396 captures of 195 individuals out of a total of 7,425 trap nights with a reasonably high overall capture rate of 5.3%. A study was conducted by Shankar (2002) about the ecology and natural history of small mammals of the Nilgiris, Southern India and found that the species richness and abundance was very high in that region. A total of nine species were trapped in the montane forest patches and three to four species in each of grassland and man-made habitat. In a study about the nesting sites of Malabar Giant Squirrel s in Sitanadi Wildlife Sanctuary by Kanoje, (2008), 10 nesting sites were identified and all of them were occurred in dense forest with closed canopies and high crown density. Two hundred and twenty four nests were located on 27 trees belongs to 30 species.

Fourteen species of non-volant small mammals were reported by Molur and Singh (2009) from Coorg District of Western Ghats. In an account of the non-volant small mammals of Western Ghats, it can be see that 22% of murids and 27% of ground shrews occurring in India are found here. Of these, 16 non-volant small mammals are endemic (Venkataraman, 2009). In a study of the pellet analysis of 4 species of owls, it has been observed that 12 species of rodents was in it and it constituted 55% of the species composition (Talmale & Pradhan, 2009). Some aspects of the ecology and conservation implications of the Malabar Giant Squirrel (*Ratufa indica*) in the tropical forests of Mudumalai Wildlife Sanctuary, southern India were studied by Baskaran *et al.* (2011). They studied its population distribution, activity, feeding, ranging and nesting behaviour across three major habitats in the tropical forests of Mudumalai Wildlife Sanctuary. In a detailed taxonomic and ecological study conducted in Kalatop-Khajjiar Wildlife sanctuary of Chamba District also known as the Mini Switzerland of Himachal Pradesh by Singh and Banyal (2012), revealed the presence of 16 species of mammals

belonging to 14 genera, 12 families and 6 orders which includes *Suncus murinus, Petaurista petaurista and Mus musculus.*

2.5.4. Status and distribution in Kerala

In Kerala there are 23 species of rodents and four species of insectivores coming under four and one families respectively. Visa (2003) studied the diversity and abundance of rodents and insectivores in Kerala Agricultural University campus and reported six species of rodents and one species of insectivore, while Shanid (2005), studied the rodents and insectivores in the Peechi-Vazhani Wildlife sanctuary. A detailed study on the status, distribution, food and feeding of Malabar Spiny Tree Mouse of Western Ghats was studied by Jayson (2006). Babu (2008) and Fasil (2010) studied the diversity and abundance of rodents and insectivores in the Chimmony Wildlife Sanctuary and reported seven species of rodent and one species of insectivore.

Jayalakshmi (2010) studied the ecology of Flying Squirrels of Chimmony Wildlife Sanctuary and Mohan (2010) studied the ecology of diurnal squirrels of Chimmony Wildlife Sanctuary. In 2011, seven species of rodents were observed from Parambikulam Tiger Reserve, Kerala (Mareena, 2011), while Thomas (2012) recorded nine species of rodents from Parambikulam Tiger Reserve. Thomas (2014) conducted a detailed ecological study on the Grizzled Giant Squirrel (*Ratufa macroura*) at Chinnar Wildlife Sanctuary. According to Nameer *et al.* (2015), there are 23 species of rodents belonging to four families and 14 genera and four species of insectivores belonging to a single family and two genera are there in Kerala.

Table 4. The checklist of rodents and insectivores seen in Kerala (Nameer *et al.*, 2015)

Order	Family	Common Name	Scientific Name
Rodentia	Sciuridae	Malabar Giant Squirrel	*Ratufa indica*
		Grizzled Giant Squirrel	*Ratufa macroura*
		Indian Giant Flying Squirrel	*Petaurista philippensis*
		Travancore Flying Squirrel	*Petinomys fuscocapillus*
		Three-striped Palm Squirrel	*Funambulus palmarum*
		Nilgiri Palm Squirrel	*Funambulus sublineatus*
		Jungle Palm Squirrel	*Funambulus tristriatus*
	Muridae	Lesser Bandicoot-rat	*Bandicota bengalensis*
		Greater Bandicoot-rat	*Bandicota indica*
		Indian Bush Rat	*Golunda ellioti*
		Blanford's Madromys	*Madromys blanfordi*
		Little Indian Field Mouse	*Mus booduga*
		Servant Mouse	*Mus famulus*
		House Mouse	*Mus musculus*
		Flat-haired Mouse	*Mus platythrix*
		Brown Rat	*Rattus norvegicus*
		Ranjini's Rat	*Rattus ranjiniae*
		Roof Rat	*Rattus rattus*
		Sahyadris Forest Rat	*Rattus satarae*
		Indian Gerbil	*Tatera indica*
		Nilgiri Vandeleuria	*Vandeleuria nilagirica*
	Platacanthomidae	Malabar Spiny tree mouse	*Platacanthomys lasiurus*
	Hystricidae	Indian Porcupine	*Hystrix indica*

Erinaceomorpha	Erinaceidae	Bare-bellied Hedgehog	*Parachinus nudiventris*
Soricomorpha	Soricidae	Pigmy white-toothed Shrew	*Suncus etruscus*
		Keelaart's long clawed Shrew	*Feroculus feroculus*
		Day's Shrew	*Suncus dayi*
		Grey musk Shrew	*Suncus murinus*
		Hill Shrew	*Suncus niger*

2.6 CONSERVATION STATUS OF RODENTS AND INSECTIVORES

Is small mammal conservation a viable issue? Merely considering the numbers of species involved, small mammal conservation should be a major component of conservation efforts. Yet generally speaking, rodents and insectivores do not have the appeal of various larger and more charismatic species of mammals. In fact, they are commonly disliked and considered pests. They often are implicated in damage to agricultural crops, or accused of transmitting zoonoses. It is abundantly clear that considerable educational effort will be needed to restore them as a group to a status where they will generate enthusiastic support for their conservation. Another reason for lack of enthusiasm for their conservation is the perception that because they are generally small, it is assumed that they occur at higher densities than do larger vertebrates. In tandem, most of them are herbivores, and so being low on the trophic ladder, they require less area per individual. Thus, they can often persist in smaller habitat fragments and in general seem less vulnerable to local extinctions. Although 330 species of rodents are considered threatened (IUCN, 2015) and many species are known to play a unique role in sustaining ecosystems and current biodiversity (Maser & Maser, 1988; Yensen *et al.*, 1992; Forget, 1997), conservation efforts for threatened rodents seem a low priority at the moment (Amori & Gippoliti, 2000).

In the Wildlife (Protection) Act 1972 of India the general term 'rats and mice' is included in schedule V as vermin category meant for animals that are considered as a nuisance and generally described as pests. All the rodents other than 16 species identified by All India Coordinated Rodent Control Project including a large number of wild muroids which live in forests are of greater utility and importance to ecosystem. By a general term rats and mice they are considered as vermin which can be treated as pests only. The squirrels including Giant Squirrels, Flying Squirrels and Striped Squirrels and Porcupines are included in the other schedules of Wildlife (Protection) Act 1972 which get adequate attention. Only the broad class of rats and mice are excluded and regarded as vermin.

Out of the 95 species of muroids in South Asia eighteen species are threatened, seven are vulnerable nine as endangered and two as critically endangered. *Cremnomys elvira* (Ellerman 1947) and *Millardia kondana* (Mishra and Dhanda 1975) which are categorised as critically endangered is facing high risk of extinction because of their restricted distribution pattern. All among the seven vulnerable species are forest dependent and restricted to primary and undisturbed habitats which possess serious threat of habitat destruction. Molur 2009 and Molur and Singh 2009 said that due to habitat alteration strictly arboreal species are affected and replaced by more common *Rattus wroughtni.* Within the insectivores there are 152 threatened species, including 66 species among the White-toothed Shrews (*Crocidura* spp.). This is more threatened species within this one genus than for the entire order Carnivora!

Lack of awareness about their true status is the greatest threat facing by rodents and insectivores. In Schedule V of the Wildlife Protection Act, 1972, all rats and mice except Malabar Spiny Tree Mouse are included as Vermin. This clumping of endangered, threatened and abundant species has perpetuated the myth of all rodents being harmful to human. However, some protection is given to rodents such as squirrels, porcupines and marmots. 27 per cent of all living rodents globally require some conservation attention (Amori and Gippoliti, 2003). Loss of habitat, competition, introduction of non-native species, non-selective hunting by

tribal communities and diseases are the major ecological threats possessed by the rodents (Menon, 2014).

Materials and Methods

MATERIALS AND METHODS

3.1 STUDY AREA

3.1.1 Area, Location and Extend

Silent valley national park is situated in the core of Nilgiri Biosphere Reserve which with an area of 237.52 km², it houses a rich mosaic of varied habitats. The core area of silent valley extend up to 89.52 km² and buffer zone is 148 km². The core zone consist of Sairandhri, Poochippara, Neelikkal and Walakkad sections excluding an area of 5 Ha from Sairandhri section along the road from entry gate to Kunthipuzha which is added to the tourism zone. Buffer zone consists of areas of Anavai forest station and Thudukki forest station of Bhavani range and buffer areas of Silent Valley range lying in Neelikkal, Poochippara and Walakkad sections and the 5 ha area excluded from core of Sairandhri section. Silent valley falls within the revenue district of Palakkad and Malappuram within the 76°24' and 76° 29' east longitude and 11°4' and 11°13' north latitude.

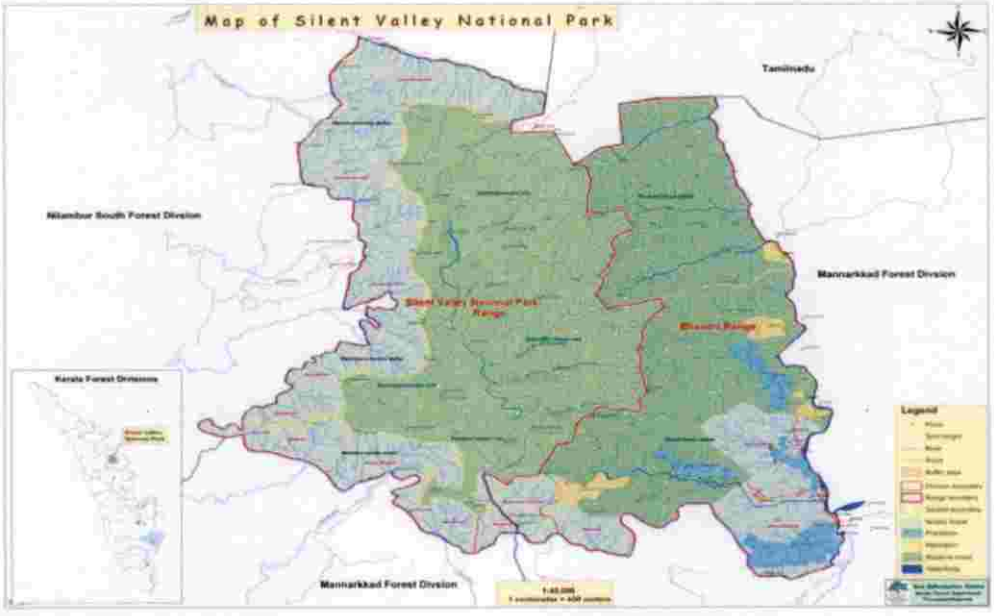

Fig. 1 Map of Silent Valley National Park, Kerala

Plate 1. A view of Silent Valley from Sairandhri section (Photo Courtesy: K.Jayram).

Plate 2. A view of River Kunthi from Neelikkal section, Silent Valley

3.1.2 Topography

The terrain is generally undulating with steep escarpments and many hillocks. The elevation ranges from 900 m to 2,300 m above MSL with the highest peak at 2383 m, Anginda peak. The silent valley plateau, lying at the southwest corner of Nilgiris, sloping towards the south and is practically winged by hills. This area lies entirely on the plateau to the north of Mannarkkad, the outer slopes of the hills forming the tableland. The lowest point of the plateau is 685.8 m on the southern boundary, where the Kunthipuzha rushes down the Ghats in a series of rapids. The west edge of the plateau rises gradually from 1127 m at Vannampara on the south west corner to 1163 m at Cherambankumban and 1245 m at Valliyamullumalai and culminates at Kovilpara, 1904 m on the northwest corner.

Plate 3. Evergreen forests in Neelikkal section, Silent Valley National Park.

3.1.3 Climate

The climate is tropical with summer rains constituting the bulk of the precipitation. Average minimum temperature varies from 8° to 14°C and average maximum temperature varies from 23° to 29°C. The hottest months are April and May when mean temperature is 23°C and the coolest months are January and February when the mean temperature is 18°C. Variation in the intensity of rainfall is observed across the area. An increase in rainfall is noticed as one goes from foothill to the high ranges. The elevated hills on the western side of Silent Valley receive an average of 5045 mm of rain as recorded at Arthala at 1200 m elevation. The annual pluvial average is over 5000mm (Singh et al, 1984) and is contributed by the south west monsoons. Over 80% of the rain is received during the South west monsoon, 12% is contributed by north east monsoon, 6% through pre-monsoon thunder showers and the rest is received during the dry season.

3.1.4 Soil

Soils in general are loam in the surface as well as in deeper layers and strongly acidic in all the three layers with a mean pH value ranging from 5.1-5.4, the mean organic carbon range between 20.64 and 23.42g/kg, and total N between 1.08-1.47 g/kg .

3.1.5 Vegetation

Silent Valley reserve forest can be classified under four forest types viz., West-coast tropical evergreen forest (600-1100m), Southern subtropical broad leaved hill forest (1300-1800m), Southern montane wet temperate forest (above 1900m) and Grasslands (Basha, 1991). The forest types in Silent Valley are

1. **West-coast tropical evergreen forest**

   It is a climax vegetation consisting of at least three tiers with the highest attaining a height of 40-45 m. Very often trees with buttress can be

seen and species with cauliflory are also there. Cylindrical, unbranched trees with umbrella shaped crown are seen in the first strata. Middle stratum is more or less candle shaped and lower is characteristically conical. The dominant upper-storey consist of *Bischofia javanica, Calophyllum elatum, Canarium strictum, Cullenia exarillata, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Mesua ferrea, Palaquium ellipticum, Persea macrantha, Polyalthia coffeoides* and so on. Following six types of species associations are identified in Silent Valley.

i. *Cullenia- Palaquium* association
ii. *Palaquium- Mesua* association
iii. *Poeciloneuron- Palaquium* association
iv. *Mesua- Calophyllum* association
v. *Ochlandra- Calophyllum* association
vi. *Ochlandra- Poeciloneuron* association

1. Southern subtropical broad leaved hill forest

Floristically rich but commercially very poor forest type. Height of the trees will not exceeds 20 m and possess trunk heavily festooned with mosses, lichens and ferns. These forests are seen from 1300-1800 m elevation. *Calophyllum elatum, Cinnamomum sulphuratum, Elaeocarpus munroii, Dimocarpus longan, Garcinia spp., Mesua ferrea, Syzygium spp.* are seen commonly.

2. Southern montane wet temperate forest

Found in cliffs and sheltered folds above 1900 metre. Tress in this forest seldom attains a height more than 10 m. Principal arborescent species in this forest are Elaeocarpus munroii, Gordonia obtusa, Meliosma pinnata, Schefflera racemosa, Symplocos spp. etc. Open grassy patches can be seen interspersed with this forest.

3. Grassland

Two type of grasslands are seen in Silent Valley which are

i. **Low level grassland below 1500 m**- Distributed within the wet evergreen forests of Silent Valley. *Allophylus serratus, Brenyia vitis-idaea, Canthium dicoccum, Careya arborea, Zizyphus rubginosa, Cymbopogon* spp., *Heteropogon* spp. and *Themeda* spp. are most common.

ii. **High level grassland above 1500m -** These are found in the upper reaches of Silent Valley above 1500 metre. These grasslands are seen interspersed with Montane Temperate Forests and Subtropical Hill Forests. *Gaultheria fragrantissima, Rhododendron arboretum* grasses like *Arundinella fuscata, Bothriochloa pertusa, Heteropogon contortus* etc are seen.

Plate 4. Grasslands shola, Neelikkal section, Silent Valley

3.1.6 Flora

Silent Valley is a small stretch of land consisting of about 8952 hectares of forest with diverse vegetation types. It harbours about 2000 plant species which

include 1000 species of flowering plants that belongs to 561 genera and 136 families (Manilal, 1988). Orchidaceae is the largest family represented by 107 species in 26 genera and followed by Poaceae, Fabaceae, Rubiaceae and Asteraceae. The gymnosperm flora is very poor and is represented by only two species belonging to the families Cycadaceae and Gnetaceae respectively (Pushpangadan and Kumar, 1991).

3.1.7. Fauna

Knowledge about the faunal wealth of Silent Valley came into light during the period of proposal for the construction of hydro-electric dam across Kunthipuzha. 1012 species of animals were reported from silent valley which represent only a small fraction of the fauna of Silent Valley. 34 species of mammals, 192 species of birds, 31 species of reptiles, 22 species of amphibian, 13 species of fishes and 717 species of insects were recorded so far from Silent Valley. Study on different taxa are still going on (Balakrishnan, 1991).

3.2 METHODS

3.2.1 Site Selection

Three base camps in Silent Valley, Sairandhri, Neelikkal and Poochippara were selected for carrying out the study. These places are more or less similar in almost all habitat conditions. Traps were placed in all these camps at two seasons viz, monsoon and summer. The months which receives heavy rainfall is considered as monsoon season and it was from September to November. The warmest season of the year is considered as summer which is from March to May in Kerala and the study was conducted in February and April months. In monsoon the work was carried in Sairandhri and Neelikkal and in summer we surveyed Poochippara and Sairandhri.

3.2.2 Traps and Trapping Method

Live Capture Techniques were employed for the present study. Sherman trapping, which is a live capturing technique was done to capture

animals. Sherman traps were exclusively used for trapping the small mammals. The Sherman trap is available in different sizes and comes in collapsible and fixed sided models. Since it comes in collapsible model it is easy to transport. In all the study areas 50Sherman traps were placed from 10m apart on either sides of the forest trails. Some of them were placed on tree trunk in the selected sites in order to catch arboreal rodents. Sherman traps placed in the ground were covered using litter in order to give a camouflage.

Plate 5. Sherman trap placed in the field

3.2.3 Baiting

To attract the rodents and insectivores baits were placed inside the traps. A combination of different food grains with banana, peanut and peanut butter was used as the bait for the animals. Traps were checked twice a day at 7 am and 5.30 pm and baits were replaced if necessary.

Plate 6. Checking Sherman trap for rodents and insectivores

3.2.4 Habitat parameters observed during the study

Thirteen site and habitat variables were measured within 2 m radius circular plots centred on traps. The following variables were measured at each location, altitude (using GPS), canopy height and canopy cover (visual estimation), litter depth (average of four measurements taken around the trap using calibrated probe), and basal area of trees > 30 cm girth. Densities of shrubs (within 2 m radius), trees, climbers, buttresses and canes, and distance to the nearest large tree (measured with a tape to a tree > 60 cm girth) were also recorded. Nearness to water body, presence of climbers, rocks and roads also noted. Along with this parameters, latitude, longitude and altitude of the trap station also was recorded. The above habitat parameters were measured around a 2m radius of each traps. That is we have taken all these parameters in the 50 trap stations in each study area.

3.2.5 Period of observation

The study was carried out from September 2015 to April 2016.

3.2.6 Measurements taken

The captured specimens from the field were carefully taken out of the trap and they were observed. Then the specimen was euthanized by using Diethyl ether and morphological measurements were taken. The measurements taken were Head to Body length (HB) from the tip of the nose to the anterior end of the anus, Tail length (T) from the ventral root of the tail above the anus to the tip of the tail vertebrae, Ear length (E) from the intertragal notch to the farthest edge of the pinna, Hindfoot length (HF) from the outer surface of the heel to the tip of the longest toe, excluding the claw or nail. The measurements were taken using Mitutoyo digital vernier callipers (Fig. 5). Body weight of the specimen were taken using Persola spring balance. Field numbers are given to each specimen and later they were changed into museum number after bringing to the laboratory. Field numbering was done on the basis of date and serial number of collection. In the laboratory all the specimens were renamed using a prescribed method. The specimens are kept in Natural History Museum of Kerala Agricultural University in College of

Forestry. So the name start with the abbreviation KAUNHM. Then they were serially numbered according to the date of collection. The specimens were fixed in in 10% formalin for three days and later were then kept in 70% ethyl alcohol.

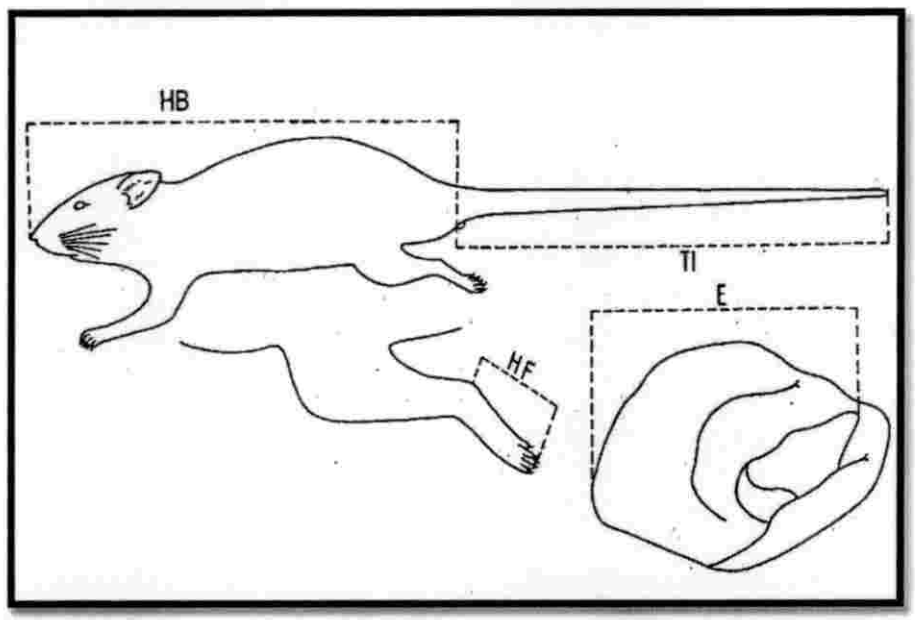

Fig. 2 Morphological measurements of a typical rodent

3.2.7 Laboratory Studies

After bringing the specimen to laboratory, they were clearly labelled and kept in 70% ethyl alcohol. Skull was extracted from each specimen. In order to extract the skull a small incision was made in the mouth region of the specimen and then slowly deepens the incision towards the jaw and separate the skin from the jaw. Then proceed towards head and take the skin out of the skull. When the skin is completely separated from the skull cut it at the neck portion without damaging the back portion of the skull. After that the skull is kept in boiled water for one minute. Then it is kept in hydrogen peroxide for six hours so that the tissue get detached from the skull. Washing with running water will help to remove all the tissue residuals in the skull. Cleaned skull are clearly labelled and kept separately. Then measurements were taken (Plate 8).

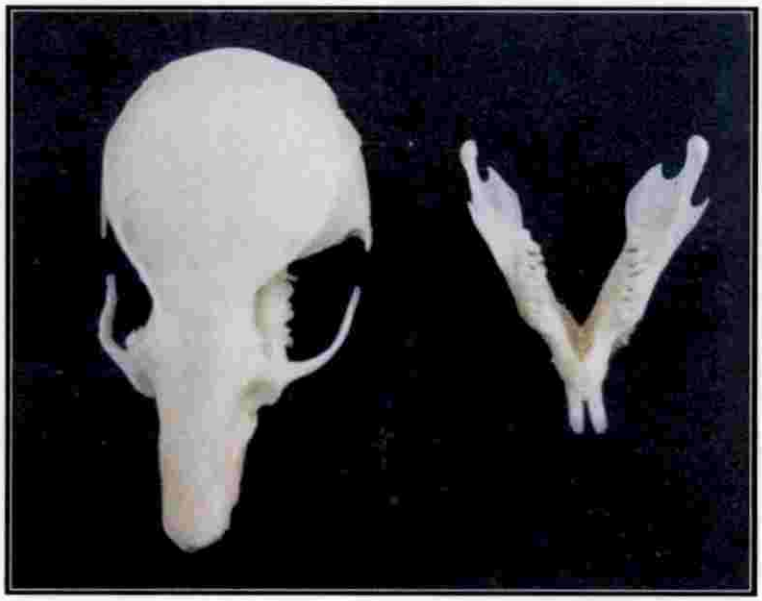

Plate 7. Extracted skull of *Rattus wroughtoni*

The skull measurements taken are

- Occipitonasal length (on) - from the most forward point of the nasal to the hindmost point on the occipital surface or to the centre of the occiput when this project backward behind the lamboidal region.

- Condylobasal length (cb)- from the most forward point of premaxilla to the hindmost point of the occipital condyle

- Greastest zygomatic width (zw)- greatest width across the outer surface of the two zygomatic arches measured at right angles to the long axis of the skull

- Interorbital width or frontal width (iw)- least width of the frontal bones between the two orbits

- Cranial width (cw)- greatest width of the cranium just above the squamosals

- Length of tymphanic bulla (b)- maximum length of the bulla in the anterio-posterior axis excluding the spinous process at the anterior end and mastoid portion at the posterior

- Nasal length (n)- maximum length of nasals in the anterio- posterior axis

- Length of anterior palatal foramen (apf)- maximum length of the anterior palatal foramen along the anterio- posterior axis

- Length of maxillary tooth row (m)- total length of the maxillary teeth on the crown

- Length of diastema (d)- from a point on the ventro-lateral side of the premaxilla where it meets the incisors to the most forward point on the base of the first maxillary tooth

- Length of palate (pl)- from the front of the incisors to the back of the palate, excluding the palatal spines

- Width of maxillary tooth row (mw)- maximum width of upper molar

- Nasal width (nw)- maximum combined width of both the nasal bones

- Width of anterior palatal foramen (apf.w)- maximum combined width of both the anterior palatal foramen

In the case of insectivores, the cranial parameters are different since the anatomy of their skull is different from that of rodents. So the parameters measured from the insectivore skull are

- Greatest length of skull (GTL) - the greater anterio-posterior diameter of the skull, taken from the most projecting point at each extremity
- Condylo- basal length (CBL)- from an exoccipital condyle to the alveolus of the anterior insicors
- Condylo-canine length (CCL) – from the exoccipital condyle to the anterior alveolus of the canine
- Zygomatic breadth (ZB) – the greatest width of the skull across the zygomatic arches, regardless where this point is situated on the arch
- Breadth of braincase (BB) – greatest width of the braincase at the posterior roots of the zygomatic arches
- Interorbital constriction (IC) – the narrowest width across the interorbital region
- Mandible length (M) – from the posterior most part of the condyle to the most anterior part of the mandible, including the lower incisors
- Mandibular toothrow ($C\text{-}M_n$) – from the front of the lower canine to the back of the crown of the last lower molar
- Maxillary toothrow ($C\text{-}M^n$)- from the front of the upper canine to the back of the crown of the last upper molar
- Anterior palatal width ($C^1\text{-}C^1$) – taken across the outer borders of the upper canine
- Posterior palatal width ($M^n\text{-}M^n$) – taken across the outer borders of the last upper molar

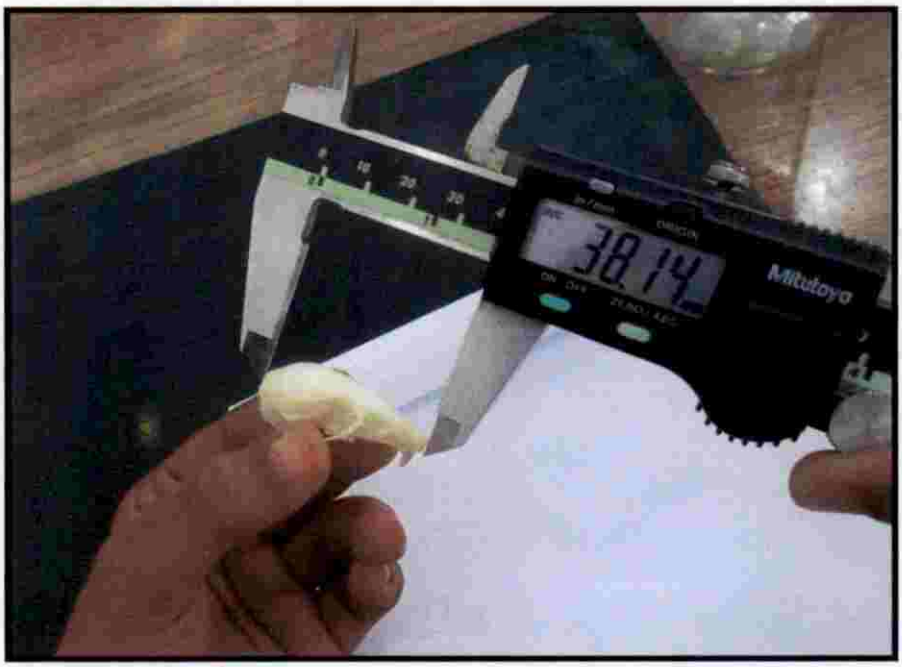

Plate 8. Taking skull measurements using digital Vernier calliper

After taking these measurements, the skull and the specimen were clearly labelled and kept in the laboratory for further references.

The morphological as well as cranial measurements and habitat measuremets were entered in microsoft excel spread sheet. Then the data were systematically arranged inorder to carryout the suitable and reliable statistical analysis. From the morphological and cranial measurements collected mean of each parameter was calculated and standard deviation was determined and compared with the mean in literature. Chi-Square test was also done on it inorder to assess the deviation from the standard value.

Independent t-test was conducted on the habitat parameters that observed from each trap station so as to find whether any of the habitat parameter influence the capture of the target species in the study area. Logistic regression test was also conducted on the habitat parameters in the plots where *Rattus wroghtoni* was present and absent.

4.3 Diversity Indices

From the data of the species collected different indices of diversity will be estimated. Diversity indices can be broadly divided into two types: those that assess species richness (how many types are there) and those that assess species evenness or dominance (how individual organisms are distributed among species) (Magurran, 1988).

4.3.1 Margalef's Diversity Index

Ramon Margalef Lopez proposed a species diversity index during the 1950s. Margalef's diversity index is a species richness index. Many species richness measures suffer from the problem that they are strongly dependent on sampling effort. The greater the sampling effort, potentially the higher the index value. Thus comparing metrics from samples collected with differing levels of sampling effort can be difficult and possibly misleading. Margalef index was one of the first attempts to compensate for the effects of sample size by dividing the number of species in a sample by the natural log of the number of organisms collected. The index is thus

$$\text{Margalef,s Index} = S - 1 / \ln N$$

where S is the number of species in a sample and N is the number of organisms in the sample. The use of the index rests on the assumption that there is a relationship between the number of species and the number of organisms in a sample. If this is not the case then the index still sensitive to the number of organisms collected, that is, it increases as the number of organism sampled increases. Margalef index increases in much the same way as the number of species increases.

4.3.2 Simpson's Index, D

Simpson (1949) gave the probability of any two individuals drawn at random from an indefinitely large community belonging to different species as

$D=\Sigma\ pi^2$

Where p_i is the proportion of individuals in the i^{th} species. In order to calculate the index, the form appropriate to a finite community is used.

$D=\Sigma\ (n_i\ (n_i-1)\ /N\ (N-1))$

Where n_1 the number of individuals in the i^{th} species and N is the total number of individuals.

As D increases, diversity decreases and usually the Simpson's Index is therefore expressed as 1-D or 1/D. It is occasionally called Yule index (Magurran, 1988).

4.3.3 Shannon Index of Diversity, H

The Shannon- Wiener Index (Shannon- Wiener, 1963) is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of 'S' species and 'N' individuals will belong. This average uncertainty increases and as the distribution of individuals among the species becomes 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 only one species in the sample, (2) H' is maximum only when all S species are represented by the same number of individuals, that is, a perfectly even distribution of abundance (Ludwig and Reynolds, 1988).

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

$H'=\Sigma\ (p_i \ln p_i)$

Where H' is the average uncertainty per species in the infinite community made up of S species with known proportional abundance $p_1, p_2, p_3, \ldots\ldots p_s$.

4.3.4 Berger- Parker Index, d

The Berger- Parker Index expresses the proportional importance of the most abundant species where N_{max} represent the maximum number of individuals in the most abundant species and N denotes total number of individuals.

$$d = N_{max}/ N$$

The reciprocal of the index is usually taken so that an increase in the value of the index accompanies an increase in diversity. This index is independent of number of species but is influenced by sample size. May (1975) concludes that it is one of the most satisfactory diversity measures available. (Magurran, 1988).

4.3.5 Eveness

The distribution of individuals over species is called evenness. It makes sense to consider species richness and species evenness as two independent characteristics of biological communities that together constitute its diversity (Heip, 1974). Several equations have been proposed to calculate evenness from diversity measures. The most frequently used measures, which converge for large samples (Peet, 1974) are:

$$E= 1- I\ min / I\ max - I\ min$$

where I is a diversity index, and I min and Imax are the lowest and highest values of this index for the given number of species and the sample size.

4.3.6 FISHER'S ALPHA

In order to compare among communities varying in number of individuals (N), Fisher's Alpha (α) is widely used as a diversity index because theoretically it is independent of sample size. This was first explained mathematically by Fisher *et al.* in 1943. Log series takes the form: αx, $\alpha x^2/2$, $\alpha x^3/3$,...$\alpha x^n/n$, where αx is the number of species predicted to have one individual, αx^2 to have two individuals etc...

$$S/N = (1-x)/x\ (-\ln(1-x))$$

Where S is the number of species, N is the total individuals

Fisher's $\alpha = N(1-x)/x$

All the above indices will be estimated and compared in order to find out the species richness, diversity and evenness between the two seasons in which the work has been carried out.

Results

RESULTS

4.1 DIVERSITY OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK, KERALA

In this study conducted on the rodents and insectivores of Silent Valley, a total of seven species of rodents and one species of insectivores were observed from different study locations of such as Sairandhri, Neelikkal and Poochippara. Three families of rodents were observed and they were Muridae, Sciuridae and Hystricidae. The insectivore observed was from the family Soricidae of the order Soricomorpha. The details of the species are given below.

Table 5. Different species of rodents and insectivores recorded from Silent Valley National Park.

Sl. No.	Common Name	Scientific Name	Family	Captured/ Observed
1.	White-bellied Rat	*Rattus wroughtoni*	Muridae	Captured
2.	Indian Bush Rat	*Golunda ellioti*	Muridae	Captured
3.	Malabar Giant Squirrel	*Ratufa indica*	Sciuridae	Observed
4.	Jungle Palm Squirrel	*Funambulus tristriatus*	Sciuridae	Observed
5.	Nilgiri Palm Squirrel	*Funambulus sublineatus*	Sciuridae	Observed
6.	Grey Musk Shrew	*Suncus murinus*	Soricidae	Captured
7.	Indian Crested Porcupine	*Hystrix indica*	Hystricidae	Observed

Plate 9. White-bellied Rat, *Rattus wroughtoni*

Plate 10. Indian Bush Rat, *Golunda ellioti*

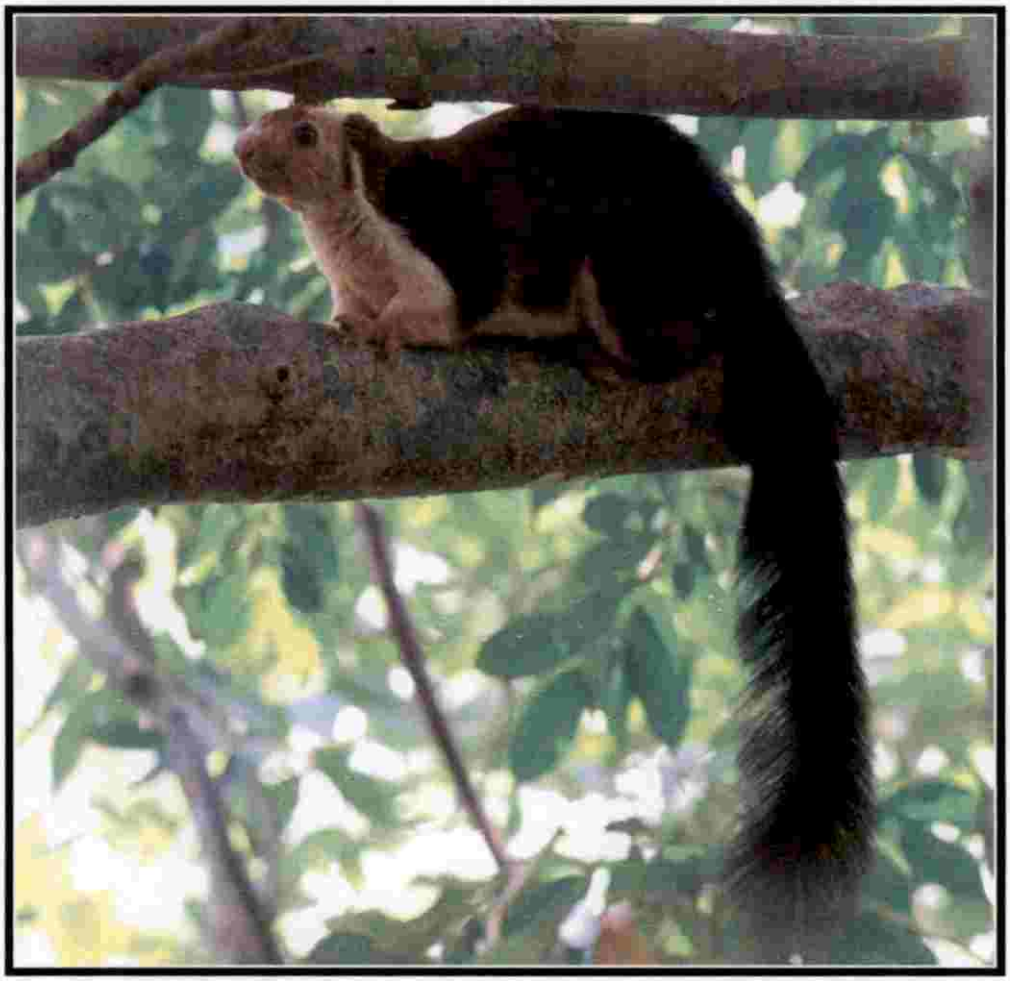

Plate 11. Malabar Giant Squirrel, *Ratufa indica*

Plate 12. Nilgiri Palm Squirrel, *Funambulus sublineatus*

Plate 13. Jungle Palm Squirrel, *Funambulus tristriatus* image captured in camera trap

Plate 14. Indian Crested Porcupine, *Hystrix indica* image captured in camera trap

Plate 15. Grey musk Shrew, *Suncus murinus*

4.2 DIVERSITY OF RODENTS AND INSECTIVORES IN DIFFERENT STUDY LOCATIONS OF SILENT VALLEY NATIONAL PARK, KERALA

4.2.1 Rodents and insectivores captured in the Sherman Trap

From the current study totally 28 individuals were captured from three locations of Silent Valley National Park which consist of two species of rodents and one species of insectivore. The different locations selected for the study were Sairandhri, Poochippara and Neelikkal with more or less same vegetation parameters. Maximum number of individuals were collected from Sairandhri. 18 individuals were collected from Sairandhri which included *Rattus wroughtoni* (White-bellied Rat), *Golunda ellioti* (Indian Bush Rat) and *Suncus murinus* (Grey Musk Shrew). We got Shrew from Sairandhri and Neelikkal. The major type of vegetation selected for trapping was evergreen and grasslands.

Table 6. List of rodents and insectivores captured from different study locations of Silent Valley National Park

Species	Locations		
	Sairandhri	Neelikkal	Poochippara
Rattus wroughtoni (White-bellied Rat)	15	3	2
Golunda ellioti (Indian Bush Rat)	2	1	2
Suncus murinus (Grey Musk Shrew)	1	2	0

4.2.2 Rodents observed in Silent Valley National Park

Besides the rodents captured in Sherman Trap, four more species of rodents were observed from different locations of Silent Valley. They are *Hystrix indica* (Indian Crested Porcupine), *Funambulus sublineatus* (Nilgiri Palm Squirrel), *Funambulus tristriatus* (Jungle Palm Squirrel) and *Ratufa indica* (Malabar Giant

Squirrel). *Ratufa indica* and *Hystrix indica* were sighted from all the three locations while *Funambulus sublineatus* and *Funambulus tristriatus* were sighted only from Sairandhri. While the *Hystrix indica* were photographed in the camera traps at all the three locations.

Table 7. Rodents and Insectivores observed in different study locations of Silent Valley National Park

Location	**Species Observed**
Sairandhri	*Rattus wroughtoni*
	Golunda ellioti
	Ratufa indica
	Funambulus tristriatus
	Funambulus sublineatus
	Suncus murinus
	Hystrix indica
Poochippara	*Rattus wroughtoni*
	Golunda ellioti
	Ratufa indica
	Hystrix indica
Neelikkal	*Rattus wroughtoni*
	Golunda ellioti
	Ratufa indica
	Hystrix indica
	Suncus murinus

4.3. SPECIES DIVERSITY

The diversity of a species can be expressed by various indices like Simpson index, and Shannon-Weiner index. At the same time species

richness can be measured by using Margalef's diversity index. The numerical importance of the most abundant species can be calculated using Berger-Parker dominance index. Diversity index gives the quantitative measure of how many different types (such as species) there are in a dataset. Fisher's Alpha (α) widely used as a diversity index to compare among communities varying in number of individuals (Magurran, 2004).

Table 8. Diversity Indices

Index	Monsoon	Summer
Dominance	0.28	0.23
Simpson Index	0.72	0.77
Shannon Index	1.50	1.58
Evenness	0.64	0.81
Margalef Index	0.37	0.32
Fischer alpha	0.72	0.77
Berger- Parker	1.50	1.58

This result indicates no significant variations in the indices of rodents and insectivore community structure between seasons. Shannon Diversity Index and Simpson Diversity Index were highest in summer season while Margalef's species richness index is highest in monsoon.

4.4 ABUNDANCE OF THE RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

Abundance of various species of rodents and insectivores in Silent Valley National Park is given in table 9. *Rattus wroughtoni* was found to be the most abundant species among the rodent followed by *Golunda ellioti*. *Suncus murinus* was the only one insectivore that trapped during the study period.

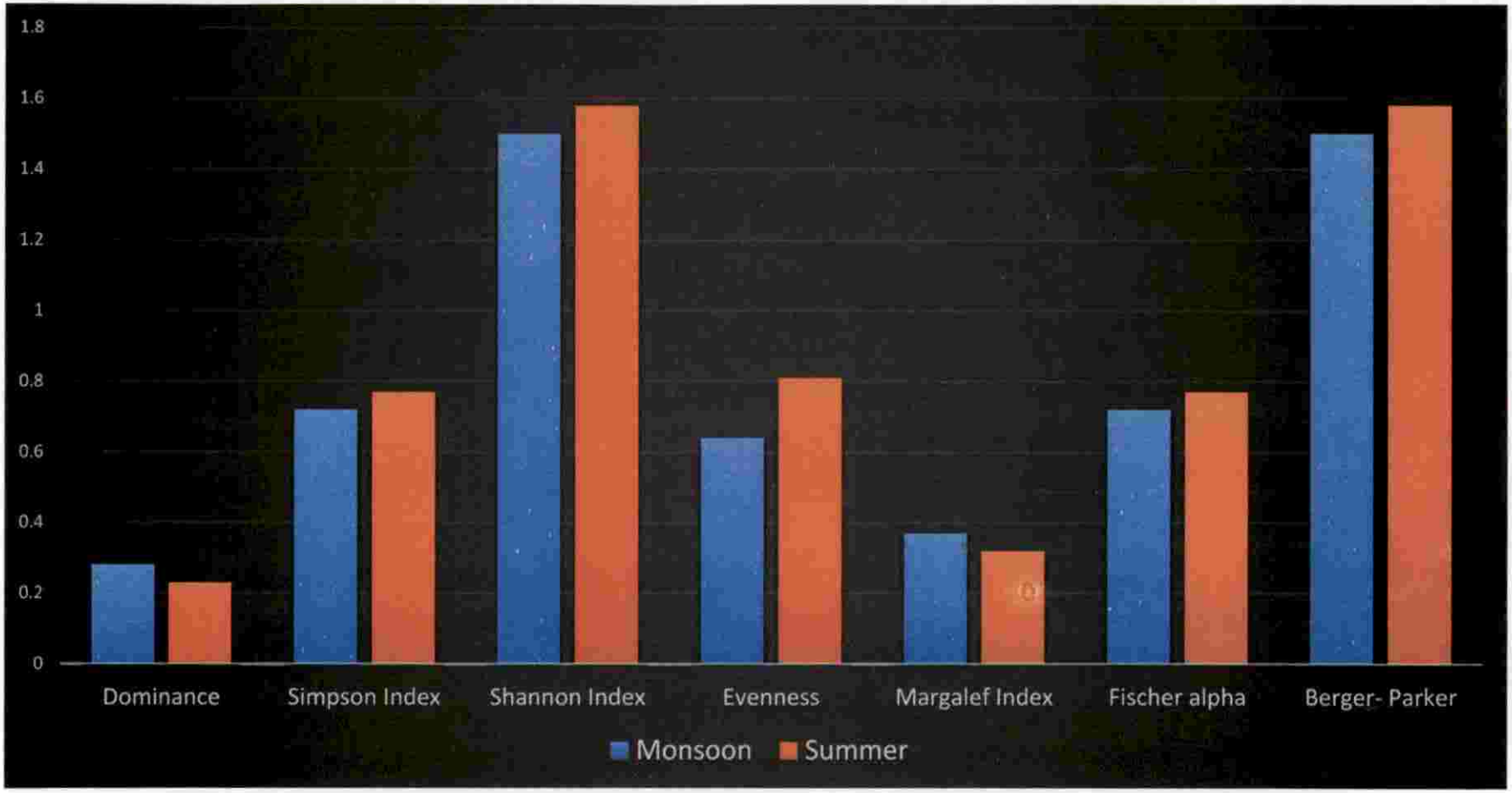

Fig. 3 Comparison of diversity indices of monsoon and summer

Table 9. Abundance of various species of rodents and insectivores in Silent Valley National Park.

Species	No. of individuals	% abundance
Rattus wroughtoni	20	71
Golunda ellioti	5	18
Suncus murinus	3	11

More to the point we have spotted four more species of rodents from SVNP. Among that two species were recorded in camera trap while the other two were seen directly. *Funambulus tristriatus* and *Hystrix indica* were detected in camera trap when *Funambulus sublineatus* and *Ratufa indica* were seen directly. *Funambulus sublineatus* was spotted only once during the entire study whereas *Funambulus tristriatus* was spotted twice in two different period of the study. *Ratufa indica* was noticed several times during the study. A pair was observed in Sairandhri in the summer season. *Hystrix indica* was photographed in a total of 19 camera traps placed in all the locations viz. Sairandhri, Poochippara and Neelikkal. A total of 50 images of *Hystrix indica* was obtained from the entire study.

4.5 DISTRIBUTION OF THE RODENTS AND INSECTIVORES OF SILENT VALLEY NATIONAL PARK

The study was mainly concentrated in two type of habitats such as evergreen forests and grasslands. *Rattus wroughtoni, Golunda ellioti* and *Suncus murinus* were collected from both the habitats. 90% of the capture of *Rattus wroughtoni* was from evergreen forests while majority of the capture of *Golunda ellioti* and *Suncus murinus* was from grasslands.

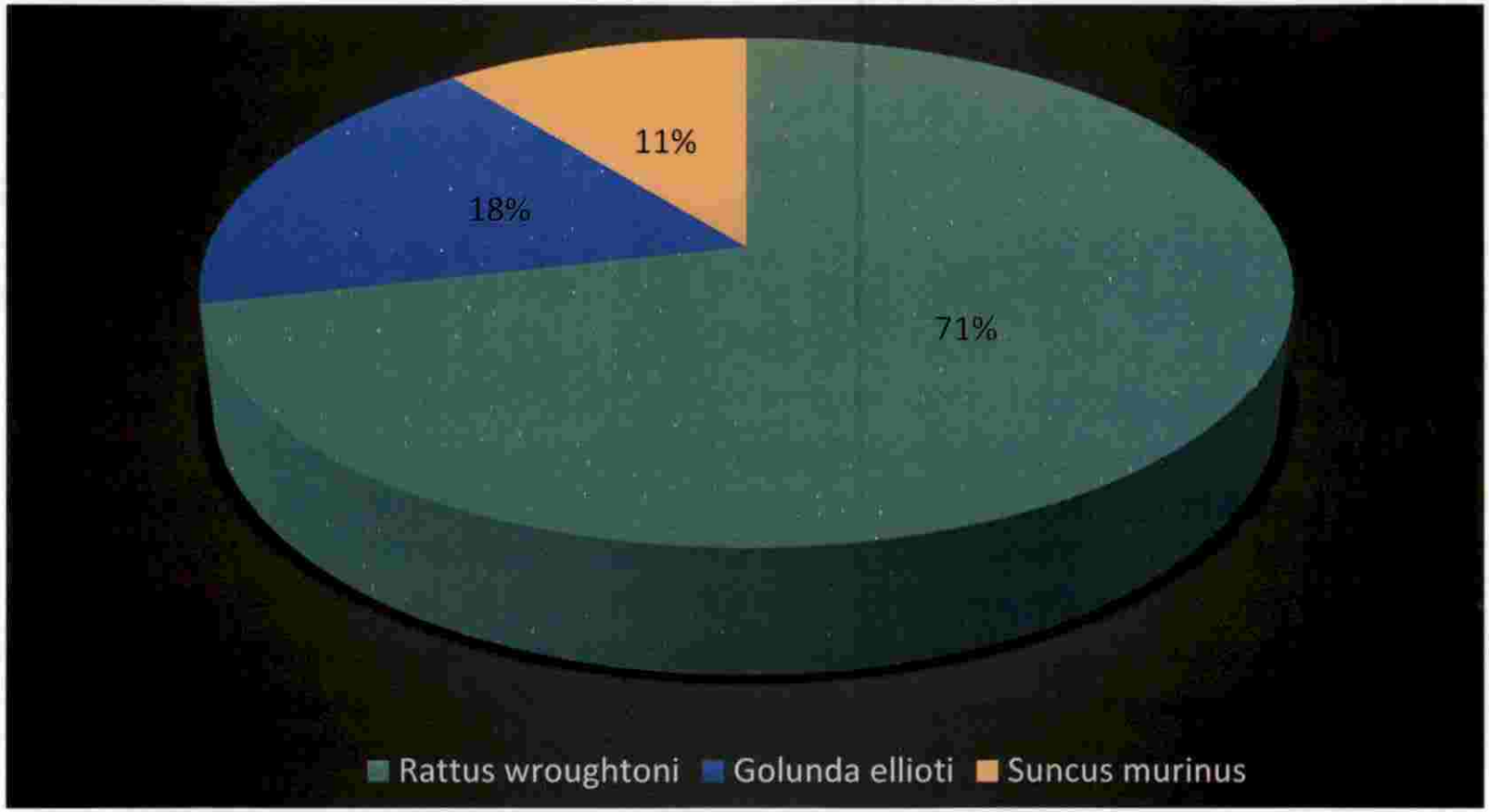

Fig.4 Abundance of various species of the rodents and insectivores of Silent Valley National Park

Table 10. Habitat preference (%) of rodents and insectivores in Silent Valley National Park

Species	Evergreen	Grasslands
Rattus wroughtoni	90%	10%
Golunda ellioti	20%	80%
Suncus murinus	33.33%	66.67%

4.6 SEASONAL PREFERENCE OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

The study was conducted in two seasons, monsoon and summer. The capture was more in the monsoon when compared to summer. 16 species were captured in monsoon while 12 were collected in summer. 70% of the capture of *Rattus wroughtoni* was in monsoon season while only 30% was caught in summer. In the case of *Golunda ellioti* and *Suncus murinus* higher capture rate was in summer.

Table 11. Seasonal preference of rodents and insectivores in Silent Valley National Park

Species	Monsoon	Summer
Rattus wroughtoni	70%	30%
Golunda ellioti	20%	80%
Suncus murinus	33.33%	66.67%

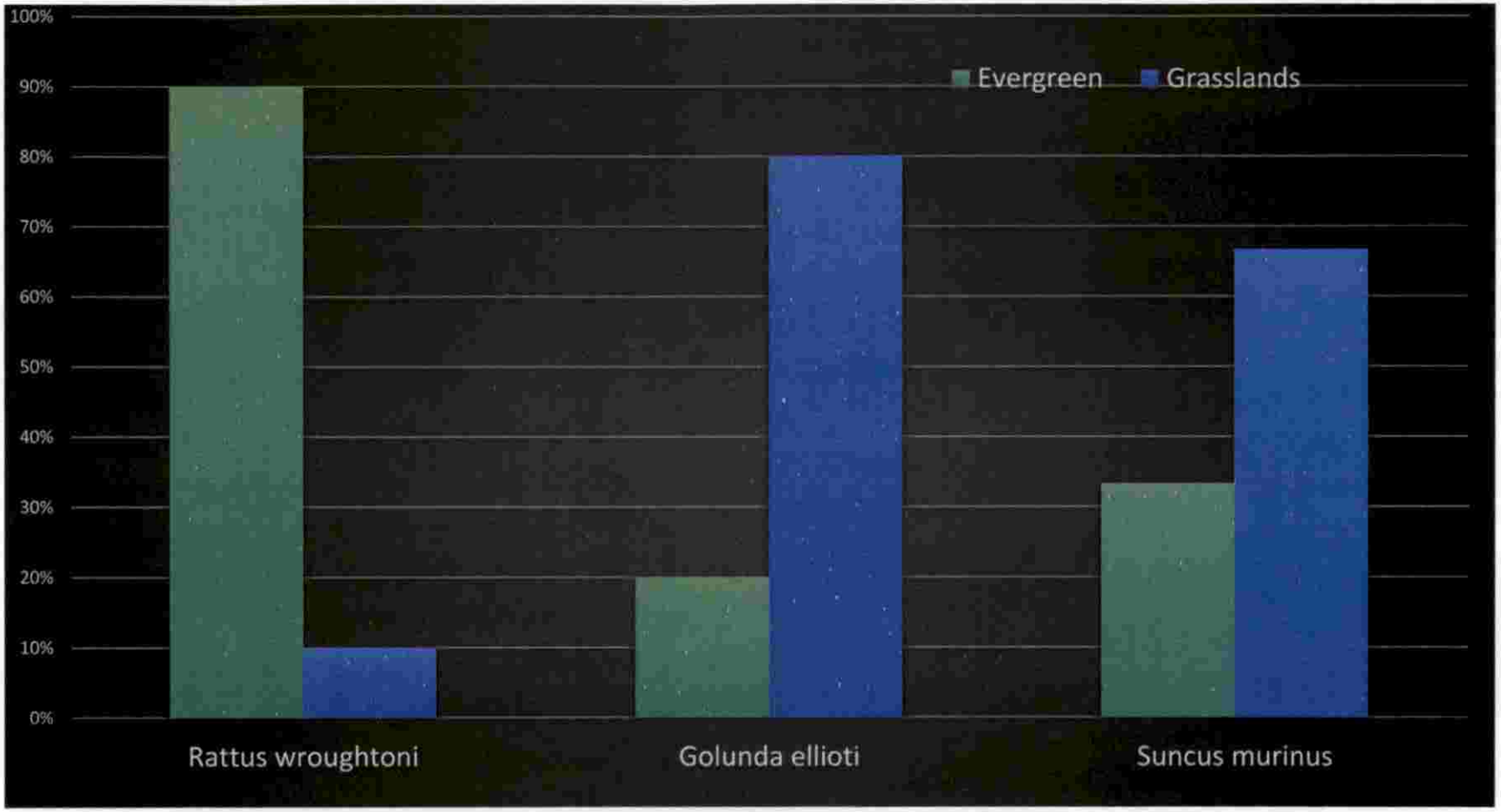

Fig. 5 Habitat preference of the rodents and insectivores of Silent Valley National Park

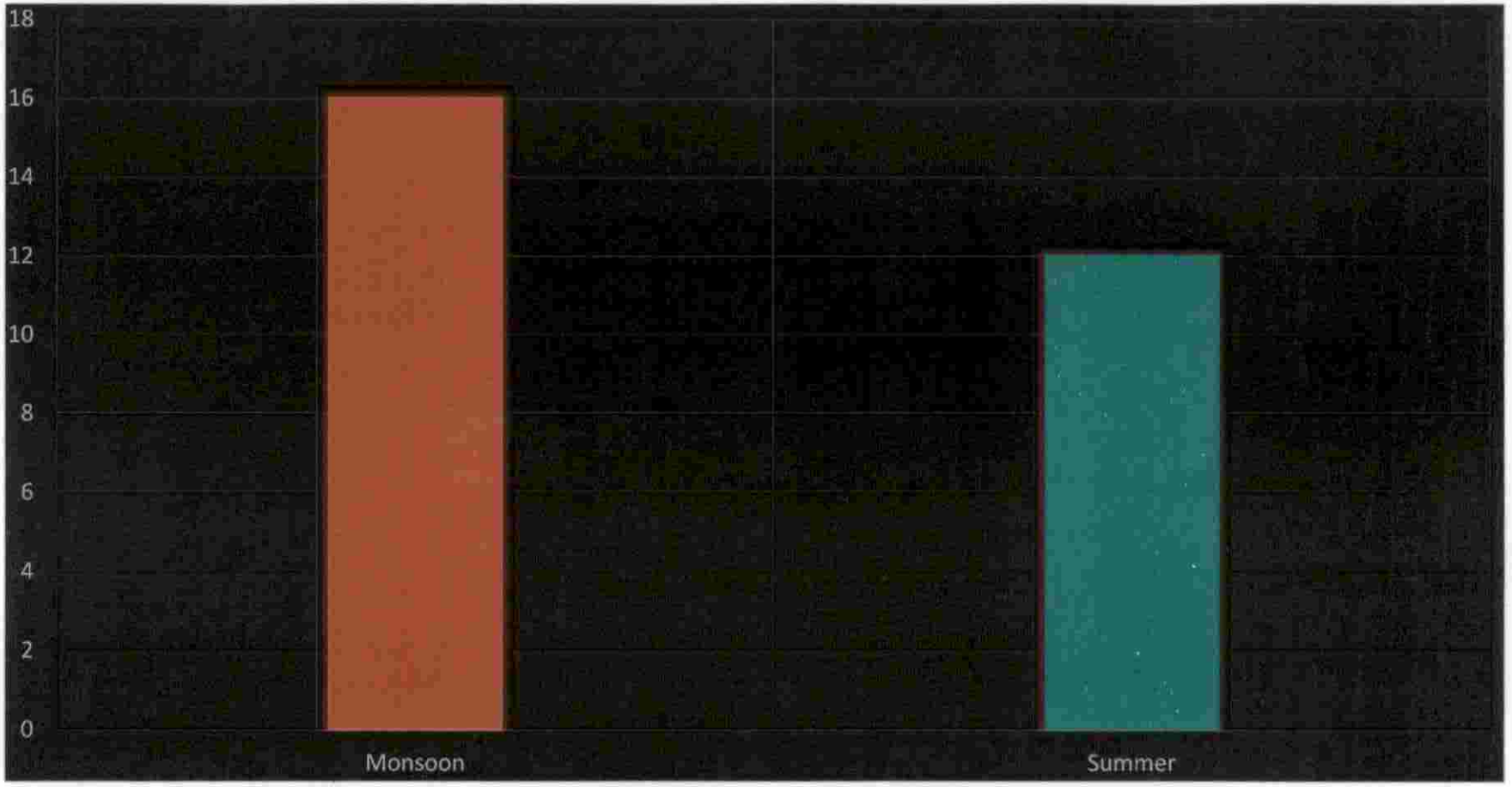

Fig. 6 Seasonal Preference of the rodents and insectivores in Silent Valley National Park

4.6.1 Sex ratio of the rodents and insectivores collected from Silent Valley National Park

The sex ratio of the rodents and insectivores collected during the study shows a high proportion of female compared to male. In the case of *Rattus wroughtoni* the ratio is 2:3, while it is 1:4 for *Golunda ellioti*. For *Suncus murinus* it is 1:2.

Table 12. Male female ratio of the rodents and insectivores

Species	No. of males	No. of females	Male: Female Ratio
Rattus wroughtoni	8	12	2:3
Golunda ellioti	1	4	1:4
Suncus murinus	1	2	1:2

4.7 MORPHOMETRIC MEASUREMENTS OF DIFFERENT SPECIES OF RODENTS AND INSECTIVORES COLLECTED DURING THE STUDY

Different species collected during the study were euthanized using Diethyl ether and different morphological measurements such as head to body length (HB), tail length (T), ear length (E) and hind foot length (HF) were measured using digital callipers. Then these measurements were compared with the standard key. In the case of rodents, Ellerman (1961) was used as the standard key while for insectivore Jiang and Hoffman (2013) was the accepted key.

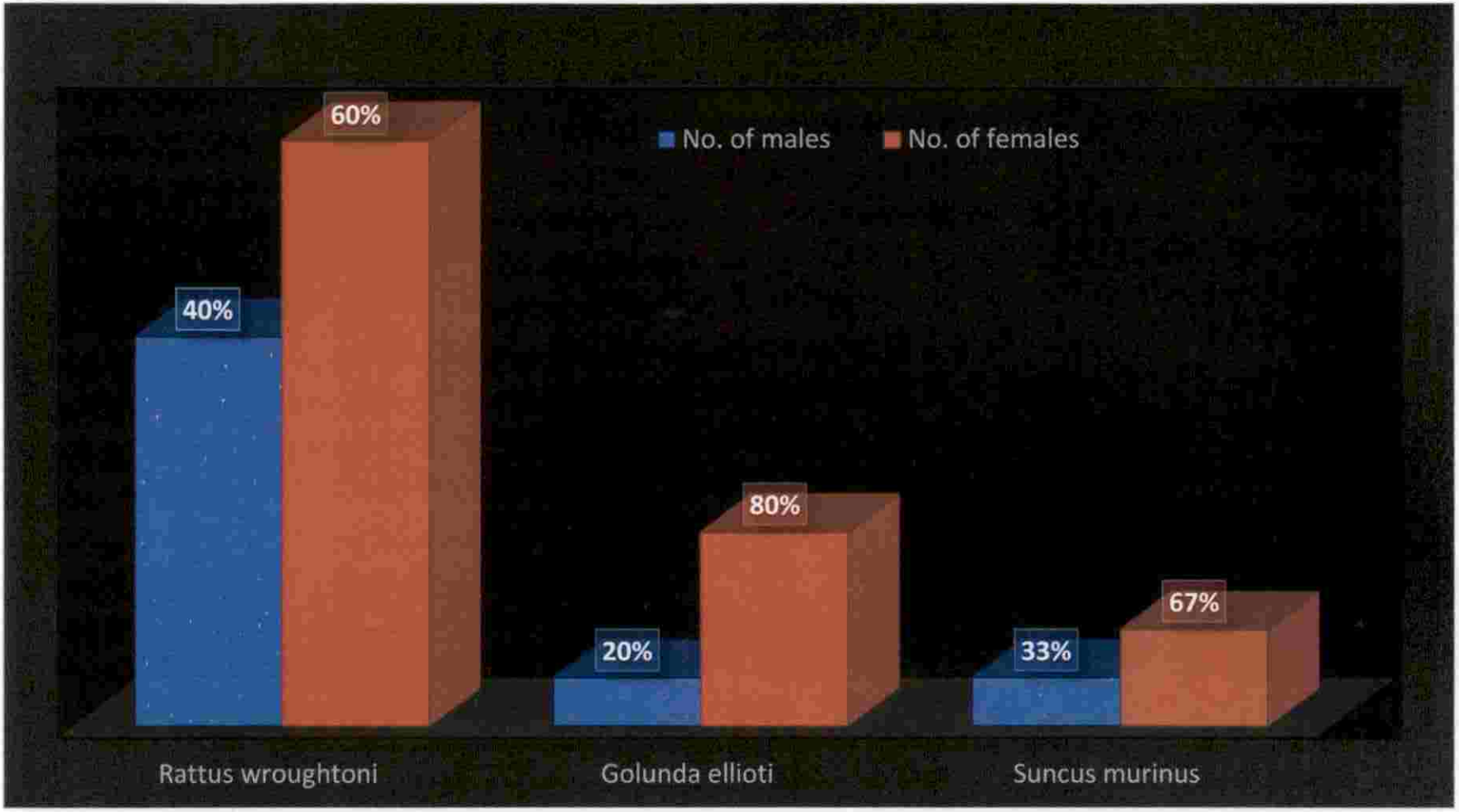

Fig. 7 Sex ratio of the rodents and insectivores of Silent Valley National Park

Table 13. Morphometric measurements of different species of rodents and insectivores collected during the study.

Species	Parameter	Mean	Range	SD	Range (as in Ellerman, 1961)
Rattus wroughtoni	HB (cm)	15.85	9.4-30.5	4.30	11.6-20.3
	T (cm)	71.5	7.8-21.6	5.54	15.9-25.6
	E (mm)	20.56	12.53-32.47	5.16	21-28
	HF (mm)	28.29	14.95-33.86	4.94	26-36

Species	Parameter	Mean	Range	SD	Range (as in Ellerman, 1961)
Golunda ellioti	HB(cm)	12.992	10.4-14.5	2.66	9.7-17.0
	T(cm)	8.172	4.25-10.6	6.02	7.4-12.9
	E(mm)	24.984	14.3-18.13	3.67	14-24
	HF(mm)	26.614	24.88-27.87	3.96	21-26

Species	Parameter	Mean	Range	SD	Range (as in Jiang and Hoffman, 2013)
Suncus murinus	HB(cm)	13.67	12.01-16.8	2.53	10.0-16.0
	T(cm)	7.81	6.9-8.9	5.73	4.5-9
	E(mm)	9.22	8.57-9.54	4.71	19-24
	HF(mm)	19.22	18.61-20.47	5.57	17-26

4.8 CRANIAL MEASUREMENTS OF DIFFERENT SPECIES OF RODENTS AND INSECTIVORES COLLECTED FROM SILENT VALLEY NATIONAL PARK

After extracting the skull various cranial measurements were taken and standard deviation was calculated. The measurements taken were detailed in the previous chapter. Then the mean of the measurements were compared with standard literature. Ellerman (1961) was the standard reference for the cranial measurements of rodents. Measurements of the captured individuals were seen to be within the standard range. The calculated standard deviation was found to be supporting the fact that the measurements taken had fallen within the standard range proposed in the literature.

Table 14. Cranial measurements of different species of rodents and insectivores collected during the study.

Species	Parameter	Mean	Range	SD	Range (as in Ellerman, 1961)
wroughtoni	ON	39.541	29-43.83	3.66	37.9-44
	CB	38.251	28.16-42.89	3.50	
	ZW	18.329	13.59-21.07	1.78	
	IW	6.3295	4.67-8.53	0.93	
	CW	17.2755	13.33-18.96	1.37	
	B	6.1375	3.86-7.6	0.91	6.02-7.5
	N	15.893	10.14-19.87	2.31	12.2-17.8
	APF	7.62	5.97-22.99	3.77	6.4-8.5
	M	6.772	4.79-7.65	0.73	5.5-7.5
	D	9.9	7.53-12.58	1.42	7.8-12.3
	PL	21.393	13.91-24.42	2.61	17.7-24.8
	MW	7.7195	5.38-8.67	0.81	5.92-6.9
	APF.W	3.358	2.4-5.4	0.72	

Species	Parameter	Mean	Range	SD	Range (as in Ellerman, 1961)
Golunda ellioti	ON	39.541	31.86-40.48	4.93	28-35.4
	CB	33.126	30.1-39.52	4.72	
	ZW	16.22	13.85-19.01	2.16	
	IW	5.62	4.35-7.45	0.95	
	CW	15.522	14.63-17.46	1.88	
	B	5.046	4.6-5.62	0.71	4.6-5.6
	N	13.058	10.14-18.42	3.69	
	APF	6.274	5.42-7.17	4.78	4.4-6.5
	M	6.438	5.32-6.93	0.80	5.8-6.8
	D	8.35	7.39-9.73	1.52	
	PL	17.352	16.5-18.17	2.37	14.4-16.5
	MW	7.084	6.21-8.21	0.96	
	APF.W	2.574	2.4-2.75	0.53	
	ON	39.541	31.86-40.48	4.93	28-35.4

Species	Parameter	Mean	Range	SD
Suncus murinus	C'-C'	2.74	2.48-2.92	0.70
	M^3-M^3	6.81	5.76-8.62	1.25
	BB	12.02	11.42-13.65	1.29
	C-M^3	10.14	9.7-10.8	0.97

	GTL	30.41	29.64-31.01	0.90
	CCL	26.06	25.31-27.55	0.84
	ZB	10.35	9.37-11.31	1.07
	IC	5.52	4.95-6.49	0.58
	M	14.84	13.66-15.73	0.55
	CBL	27.27	26.32-28.68	1.58
	CM_3	8.19	7.56-8.55	0.23

4.9 MICRO-HABITAT PARAMETERS OF THE STUDY AREA IN SILENT VALLEY NATIONAL PARK

Thirteen site and micro-habitat variables were measured within 2m radius circular plots centred on traps with captures of rodents and insectivores. In a study area we have placed 50 trap station. So we have collected all the habitat parameters from all these 50 trap stations. The collected information on the habitat parameters were analysed using independent t- test and logistic regression test.

An independent t-test was carryout for testing whether habitat parameters influence the capture of the rodents and insectivores. It has been found that among the 13 habitat parameters observed, only the climber density was found to be significant in the presence of the animal.

Table 15. Results of t-test of habitat parameter

Habitat Parameter	Capture plot mean	Non capture plot mean	T value
Altitude	1036.09	1047.71	1.771^{ns}
Canopy Cover	50.41	59.58	1.145^{ns}
Canopy Height	16.50	16.65	0.057^{ns}
Litter Depth	1.49	1.98	1.590^{ns}
Shrub	20.68	16.97	1.499^{ns}
Trees	4.82	4.07	0.903^{ns}
Largest tree	14.95	14.48	0.185^{ns}
Water Body	0.14	0.15	0.210^{ns}
GBH	94.09	94.12	0.002^{ns}
Log	0.77	0.82	0.23^{ns}
Rock	0.64	0.78	1.51^{ns}
Climbers	1.55	0.57	3.09*
Road	0.55	0.53	0.127^{ns}

*- Significant at 5% level ns- Non significant

4.10 ANALYSIS OF DATA OF *HYSTRIX INDICA* (INDIAN CRESTED PORCUPINE) OBSERVED IN CAMERA TRAPS

Along with the study of rodents and insectivores, a study on the small carnivores were also carried out in Silent Valley National Park. In the camera traps placed in different locations of Silent Valley, we got images of Indian crested Porcupine. We also collected observations of habitat parameters of the trap stations. A logistic regression test was carried out on the habitat parameters in order to predict the presence or absence of the species in the studied trap stations. It has been found that the presence of rock in the trap stations had significant influence in the presence of the species.

Table 16. Analysis of habitat parameters for the presence or absence of *Hystrix indica*

Source	Regression coefficients	Wald Chi-Square	P-value
Canopy Height (m)	-0.046	0.678	0.410
Canopy cover (%)	-0.020	1.699	0.192
Litter depth(cm)	-0.062	0.042	0.838
shrub density(trees/area)	0.015	3.366	0.067
Tree density	-0.130	1.687	0.194
Climber density	0.095	0.873	0.350
Buttress density	0.362	1.015	0.314
Canes	-0.199	0.098	0.754
Distance to largest tree (m)	0.032	0.148	0.700
GBH (cm)	0.002	0.153	0.696
Hole	0.233	0.022	0.881
Water body	-1.764	3.386	0.066
Rock	2.131	7.094	0.008*
Fruiting Tree	1.381	2.660	0.103
Swamp	0.373	0.056	0.814
Roots	-1.287	2.276	0.131
Roads	0.793	0.972	0.324
Log	1.283	2.065	0.151

*significant at 5% level

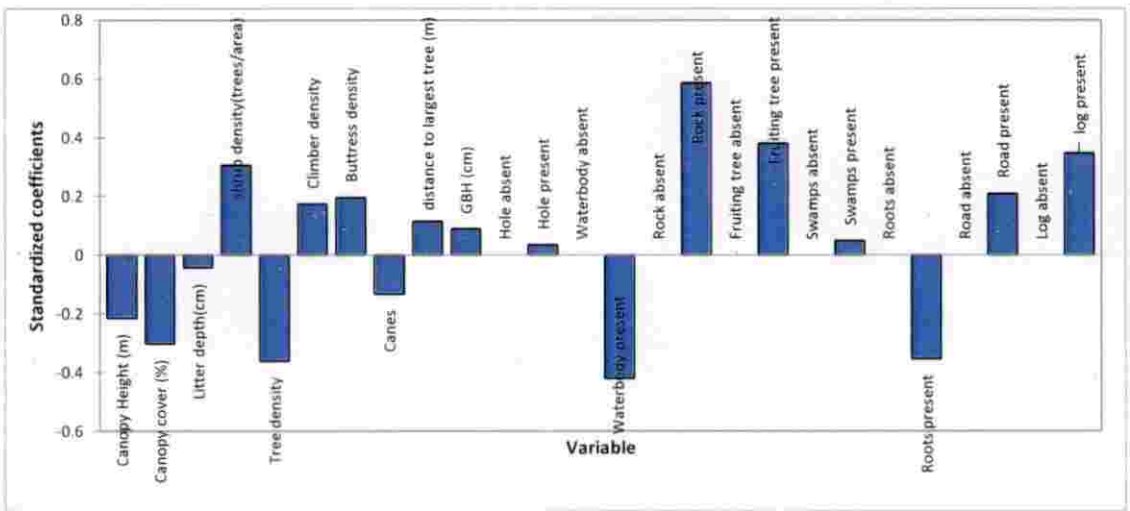

Fig. 8 Analysis of habitat parameters for the presence or absence of *Hystrix indica*

Discussion

DISCUSSION

5.1 DIVERSITY OF RODENTS AND INSECTIVORES OF SILENT VALLEY NATIONAL PARK

The present study identified the presence of six species of rodents and one species of insectivore in Silent Valley National Park. This includes two species of murids viz. *Rattus wroughtoni* and *Golunda ellioti*, three species of sciurids viz. *Funambulus tristriatus*, *Funambulus sublineatus* and *Ratufa indica,* one species of porcupine, *Hystrix indica*. While the insectivore that was sighted from SVNP was *Suncus murinus*.

5.1.1 Rodents

5.1.1.1 White-bellied Rat or Common House Rat

Scientific Name: *Rattus wroughtoni* (Hinton, 1919)

Family: Muridae

Order: Rodentia

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016).

Distribution: Throughout India and Pakistan in South Asia.

Ecology and Behaviour: They are nocturnal, terrestrial as well as arboreal, and live in temperate montane forests, tropical and subtropical evergreen forests, montane forests, arable land, cultivated land, plantations and human habitation at <2000 m.

This was the species caught most during the study. 38% of the total species encountered in the study was White-bellied Rat. This is a medium-sized rat with short and rough brown or greyish-brown dorsal pelage mixed with or without soft spines, and grey or white ventral pelage. The hands and feet have brown streaks

dorsally. The tail is unicoloured brown, and is distinctly longer than head and body length. The underside of the body is grey or white (Prakash *et al.*, 2015). During the present study, 20 individuals were caught from both evergreen and grassland and in monsoon as well as in summer.

5.1.1.2 Indian Bush Rat

Scientific Name: *Golunda ellioti* (Gray, 1837)

Family: Muridae

Order: Rodentia

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016)

Distribution: Throughout India; Bhutan, Iran, Nepal, Pakistan, Sri Lanka.

Ecology and Behaviour: They are partially diurnal, fossorial and terrestrial, semi-arboreal, not particularly gregarious and herbivorous. They are found in varied habitat conditions, from tropical dry deciduous, shrub, thorn forests to grasslands at 100–1300 m.

This is a monotypic genus with a fair distribution in India and the neighbouring countries of Nepal, Pakistan and Sri Lanka (Molur et al. 2005). This is a thickly-haired medium-sized rat with greyish-brown to blue/blackish dorsal pelage blending into the bluish-grey ventral pelage. The hands and feet are greyish-white to brown dorsally and six small black plantar pads are seen ventrally. The tail has short and coarse hairs, is bicoloured dark above and paler below, and slightly shorter than head and body length. IUCN Red List Threatened Species as Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>). Due to wide distribution and no major threats affecting its population. During this study five individuals were caught from three of the study areas.

5.1.3 Jungle Palm Squirrel

Scientific Name: *Funambulus tristriatus* (Waterhouse, 1837)

Family: Sciuridae

Order: Rodentia

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016)

Distribution: Endemic to Western Ghats. Seen in Kerala, Karnataka, Tamil Nadu and Maharashtra.

Ecology and Behaviour: It inhabits in evergreen forests of the Western Ghats (Moore and Tate, 1965), but also in plantations and villages close to forests. This squirrel is more arboreal than some other species of the same genus. Jungle Palm Squirrel is omnivorous who consumes paddy grains, coconut flowers, termites, caterpillars, fruits, ants and beetles (Bhat and Mathew 1985).

Jungle Palm Squirrel also known as Western Ghats Squirrel is the largest species of this genus. There are three narrow white or pale buffy stripes on the back separated by brown or blackish bands and underparts are light or whitish. The tail is most often shorter than the head to body length whose underside is bright rufous (Datta and Nandini, 2015). Fourth finger is usually dominant in the hand. The species is endemic to Western Ghats (Prater, 1971 and Menon 2014). This species was rare in the study area and observed only twice during the study, captured in the camera traps on both the occasions.

5.1.4 Nilgiri Palm Squirrel

Scientific Name: *Funambulus sublineatus* (Waterhouse 1838)

Family: Sciuridae

Order: Rodentia

IUCN Status: Vulnerable (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016).

Distribution: This species is endemic to Western Ghats and is seen in the evergreen forests of Western Ghats at an elevation above 700m.

Ecology and Behaviour: The species is shy and secretive, occurring in damp areas in very dense forests among lianas, climbers and dense undergrowth.

This is a small dark rather soft-furred squirrel with rather narrow tail, which lacks the red mid ventral line. The tail averages a little longer the head and body. The body colour is a dark grizzled olive, tinged tawny brown above, with three pale lines alternating with four dark brown longitudinal stripes on back and rump (Datta and Nandini, 2015). Prater (1948) and Thorington *et al.* (2012) described two subspecies *Funambulus sublineatus sublineatus* which occurs in India and *Funambulus sublineatus obscurus* which occurs in Sri Lanka. However, Dissanayake and Oshida (2012) consider the Sri Lankan subspecies as a distinct species and now the species in India is named as Nilgiri Palm Squirrel. During the study it was found only once in Sairandhri section.

5.1.5 Malabar Giant Squirrel

Scientific Name: *Ratufa indica* (Erxleben, 1777)

Family: Sciuridae

Order: Rodentia

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016)

Distribution: Occurs in Western Ghats, Eastern Ghats and the highlands of central India.

Ecology and Behaviour: Throughout its range, the species is patchily distributed as it is restricted to mature forests, with continuous tree canopy

cover and high tree diversity. They are diurnal. The giant squirrel is a facultative frugivorous, generalist herbivore. It prefers nutrient-rich seeds, but also consumes ripe and unripe fruit pulp, leaf buds and tender leaves, mature leaves, leaf petioles, flowers, nectar and tree sap. They are solitary, with a complex social system that includes elements of territoriality and dominance.

Malabar Giant Squirrel, also known by the name Indian Giant Squirrel is an endemic species to India. It is a large, arboreal squirrel with a long fluffy tail and tufted ears (Borges, 2015). This species appears in varying bright pelages. The upper part is a mixture of maroon and black colour and all the under parts are creamy or buff coloured. The tail is either all black or in varying shades of red coupled with a creamy yellow tip and a pale mid ventral line. Four subspecies of *R. indica* were identified by Moore and Tate (1965). They are *R. indica maxima* in the extreme southern Western Ghats with a black tail, black shoulders, nape, rump and thighs; *R. indica indica* of the mid-Western Ghats with a red maroon back and white yellow tail tip; *R indica centralis* of central India and Eastern Ghats with black patches in the shoulders and *R. indica dealbata* of the Surat danges was albinistic which is now believed to be extinct (Borges, 1991). In the northern Western Ghats, this Squirrel is brownish maroon in appearance with all brown or white tail (Prater, 1971). In the present study, the species was reported from Sairandhri and Poochippara sections.

5.1.6 Indian Porcupine

Scientific Name: *Hystrix indica* (Kerr, 1792)

Family: Hystricidae

Order: Rodentia

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016)

Distribution: Occurs from Sri Lanka northwards to Bangladesh, Nepal and Kashmir, westwards through Baluchistan, Russian Turkestan, Syria, Israel, Iraq and Saudi Arabia (Ellerman 1961, Alkon and Saltz 1988).

Ecology and Behaviour: The Indian Porcupine occurs from the moist, temperate, deciduous forests as well as evergreen forests. They inhabits in rock crevices or burrows dug by them. They have well defined home range, which varies to the habitat occupied by the animals. Porcupines are herbivores and spend considerable time foraging (Saltz 1985, Sever 1985). They are monogamous and females display aggressive behaviour on the approach of unfamiliar males.

Indian Porcupine, with a long crest of thin bristles from the forehead to the back of the head, is also known as the white-tailed porcupine. It is the largest rodent in Central and South India and also it is the common and largest porcupine of India (Alkon and Saltz 1983-84). The body is covered with long black and white quills with a long crest of spines flowing from forehead to the middle of the back. Its tail ends in a bunch of thick white quills. In southern India sub-species is often referred to as the "Red Porcupine" which has quills with a rusty tinge on its back (Sharma, 2015). During the present study at SVNP, 13 individuals were captured in camera traps set up in different locations such as Sairandhri, Neelikkal and Poochippara.

5.1.7 Grey Musk Shrew

Scientific Name: *Suncus murinus* Linnaeus, 1785

Family: Soricidae

Order: Soricomorpha

IUCN Status: Least Concern (The IUCN Red List of Threatened Species. Version 2016-1. <www.iucnredlist.org>. Downloaded on 30 June 2016)

Distribution: Broadly distributed in South Asia. Throughout seen in India and Kerala.

Ecology and Behaviour: Seen in and around human habitation, rice fields, and grain warehouses though some of the montane forms live in natural habitats, including grasslands, scrub and forest. Musk shrew is beneficial to humans because its diet includes mostly of harmful insects, and it is intolerant to rats, helping keep away them. They also have vegetable matter and are active in both day and night.

This species is also known as Asian House Shrew. This is the commonest among shrew species and is distribution in India and the neighbouring countries of Bhutan, Bangladesh, Nepal, Pakistan and Sri Lanka (Molur et al. 2005). The House Shrew is broadly distributed in the South Asian regions extending north to Afghanistan, eastward to southern China, Taiwan and Japan and Southward throughout Southeast Asia, including Thailand, Vietnam, Malaysia, Indonesia and the Philippines. It lives in all kind of habitats and also in human habitation. The characteristic odour they leave behind give the name Musk Shrew. There is a strong odour of musk, derived from a gland on each side of the body, surrounded by stiff hairs directed inwards. There is also considerable variation in colour, from blackish to brownish to light bluish grey, with ventral side slightly lighter. The tail is thickened at the base and tapers to a fine point, and is scattered with a few long bristly hairs. The ear is naked, with distinctive folds within the conch. It is a Least Concern species in India (Molur et al. 2005) and also globally (Hutterer et al. 2008) according to the 2015 IUCN Red List of Threatened Species. During the study at SVNP three individuals were caught from Sairandhri and Neelikkal sections.

5.2 SPECIES DIVERSITY AND ABUNDANCE OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

From Silent Valley National Park, six species of rodents and one species of insectivores were identified. We got 28 individuals from a total of 200 traps placed in different locations. Akonda and Khan (2000) reported twenty one species of rodents and four species of insectivores from Bangladesh. Kasangaki *et al.* (2003), who studied the small mammals in Bwindi National Park, Uganda found that the species richness of the small mammals decrease with an increase in altitude.

Chandrasekara-Rao and Sunquist, (1996) reported five species of rodents from Anamalais. While Venkataraman *et al.* (2005) reported six species of rodents and one insectivore from Mudumalai Wildlife Sanctuary. They were represented by 396 captures of 195 individuals out of a total of 7,425 trap nights with a reasonably high overall capture rate of 5.3% (Venkataraman 1997, Venkataraman *et al.* 2005). A total of 11 species of non-volant small mammals were recorded by Srinivasulu *et al.* (2006) in a study on the non-volant small mammals of Kasu Brahmananda Reddy National Park, Andhra Pradesh. The family Muridae recorded with a maximum number of species followed by Sciuridae in a study on the mammals of Meghamalai, north-eastern side of Periyar Tiger Reserve by Babu et al. (2013), in which 63 species of mammals belonging to 24 families were recorded from the landscape. Fourteen species of non-volant small mammals were reported by Molur and Singh (2009) from Coorg District of Western Ghats. They carried out the study in various habitats such as forest fragments, coffee and cardamom plantations, open area including grasslands, agricultural fields including paddy and ginger cultivations, bamboo and in an around human habitations for a total of 11060 trap nights with an overall trap success of 3.8%. In their study also *Rattus wroughtoni* was the most commonly caught species.

In similar studies conducted in two protected areas of Kerala such as Chimmony Wildlife Sanctuary and Parambikulam Tiger Reserve similar findings were obtained. Seven species of rodent and one species of insectivores were reported by Babu (2008) while studying the diversity and abundance of rodents and

insectivores in the Chimmony Wildlife Sanctuary. Fasil (2010) also reported seven species of rodents from Chimmony. Mareena (2011) reported seven rodents while Thomas (2012) recorded nine species of rodents and one species of insectivore from Parambikulam Tiger Reserve.

5.3 STATUS OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

Out of seven rodents recorded from Silent Valley National Park, we were able to capture only two species viz. *Rattus wroughtoni* and *Golunda ellioti*. One species of insectivore captured was *Suncus murinus,* whose three individuals were captured from two different sites. The most abundant species captured was *Rattus wroughtoni* with 20 individuals followed by *Golunda ellioti* with only five captures. The image of *Hystrix indica* was obtained in the camera traps. We got 50 images from 19 camera traps which placed in different locations of the study area which indicates its presence all over the study area. *Ratufa indica* was there in two of our study areas while other sciurid members like *Funambulus tristriatus* and *Funambulus sublineatus* were very rare so that we could encounter them only once and only in one section of Silent Valley.

Among the species that encountered in Silent Valley, two were endemic to Western Ghats and one is endemic to Peninsular India. The Malabar Giant Squirrel, *Ratufa indica* is endemic to peninsular India while Nilgiri palm Squirrel, *Funambulus sublineatus* and Jungle Palm Squirrel, *Funambulus tristriatus* are endemic to Western Ghats.

5.5 HABITAT PREFERENCE OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

The two different habitats selected of the study were evergreen forest and grasslands. The capture of *Rattus wroughtoni* was more in evergreen forest while the capture of *Golunda ellioti* and *Suncus murinus* were more in grasslands.

We have collected 13 habitat parameters from all the 200 trap stations. However, among these habitat variables, the climber density has been the sole

factor that was found to be significant (0.05%) in determining the presence of the small mammals at SVNP. Mudappa *et al.* (2001), made a similar observation on the Spiny Tree Mouse *Platacanthomys lasiurus,* where the presence of the Tree Mouse was influenced by the climber density of the area.

5.6 SEASONAL PREFERENCE OF RODENTS AND INSECTIVORES IN SILENT VALLEY NATIONAL PARK

The present study was carried out in two seasons viz monsoon, from September to November and summer, from February to April. Majority of the capture was in monsoon season. The capture was low in summer. Availability of water may be the factor which influenced the capture of animals. Shanker (2000), also reported that in his study on the small mammals in tropical montane forests of Upper Nilgiris the capture was more in rainy season than in dry season. In his study on the species richness, endemism and richness of threatened species of rodents and insectivores of Africa Amori *et al.* (2011), they found that both rodents and insectivores showed species richness increased with rainfall.

Summary

SUMMARY

Rodents and insectivores are the important members of the category non-volant small mammals which are least studied group in India as well as in Kerala. As far as Kerala is concerned little knowledge is available on the diversity, ecology, abundance and habitat preference of rodents and insectivore of Kerala. The present study is the first-ever study on the rodents and insectivores of Silent Valley National Park. The objectives was to study the species diversity, relative abundance, distribution and habitat preference of the rodents and insectivores - such as squirrels, mice, rats and shrews in Silent Valley National Park. The study was carried out from September 2015 to April 2016. The method used for the study was using Sherman Trap technique. The study was conducted in three sites within the core area of Silent Valley National Park viz. Sairandhri, Poochippara and Neelikkal. The study was carried out mainly in two seasons' viz. monsoon and summer and in the evergreen forests and the grasslands. 50 traps were placed in each of the study area. The major findings of the study are summarized below.

- A total of six species of rodents and one species of insectivore were reported from Silent Valley National Park
- Among the six rodents two were rats, three were squirrels and the remaining one was porcupine
- The rats were *Rattus wroughtoni* (White-bellied Rat) and *Golunda ellioti* (Indian Bush Rat)
- The squirrels were *Ratufa indica* (Malabar Giant Squirrel), *Funambulus tristriatus* (Jungle Palm Squirrel) and *Funambulus sublineatus*
- The Malabar Giant Squirrel, *Ratufa indica* is endemic to peninsular India while Nilgiri palm Squirrel, *Funambulus sublineatus* and Jungle Palm Squirrel, *Funambulus tristriatus* are endemic to Western Ghats.
- The porcupine identified was *Hystrix indica* (Indian Crested Porcupine)

- The one and only insectivore captured was *Suncus murinus* (Grey musk Shrew)
- A total of 7600 trap days of sampling was carried out within 38 days with a total of 182400 trap hours.
- The capture of individuals was more in monsoon season than in summer season
- The majority of capture was from evergreen forests than in grasslands
- Out of the total individuals observed, 71% was *Rattus wroughtoni,* 18% was *Golunda ellioti* and 11% was *Suncus murinus*
- Among the 13 habitat parameters observed from the 200 trap stations, only the density of lianas were found to be significantly influencing the presence of the animal in the capture plot

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Taxonomic inventory and ecology of the rodents and insectivores of Silent Valley National Park, Kerala

By

DEVIPRIYA , K. S

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ABSTRACT

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Faculty of Forestry

Kerala Agricultural University

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

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ABSTRACT

Rodents and insectivores accounts for about 55% of the total mammalian diversity of the world and is true with Kerala too. Very little studies have been done on the rodents and insectivores of Kerala and no previous studies have been done in Silent Valley NP. Thus, a study was conducted on the taxonomic inventory and ecology of the rodents and insectivores of Silent Valley National Park, which is one of the few remaining pristine rain forests of Kerala. The objectives was to study the species diversity, relative abundance and habitat preference of the rodents and insectivores - such as squirrels, mice, rats and shrews in Silent Valley National Park. The study was carried out from September 2015 to April 2016. The method used for the study was using Sherman Traps technique. 50 Sherman traps were used in each of the four study locations. The study was carried out in two season viz. monsoon and summer and in two habitat types, evergreen forests and grasslands.

Six species of rodents and one species of insectivore were recorded from Silent Valley National Park. The rodents recorded were members of Muridae, Sciuridae and Hystricidae families. These includes *Rattus wroughtoni, Golunda ellioti, Ratufa indica, Funambulus tristriatus, Funambulus sublineatus* and *Hystrix indica.* The insectivore observed at SVNP was Suncus murinus of the family Soricidae. Though the rodent and insectivore abundance was more during the monsoon season, there was no significant difference. Similarly though the rodent abundance was more at the evergreen forests, this was also insignificant. Among the microhabitat parameters studied, the climber density has found to be significantly influencing the rodents at Silent Valley. *Rattus wroughtoni* was the most abundant species of rodent at Silent Valley. Among the rodents of Silent Valley, Ratufa indica is endemic to peninsular India while *Funambulus tristriatus, Funambulus sublineatus* are endemic to Western Ghats. The Funambulus sublineatus is a threatened species of squirrel seen at Silent Valley and the IUCN Redlist category of this is Vulnerable.

Appendices

Table. 1 Morphological measurements of rodents captured from Silent Valley National Park

Study Area	Location	Date	Specimen No.	*Species*	Weight	HB (CM)	T(CM)	E(MM)	HF(MM)	Sex
Silent Valley	Sairandhri	26-09-2016	KAUNHM 201548	*Rattus wroughtoni*	67	12.6	17.7	22.71	31.05	F
Silent Valley	Sairandhri	29-09-2015	KAUNHM 201549	*Rattus wroughtoni*	120	16.8	21.2	23.68	28.85	M
Silent Valley	Sairandhri	02-10-2015	KAUNHM 201553	*Rattus wroughtoni*	34	11.4	12.9	16.89	26.73	F
Silent Valley	Sairandhri	30-09-2015	KAUNHM 201550	*Rattus wroughtoni*	33	10.5	13.5	19.3	25.55	F
Silent Valley	Sairandhri	05-10-2015	KAUNHM 201556	*Rattus wroughtoni*	130	17	20.8	22	31.15	F
Silent Valley	Sairandhri	30-09-2015	KAUNHM 201551	*Rattus wroughtoni*	61	13.2	18.4	20.18	32.47	F
Silent Valley	Sairandhri	02-10-2015	KAUNHM 201552	*Rattus wroughtoni*	130	16.8	21.6	23.01	27.95	F
Silent Valley	Sairandhri	06-10-2015	KAUNHM 201557	*Rattus wroughtoni*	27	9.4	12.2	14.69	26.51	F
Silent Valley	Sairandhri	04-10-2015	KAUNHM 201554	*Rattus wroughtoni*	20.4	10.5	12.5	12.84	20.65	F
Silent Valley	Sairandhri	04-10-2015	KAUNHM 201555	*Rattus wroughtoni*	135	19.2	20.8	21.88	31.38	F
Silent Valley	Poochippara	26-02-2016	KAUNHM 201625	*Rattus wroughtoni*	72	14.3	19.5	20.09	32.9	M
Silent Valley	Poochippara	25-02-2016	KAUNHM 201623	*Rattus wroughtoni*	69	13.37	17.5	22.26	30.89	F
Silent Valley	Poochippara	25-02-2016	KAUNHM 201622	*Golunda ellioti*	82	13.7	6.7	17.1	27.11	F
Silent Valley	Poochippara	26-02-2016	KAUNHM 201624	*Golunda ellioti*	73.5	13.16	4.25	17.17	25.94	F
Silent Valley	Sairandhri	07-04-2016	KAUNHM 201626	*Golunda ellioti*	76	14.5	10.07	17.36	27.27	F
Silent Valley	Sairandhri	07-04-2016	KAUNHM 201629	*Golunda ellioti*	66	13.2	94.45	18.13	27.87	F
Silent Valley	Sairandhri	14-04-2016	KAUNHM 201633	*Rattus wroughtoni*	96	15.7	19	21.92	31.92	F
Silent Valley	Sairandhri	07-04-2016	KAUNHM 201627	*Rattus wroughtoni*	79	15.1	19.5	20.91	31.38	M
Silent Valley	Sairandhri	07-04-2016	KAUNHM 201628	*Rattus wroughtoni*	90	14.5	21.3	20.44	30.79	M
Silent Valley	Sairandhri	10-04-2016	KAUNHM201631	*Rattus wroughtoni*	64	12.2	18.4	21.34	30.99	M
Silent Valley	Sairandhri	10-04-2016	KAUNHM 201632	*Rattus wroughtoni*	130	17.7	22	22.53	33.86	M
Silent Valley	Neelikkal	23-11-2015	KAUNHM 201558	*Rattus wroughtoni*	56	30.5	17	18.55	28.69	M
Silent Valley	Neelikkal	25-11-2015	KAUNHM 201560	*Rattus wroughtoni*	43	18.9	7.8	12.53	14.95	F
Silent Valley	Neelikkal	25-11-2015	KAUNHM 201561	*Golunda ellioti*	29	10.4	10.6	14.3	24.88	M
Silent Valley	Neelikkal	25-11-2015	KAUNHM 201562	*Rattus wroughtoni*	63	21.5	17	21.33	29.35	M

Table. 2 Cranial measurements of rodents captured from Silent Valley

Specimen No.	ON	CB	ZW	IW	CW	B	N	APF	M	D	Pl	MW	APF.W
KAUNHM 201548	37.2	36.32	18.59	5.98	17.65	6.05	13.3	6.54	5.9	9.32	22.01	6.99	2.4
KAUNHM 201549	40.36	39.03	19.1	6.06	16.68	6.83	15.46	6.85	7.41	9.56	23.19	8.09	2.7
KAUNHM 201553	40.42	39.22	19.76	6.77	17.04	7.3	15.74	7.02	7.34	10.56	23.03	8.67	3.02
KAUNHM 201550	39.4	37.35	17.98	6.43	16.43	6.4	13.6	5.97	6.01	8.98	22.5	7.57	2.6
KAUNHM 201556	42.76	40.23	19.02	8.53	18.42	7.43	16.33	6.72	7.42	10.73	22.67	8.45	4.53
KAUNHM 201551	38.6	36.89	18.93	5.96	15.58	6.6	13.8	6.01	5.97	9.01	22.91	8.01	2.9
KAUNHM 201552	43.83	42.89	19.44	6.33	18.73	6.39	16.16	7.82	6.95	11.59	23.21	7.79	3.1
KAUNHM 201557	43.21	41.94	20.02	7.93	17.31	7.6	13.6	6.74	7.65	11.76	24	7.64	3.56
KAUNHM 201554	39.33	38.32	17.51	6.89	18.14	6.5	14.22	6.06	5.67	9.04	23.4	7.75	3.01
KAUNHM 201555	43.52	42.49	21.07	7.04	16.78	6.48	16.7	8.7	6.69	12.38	24.42	8.25	3.87
KAUNHM 201625	38.83	36.82	18.15	5.64	17.94	6.06	17.14	6.84	6.79	9.56	20.44	8.1	3.57
KAUNHM 201623	37.83	36.14	17.72	6.77	17.6	5.48	13.79	6.18	7.35	9.39	19.87	8.38	5.4
KAUNHM 201622	33.68	32.54	16.47	7.45	14.69	5.62	10.14	6.9	6.89	7.89	17.78	6.98	2.49
KAUNHM 201624	31.89	31.85	15.79	4.67	14.63	4.87	11.47	6.04	6.25	7.78	16.63	6.91	2.4
KAUNHM 201626	40.48	39.52	19.01	5.81	17.46	5.07	18.42	7.17	6.93	9.73	18.17	8.21	2.75
KAUNHM 201629	32.44	31.62	15.98	4.35	16.01	4.6	13.73	5.84	6.8	8.96	17.68	6.21	2.49
KAUNHM 201633	42.32	41.27	17.14	6.16	18.4	6.07	19.54	6.7	7.21	9.02	22.88	8.28	3.32
KAUNHM 201627	42.55	41.27	19.21	5.98	18.36	5.84	19.58	7.56	7.09	10.73	21.74	8.08	2.95
KAUNHM 201628	33.63	33.63	16.07	4.7	15.53	4.85	17.83	6.75	7.09	7.53	19.45	6.79	2.71
KAUNHM201631	40.04	38.43	18.44	5.78	17.97	5.45	17.92	7.18	6.6	9.64	18.34	8.08	2.8
KAUNHM 201632	42.38	40.89	20.83	6.37	18.96	5.44	19.87	22.99	7.04	12.58	19.64	8.22	3.29
KAUNHM 201558	38.15	36.46	16.13	6.81	17.81	6.53	13.58	6.58	7.44	7.97	18.2	6.29	4.31
KAUNHM 201560	29	28.16	13.59	4.7	13.33	3.86	12.26	6.14	4.79	8.53	13.91	5.38	3.29
KAUNHM 201561	31.86	30.1	13.85	5.82	14.82	5.07	11.53	5.42	5.32	7.39	16.5	7.11	2.74
KAUNHM 201562	37.46	37.27	17.88	5.76	16.85	5.59	17.44	7.05	7.03	10.12	22.05	7.58	3.83

Table 3. Morphological measurements of *Suncus murinus* captured from Silent Valley National Park

Study Area	**Location**	**Date**	**Specimen No.**	***Species***	**Weight**	**HB (CM)**	**T(CM)**	**E(MM)**	**HF(MM)**	**Sex**
Silent Valley	Sairandhri	08-04-2016	KAUNHM 201630	*Suncus murinus*	29	12.01	8.92	8.57	20.47	M
Silent Valley	Neelikkal	25-11-2015	KAUNHM 201559	*Suncus murinus*	20.6	16.8	6.9	9.54	18.65	F
Silent Valley	Neelikkal	27-11-2015	KAUNHM 201563	*Suncus murinus*	34	12.2	7.6	9.56	18.61	F

Table 4. Cranial measurements of *Suncus murinus* captured from Silent Valley National Park

Specimen No.	**GTL**	**CBL**	**CCL**	**ZB**	**BB**	**IC**	**M**	**CM^3**	**CM3**	**M^3-M^3**	**C^1-C^1**
KAUNHM 201630	31.01	28.68	27.55	11.31	13.05	5.13	13.66	9.7	7.56	5.76	2.81
KAUNHM 201559	30.57	26.32	25.31	10.36	11.58	6.49	15.14	9.92	8.47	8.62	2.48
KAUNHM 201563	29.64	26.81	25.31	9.37	11.42	4.95	15.73	10.8	8.55	6.04	2.92