ECOLOGY OF THE LESSER KNOWN MAMMALS OF CHIMMONY WILDLIFE SANCTUARY

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Ecology of the lesser known mammals of Chimmony Wildlife Sanctuary"** is a bonafide record of research done by me during the course of research and that this 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.

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Malik Fasil Madala

Dedicated to

The lesser known mammals of Western Ghats

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Introduction

INTRODUCTION

Mammals are air breathing vertebrate animals under the class mammalia. They are called mammals because of the possession of mammae or teats. They give birth to young ones and nourish them with milk from the mammary glands. Another characteristic feature of the mammals is the presence of hair over the body. Mammals are the only animals having hair on the body. Mammals evolved from reptiles nearly 180-220 million years ago, and they have got rampant growth on earth after the extinction of dinosaurs. They are considered to be the most successful animals on earth. Mammals encompass approximately 4629 species, distributed in about 1,135 genera, 136 families, and 26 orders (Wilson and Reeder, 1993). Four hundred and ten species of mammals (8.865% of the world's mammals) are known from India (Nameer, 2008). Around 145 species of mammals have been reported within the political boundaries of Kerala state.

Class mammalia shows varying life forms such as the largest creature of present world, the blue whale to the smaller forms of bats, rodents and insectivores. They also possess various kinds of adaptations which enable them for wide distribution in the world. Mammals are present in all forms of ecosystems in all the biomes in the biosphere. Most of the mammals are adapted to live in terrestrial habitats such as tropical and temperate forests, grasslands, deserts and in the polar ice-caps. Some mammals like the whales, dolphins and dugongs are adapted to live in water. Similarly the bats are adapted for an aerial mode of life. They also vary in their dietary habits. There are herbivores, carnivores including flesh-eaters and scavengers, frugivores, insectivores and omnivores among the mammals. All these make the mammals as the most successful group of animals on earth.

Most of the studies and researches on the fauna of India are focused on the larger mammals. Little attention has been given to the small mammals of the orders such as insectivores, rodents and chiropterans that account 75% of Indian mammals.

Order Rodentia has the maximum number of endemic species of Indian mammals (42.5%) followed by Chiroptera (17.5%), and Insectivora (15%). Even basic information such as the distributional range of these species is not known (Nameer, 2000).

There are several constraints in studying the small carnivores, rodents, insectivores and bats. Most of these animals besides being small, are also rare, nocturnal or crepuscular (active at sunrise and sunset), solitary, and often inhabit areas with poor visibility due to thick vegetation. This makes hard to find and observe these animals for studying their behavior and habits. Some of the rodents like the squirrels and tree mouse, and insectivores like tree shrews are strictly arboreal, and the rest of the rodents and insectivores are burrowing in nature. This makes the research and studies in these animals very difficult. So, very less information is available about these animals. Hence, they are called 'lesser known mammals'. So the lesser known mammals include the small mammals (rodents and insectivores), small carnivores (herpestids, viverrids, mustelids and small cats of felids) and bats. The number of species in various families of lesser known mammals in India and in Kerala as per the Checklist of Indian Mammals by Nameer (2008) is given in Table. 1.

The lesser known mammals play important ecological roles in the ecosystem functioning in tropical forests and their removal has a cascading effect on entire communities. Small mammals are an integral component of forest animal communities, contributing to energy flow and nutrient cycling, and playing extremely important roles as predators, seed dispersal agents, and pollination agents in tropical forests (Fleming, 1975). They also form an important prey base for medium sized carnivores and raptors. The term 'small mammal' is generally considered to apply to any non-flying mammal weighing less than one kg when adult. 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, and quite a lot of

the Mustelids (e.g. ferrets, weasels) are diminutive, in practice the term is generally restricted to rodents, marsupials, insectivores and elephant shrews (Barnett and Dutton, 1995).

Table 1. Number of species in various families of lesser known mammals in India and in Kerala (Nameer, 2008)

Sl. No.	Family	Number of species in	
		India	Kerala
I	**Small Carnivores**		
1	Herpestidae	6	4
2	Viverridae	9	4
3	Mustelidae	11	4
4	Felidae (small cats only)	10	4
II	**Rodents**		
5	Muridae	55	18
6	Hystricidae	3	1
7	Cricetidae	12	0
8	Sciuridae	27	9
9	Dipodidae	1	0
10	Platacanthomyidae	1	1
11	Spalacidae	2	0
III	**Insectivores**		
12	Erinaceidae	3	1
13	Soricidae	29	7
14	Talpidae	2	0
IV	**Bats**		
15	Pteropodidae	13	5
16	Rhinolophidae	17	3
17	Hipposideridae	13	8
18	Megadermatidae	2	2
19	Rhinopomatidae	3	1
20	Emballonuridae	6	4
21	Molossidae	4	3
22	Vespertilionidae	56	17
TOTAL		**285**	**96**

Rodents constitute the largest group of mammals in the world. Not only in the multiplicity of taxa but also in the enormous swarms of individuals, this group stands unique among all mammals. Rodents comprise practically half of the known living mammals of the world. They are cosmopolitan in distribution and have adapted themselves to all sorts of habitat viz; arboreal, terrestrial, subterranean and aquatic. Some of them are found from snowy heights of about 5790 m to the extreme arid tracts of the world. They have been successful even in crossing the natural barriers between Asian land mass and Australia without human aid, which no other group of sub human living mammal has been able to perform. The ecological distribution of rodents is influenced by the climate, geological and vegetative diversities and varies from voles in temperate zones, gerbils in deserts to flying squirrels in rain forests and bandicoots in plains (Prater, 1971).

Mammals less than about five kilogram in body weight belonging to the order carnivora are generally called the small carnivores (Yoganand and Kumar, 1999). Due to the similarity in body size, they often share more or less the same variety of food items that include small mammals, birds, amphibians, reptiles, fishes, invertebrates and often fruits and seeds. Unlike the large carnivores which depend on a relatively narrow prey base, the survival of a large assemblage of the small carnivores depends on the availability of an equally large assemblage of prey species and food plants. The richness, abundance and distribution of the small carnivores, therefore, are very good indicators of biodiversity both in terms of species and habitat. Many of them play a major role in seed dispersal and thereby in the vegetation dynamics of their habitat.

Bats are the only true flying mammals. They are the second largest group of mammals after rodents. Many species echolocate and they have a wide range of feeding and roosting habits, social behaviour and reproductive strategies. Their nocturnal habits and their diversity in biology make bats, not only a fascinating group of animals to study but also a difficult one. The fruit bats are important seed-

dispersers and pollinating agents in tropical rainforests and the insectivorous bats help in maintaining the insect population at optimum level. Almost three-fourths of the bats in the world are insectivorous. These bats consume many types of insects including common crop pests such as many species of moths, beetles, corn borers, bugs and even mosquitoes. The majority of bats in South Asia feed upon insects, yet we know very little about the beneficial economic impacts they might have on agricultural systems.

Most of the protected areas of the country in general and Kerala in particular do not have a comprehensive inventory of the mammals present there. The recent survey conducted by Nameer *et al.* (2009) showed that the Chimmony Wildlife Sanctuary is very diverse in its life forms. But a firsthand knowledge about the mammalian fauna, especially the lesser known mammals is not available. Hence, the present study was focused on these lesser known mammals and it is obvious that it will help to bolster the management and conservation of the biodiversity of Chimmony Wildlife Sanctuary.

The broad objective of this study is to understand the ecology of the lesser known mammals of Chimmony Wildlife Sanctuary. The specific objectives are;

1. To understand the diversity and abundance of lesser known mammals in Chimmony Wildlife Sanctuary
2. To understand the community structure of lesser known mammals in Chimmony Wildlife Sanctuary
3. To study the macro and micro habitat preference of lesser known mammals in Chimmony Wildlife Sanctuary
4. To study the seasonal variation in the habitat use of lesser known mammals in Chimmony Wildlife Sanctuary
5. To understand the conservation status of lesser known mammals in Chimmony Wildlife Sanctuary

Review of Literature

REVIEW OF LITERATURE

Ecology is the branch of science that studies the distribution and abundance of living organisms, and the interactions between organisms and their environment. The environment of an organism includes both its physical habitat, which can be described as the sum of local abiotic factors like climate and geology, as well as the other organisms which share its habitat. The term was coined in 1866 by the German biologist Ernst Haeckel from the Greek *oikos* meaning "household" and *logos* meaning "science": the "study of the household of nature" (Odum, 1971). Here the ecology of lesser known mammals in Chimmony Wildlife Sanctuary was studied. Studies about these animals are very less, especially regarding their ecology and behaviour, though some studies are made with respect to their geographic distribution (Nameer, 2008).

2.1 MAMMALIAN STUDIES IN INDIA

Early exploration on mammals began after Linnaeus, which Chakraborty (1986) referred to as Pre-Hodgson period. Belanger, Jacquemont, Leschenault, Duvaucel, Geofferoy and Blainville were the pioneer mammalogists and many Indian species were named by them. Pallas and Erxlenben also contributed by describing new species during the Pre-Hodgson period. Hodgson (1844; 1845) made extensive collection from India and Nepal and described several new species. Blyth, the curator of Museum of Asiatic Society of Bengal published detailed accounts on small mammals, rodents and bats. Blandford and Anderson (1888; 1891) made elaborate studies on mammals of India and wrote the *Fauna of British India* Volumes. Blanford's *Mammalia*, formed the first part of *The Fauna of British India* series of which he was the first editor and author. The *Mammalia* was published in two parts, part I in 1888 and part II in 1891. He enumerated and described just over 400 species. This work was the first authoritative account on the Indian Mammals and it has only been superseded in parts.

The mammalian survey became active when the Bombay Natural History Society (BNHS), the pioneering conservation agency in India came into being. The Society made extensive surveys during 1911 to 1929 and about 25,000 specimens were collected with adequate field data. These surveys threw much light on the faunal diversity of India (Thomas and Wroughton, 1915; Hinton, 1918a; Hinton, 1918b; Hinton, 1918c; Hinton, 1918d; Thomas, 1919; Thomas, 1922; Thomas, 1923; Wroughton, 1920a; Wroughton, 1920b). Based on these surveys Pocock (1939; 1941) published Fauna of British India covering the primates and carnivora. Finn (1929) published the Mammalia of India. This was further followed by John R. Ellerman's volume on Rodents in 1961. In 1951 Ellerman and Morrison-Scott's *Checklist of Palearctic and Indian Mammals* was published, which is the only existing nomenclatural list on Indian Mammals. However, present day interest in field studies owes so much to Prater's (1948) beautifully illustrated, *The Book of Indian Animals,* which is an excellent field guide cum reference book. Besides these, some of the latest authentic reference books available on Indian mammals are *'Mammals of Indomalayan region: A systematic overview'* by Corbet and Hill (1992), *'A Field Guide to Indian Mammals'* by Menon (2003) and the latest updated checklist of Indian mammals by Nameer (2000; 2008).

2.2 SMALL CARNIVORES

2.2.1 Small carnivores of the world

Most of the studies and researches on the order Carnivora are focused on the larger carnivores. Little attention is given to the small carnivores like herpestids, viverrids, mustelids and small cats of felids. However Zieliński (1988) studied the influence of daily variation in foraging cost on the activity of small carnivores. Norrdahl (1995) studied the prey population dynamics of small carnivores in summer. The status and distribution of Fishing Cat was studied by Roland (1996). Chris and Stuart (1998) studied about the White-tailed Mongoose in Southern Arabia. They also

gave a detailed account on the herpestids and viverrids of Zanzibar Island and also about the weasels and mongooses of Southern Africa. Martino and Gimeno (1998) worked on the various diseases prevailing in wild Martens. A detailed account on the small carnivore group called 'Genets' was given by Powell and Rompaey (1998) from the Niger Delta. Chris (1998) studied on the diet of viverrids of South Africa. Engel (1998) studied the process of seed dispersal by small carnivores. Dunham (1998) worked on the Ring-tailed Mongoose of Madagascar. The movements and fruit selection of the viverrids in Thailand was studied by Grassman (1998).

Conservation breeding studies of the Owston's Palm Civet in Vietnam was carried out by Rosenthal (1999). Rozhnov and Anh (1999) described a new species of civet from Vietnam called the Tainguen Civet. It was a great finding which paved the way for further studies about the small carnivores. Pulliainen (1999) studied the fidelity and core area in the space and resource use system of the Pine marten. Sidorovich (1999) gave a detailed account on how to identify the mustelid tracks during surveys and researches. A detailed account on the badgers of Ireland was given by Sleeman *et al.* (1999). Tumanov and Sorina (1999) studied the age dynamics in body weight and physiological indices in some mustelid species. Study conducted by Austin and Tewes (1999) threw light on the viverrid, mustelid and herpestid species of Thailand. Abel and Griffiths (1999) studied the current status of Marbled Polecat throughout its historical range.

The ecology of the small carnivores is still unknown to the scientific community. However Salazar (1999) conducted ecological studies on the endemic small carnivores of Mexico. He also studied the natural history, movement patterns, home range size, and temporal and spatial resource utilization of the species. Sidorovich and Krasko (2000) studied the behavioral interactions between the naturalized American Mink, *Mustela vison* and the native riparian mustelids, with implications for population changes. Zagrebelny (2000) carried out detailed studies on the mustelids of Russia. A regional collection plan for the mustelids in Europe was

prepared by Blomqvist and Maran (2000). They also described the need for the conservation and also about the taxonomic uniqueness of mustelids. Colyn *et al.* (2000) studied about the endemic Gambian Mongoose of Guinea. Mcdonald (2000) studied the secondary poisoning risks in small carnivores. He also studied the hazards caused to small carnivores by the widespread use of rodenticides. Su and Sale (2007) studied the niche differentiation between Common Palm Civet (*Paradoxurus hermaphrodites*) and Small Indian Civet (*Viverricula indica*) in regenerating degraded forests of Myanmar. Belden *et al.* (2007) studied about the small carnivores in mixed-use forests of Malaysia.

Similarly information regarding the feeding habits and foraging behavior of small carnivores are also meager. However, Marinis and Asprea (2001) studied the Pattern of variation in the feeding habits of the badgers. Sleeman and Cussen (2001) conducted similar studies on badgers. They studied on the badgers of Fenit Island, Ireland and also their presence or absence in other islands. Veron (2001) studied on the palm civets of Malaysia whereas Roberton (2001) conducted studies on Owston's Palm Civet. He also explained the methods used to record growth and health in captive Owston's Palm Civets. Kruuk (2000) studied on the status and foraging of the Pantot or Palawan Stink-badger. Parr and Duckworth (2007) studied on the diet, habituation and sociality of Yellow-throated Marten (*Martes flavigula*).

There are some studies which described the ways to measure the small carnivore diversity and density. Sidorovich *et al.* (2001) explained a new method to estimate the species diversity, density and biomass of water-living prey of semi aquatic mustelids in ponds and small streams. Zabala and Garin (2001) studied on the trapping of small carnivores and also the impacts of seasonal changes in small carnivore trappability. The little known small carnivores of Thailand and southern China were surveyed by Tizard (2002). Their methodology is well accepted by the scientific community. Similarly the monitoring of small carnivores via indirect evidences was also studied world around. In this line a study was conducted by

Francis (2002) on the Hose's Civet, *Diplogale hosei* of Brunei. Marassi and Biancardi (2002) studied on the use of Eurasian Badger, *Meles meles* setts and latrines in an area of the Italian Prealps.

A detailed account on the small carnivores of Borneo was given by Dinets (2003). Walston and Duckworth (2003) gave the first record of Small-toothed Palm Civet, *Arctogalidia tiairgata* from Cambodia. Rompaey and Jayakumar (2003) studied on the Stripe-necked Mongoose (*Herpestes vitticollis*) of Indian subcontinent. Abramov (2003) studied the head colour patterns of the Eurasian Badgers. Azlan (2003) studied the diversity and conservation of mustelids, viverrids, and herpestids in disturbed forests of Peninsular Malaysia. Moutou (2004) studied the possible role of Oriental civets in the SARS epidemic. He also mentioned on the trade of these civets which led to the spread of this epidemic. Colyn and Dufour (2004) studied the importance of small carnivores in forest bush meat hunting in the classified forests of Guinea. Boonratana (2004) studied on the viverrids of Vietnam. The presence, distribution and threats of small carnivores of Tanzania was studied by Luca (2005). Lynam *et al.* (2005) studied on the Large Spotted Civets of Thailand and Myanmar.

Small carnivore monitoring by camera trap and small mammal cage trapping on viverrid and herpestid in the lowland rainforests of Borneo was studied by Wells *et al.* (2005). Their methodology can be followed anywhere. Goodman *et al.* (2005) rediscovered the Narrow-striped Mongoose (*Mungotictis decemlineata*) from Madagascar. He also worked on the taxonomic status and distribution of this mongoose in Madagascar. Su (2005) studied about the small carnivores and their threats in Myanmar. Duckworth and Robichaud (2005) studied on the species range in small carnivores of South-East Asia. Azlan and Azad (2005) studied on the activity patterns of viverrids in secondary forests of peninsular Malaysia. The small carnivores of Central Sumatra were surveyed by Holden (2006). Long and Hoang (2006) worked on the conservation status of small carnivores in Central Vietnam.

Jennings *et al.* (2006) studied on the ranging behavior, spatial organization and activity pattern of the Malay Civet (*Viverra tangalunga*) on Button Island.

2.2.2 Small carnivores of India

Most of the studies pertaining to small carnivores are from Western Ghats and also from north eastern India. Yoganand and Kumar (1995) studied on the distribution of small carnivores in the Nilgiri Biosphere Reserve. It was actually a preliminary report on small carnivores from the Western Ghats. Bahuguna (1998) studied the small carnivores of Darjeeling with a special reference to Red Panda. Mudappa (1998) studied on the use of camera traps to survey small carnivores in the tropical rainforests of Western Ghats. She found out that it is an efficient tool for surveying these animals.

Choudhury (1999; 2000) studied on the conservation of small carnivores of Bengal. He also gave a detailed account on the small carnivores of Nagaland. It was a comprehensive study on the small carnivores of north eastern India. Mudappa (2002a) gave detailed study on the small carnivores of Tamil Nadu. Choudhury (2004) gave detailed account on the small carnivores of different sanctuaries in Assam. Kumara and Singh (2006a) conducted an extensive survey to study the small carnivores of Karnataka. He reported 11 species of small carnivores from the state of Karnataka.

More recently, Mudappa *et al.* (2007) studied the responses of small carnivores to rainforest fragmentation in southern Western Ghats. Datta *et al.* (2008) conducted recent studies on the occurrence and conservation status of small carnivores in two protected areas in Arunachal Pradesh. He reported 15 species of forest-dwelling small carnivores, apart from three other otter species from the region.

A very recent study based on the observations of small carnivores from the south Western Ghats was conducted by Pillay (2009). The recent survey conducted

by Nameer *et al.* (2009) shows that the Chimmony Wildlife Sanctuary is very diverse in its life forms. They also reported five species of small carnivores from Chimmony such as Jungle Cat (*Felis chaus*) Grey Mongoose (*Herpestes edwardsi*) Smooth-coated Otter (*Lutrogale perspicillata*) Asian Palm Civet (*Paradoxurus* hermaphrodites) and Small Indian Civet (*Viverricula indica*).

2.2.2.1 ***Studies on mustelids***

The members of the Mustelidae are the most diverse group and may be paraphyletic (Wozencraft, 1989). They are mainly solitary, with males and females getting together only for the purpose of reproduction (Kuruska, 1990). In south India, otters are represented by three species namely, the Eurasian otter, the small-clawed otter and the smooth-coated otter (Nagulu, 1996). The otters show preference for rocky stretches in all seasons since these stretches provide sites for den and resting (Hussain and Choudhury, 1995). Fish is the major prey of otters and exceeds more than 80 per cent of the diet.

On the otters of Western Ghats, perhaps the first comprehensive study was done by Anoop and Hussain (2004; 2005), who studied the ecology and feeding behavior of Smooth-coated Otter at Periyar Tiger Reserve. Meena (2001) reported on the poaching of otters in the Palni Hills. Shenoy (2006) studied on the factors determining the habitat choice of the Smooth-coated Otter.

Studies on the Nilgiri Marten are very less. Earlier, Hutton (1944) studied the feeding habits of Nilgiri Marten. He reported Nilgiri Marten preying on Malabar Giant Squirrel in the high wavy mountains of Kerala. Similarly Gouldsbury (1949) reported its feeding on crows in the high ranges of Kerala. Yoganand and Kumar (1995) reported Niligiri Marten from Nilgiri Biosphere Reserve and Madhusudan (1995) from Eravikulam National Park. Christopher and Jayson (1996) also reported it from Peppara Wildlife Sanctuary. Kurup and Joseph (2001) made certain observations on the behavior of Nilgiri Marten from the Periyar Tiger Reserve.

Balakrishnan (2005) gave a sighting report and habitat characteristic study of the Nilgiri Marten from Western Ghats. More recently Nandini and Karthik (2007) reported on the Yellow-throated Martens of north east India.

2.2.2.2 *Studies on viverrids*

The members of the family viverridae are characterized by the presence of scent glands and perennial gland (Pocock, 1941 and Wozencraft, 1989). Most of the members have spots or stripes on the body and the tail has ring like marks (Pocock, 1939). The common palm civet is an omnivore and feeds on birds, rodents, insects and fruits such as tendu, banana, pineapple, coffee and berries (Pocock, 1939).

Malabar civet is endemic to Western Ghats (Pocock, 1933). There are only two reports of its occurrence in Western Ghats (Hutton, 1949 and Karanth, 1986). This species was once very common in the districts of Malabar and Travancore in southwest India, but by the late 1960s it was thought to be near extinction, it was not sighted again until 1987. The population status is unknown. It was thought to be possibly extinct, then rediscovered (Kurup, 1989 and Ashraf *et al.*, 1993a), but there is no recent information and sightings of live Malabar civets (Rao *et al.*, 2007). After being listed as possibly extinct, it was rediscovered in Elayur, in the lowland Western Ghats, in Malappuram district, Kerala (Kurup, 1989). Ashraf *et al.* (1993a) reported its presence in the thickets in cashew plantation and highly degraded lowland forests.

Mudappa and Chellam (2002) made some capture and immobilization studies of wild Brown Palm civets in Western Ghats. Mudappa (2002b; 2006) also made some extensive studies on the Brown Palm Civets of Western Ghats. She studied the distribution and status of this animal in the Western Ghats and also studied its day bed choice in this region. Choudhury (2002) reported the Spotted Linsang (*Prionodon pardicolor*) from India. Krishnakumar and Balakrishnan (2003) studied the feeding ecology of Common Palm Civet in the semi urban areas of Kerala.

Gupta (2004) reported the poaching of civets for meat and scent in India. Balakrishnan and Sreedevi (2007a; 2007b) made some detailed studies on Small Indian Civets. They studied the intestinal parasites and diseases among the Small Indian Civet and also did some captive breeding trials on the animal. Rao *et al.* (2007) made an exhaustive search in Kerala and Karnataka for finding out the Malabar Civet. They succeeded in obtaining certain indirect evidences but a true picture is still lacking.

2.2.2.3 *Studies on herpestids*

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

Roy (2002) studied on the Small Indian Mongoose (*Herpestes javanicus*) of India. He also reported that it is one of the most successful small carnivores in the world. Bose *et al.* (2003) made some studies on the diseases of mongoose. The status of mongooses in Central India was studied by Shekhar (2003). He also reported a list of factors that affects the distribution of mongooses in India. Very recently Mallick (2009) made some studies on the status of Endemic Marsh Mongoose (*Herpestes palustris*) in the wetlands of Kolkata.

2.2.2.4 *Studies on lesser cats*

Chavan (1987) conducted the first comprehensive studies on lesser cats. He studied the status of lesser cats in Gujarat. Some studies on the melanism in Jungle Cat were carried out by Chakraborty *et al.* (1988). Bharadwaj and Sharma (1991) studied the anatomy of the diaphragm of Jungle Cat with special reference to its nerve

supply. Bhattacharyya (1992) made some studies on the breeding biology of Fishing Cat (*Felis viverrina*).

Gogate (1997) surveyed the lesser cats of Maharashtra. He found out five species of lesser cats from there and also indicated the need for specific conservation strategies in the region. Mukherjee *et al.* (2003) studied the importance of rodents in the diet of Jungle Cat (*Felis chaus*) and Caracal (*Caracal caracal*) Khan (2004) made some extensive studies on the food habits of Leopard C at (*Prionailurus bengalensis*) in the Sunderbans.

Duckworth *et al.* (2005) studied the population status of Jungle Cat in Indo-China border. They reported that it is a threatened population over there. They also found out that the Jungle Cat is a widespread and adaptable species. Mukherjee and Groves (2007) made a recent study on the geographic variations in Jungle Cat. They also studied the differences in body sizes of Jungle Cat in different regions.

2.3 SMALL MAMMALS

2.3.1 Studies across the world

2.3.1.1 *Diversity and abundance*

The abundance of small mammals in conifer plantation was studied by Smith (1959) in Scotland and reported five species of rodents including the now extinct harvest mouse. Diversity of Asian species of *Mus* was described by Marshall (1977). Demographic implications for the control of grey squirrels were studied by Gurnell (1989). He concluded that average abundance varied according to age and tree species composition of the forest. Food shortage and severity of winter were the key limiting factors determining the abundance during the annual cycle. In the riparian habitat in Nevada, small mammal populations in grazed and ungrazed conditions were compared by Medin and Clary (1989) for 11 years in north eastern Nevada. They pointed out that density, species richness and species diversity were greater in

the ungrazed area. Oguge (1995) studied the diet, seasonal abundance and micro habitat of *Praomys natalensis* and other small rodents in Kenyan sub humid grass land community. It was suggested that differences in micro habitat used and dietary habits among the rodents were important factors in resource partition. Availability of adequate cover associated with the rainfall was a notable component influencing *Praomys natalensis* abundance in the habitat studied.

Hayward and Hayward (1995) studied the relative abundance and habitat association of small mammals in Chamberlain Basin in Central Idaho. According to them, the habitat associations of the common small mammals, differed based on both broad patterns and micro habitat gradients. The fauna of rodents in the Mediterranean region was studied by Yüzbas and Benli (1996) and concluded that the diversity is negatively correlated with altitude. King *et al.* (1996) studied the distribution and abundance of small mammals in relation to habitat in Pureora Forest Park. They marked a reciprocal relationship between the distributions of ship rats and of mice. The effect of selective logging and conversion to exotics was also monitored. The presence of rodents in the grassland and agricultural field was studied in Central Ethiopia by Bekele *et al.* (1997). In both habitats, the small mammal fauna consisted of same species but in different relative proportions. A survey of small rodents in three sentinel farms in Costa Rican island was conducted by Jimenez *et al.* (2000). Eleven species of small rodents were collected and identified by them.

Diversity of rodents and insectivores of Bangladesh was carried out by Akonda and Khan (2000). 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. They found that rodent diversity in the forest area was significantly higher than the farmlands. Diversity was found to be negatively correlated with the farming intensity. 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.

2.3.1.2 *Ecological studies*

Johnson and Vaughan (1993) studied the way the small terrestrial rodents used their habitats. They found that the number of individuals increased from primary forest to non-forested habitat. Also, the rodent population increased with the beginning of rainy season, but the degree of fluctuations differed among species and habitats. Seasonal activity and movements of rodents in a Hawaiian Macadamia orchard was studied by Tobin et *al.* (1996). According to them, most of the rats remained in burrows during the day. They emerged one to two hours after sunset, ascended into the canopy and returned to their burrows one to two hours before sunrise. Seasonal changes in the population of the rice field rat were studied in West Java by Tristiani *et al.* (1998). They concluded that population exhibited clear peak periods annually. Each peak occurred two to four weeks after the rice harvest. The population dynamics of *Mus minutoide* and *Statomys pratensis* in a sub tropical grass land in Swaziland was studied by Monadjem (1999). The study showed that the numbers of *Mus minutoide* were relatively high in winter, declined in spring and the population disappeared in summer and autumn. By contrast, numbers of *Statomys pratensis* increased gradually from winter to summer and reached the peak in autumn. In Central Argentina, seasonal changes in microhabitat use and niche overlap between two species of rodents were studied in agroecosystems by Bilenca and Kravetz (1999). In summer, trap data showed that both species had low densities. In contrast, winter data revealed sharp habitat segregation.

Lin and Lin (2000) studied the population and community ecology of small rodents in montane forest in Taiwan. Another study conducted by Butet and Delettre (2003) on response of the small mammal community to changes in western French agricultural landscapes proved that richness and species composition of the small mammal community were not affected by the degree of cultivation, but variations in species frequency could be observed.

2.3.2 Studies in India

2.3.2.1 *Diversity and abundance*

A survey of rodents in Central India was carried out by Thomas *et al.* (1993) and a total five species, *Bandicota bengalensis, Rattus rattus, Millardia meltada, Mus musculus and Funambulus pennanti* were recorded from fields, poultry farms, houses and shops. The relative abundance of sympatric flying squirrels of Western Ghats in India was studied by Ashraf *et al.* (1993b). A census on small rodents and study on effects of environmental changes on small rodent population was conducted by Saitoh (1997).

Shanker (2000) formulated some methodologies to find out the abundance and density of the small mammals using some capture-recapture models as well as using the program CAPTURE. Molur and Singh (2009) conducted a study to understand diversity and changes in non-volant small mammal composition in the Western Ghats of Coorg District, Karnataka. This study got maximum number of species compared to similar studies conducted in southern India. Total 14 species of non-volant small mammals were trapped as 412 unique individuals contributing to an overall trap success of 3.8%. *Rattus wroughtoni* was the most commonly caught taxon followed by *Suncus murinus* and *S. niger*. The abundance of small mammals was the highest in bamboo and in forest fragments whereas the plantations supported very low abundance.

2.3.2.2 *Ecological studies*

Several rodent species, like squirrels, are diurnal in habits, but many others, such as rats, mice, bandicoots, gerbils, shrews and porcupines are nocturnal. Many species such as rats, mice and bandicoots are fossorial and live in burrows or restricted places such as crevices where they nest, while others live in open ground or are arboreal. Some rodents adapt themselves to a wide variety of habitats while others are more restricted in their choice. These habitats have been discussed by Barnett and Prakash (1975) for species of economic importance. Roonwal (1949) discussed the preferences of various ecological habits, e.g. evergreen jungle, oak scrub, riverine meadow, etc., by several species of rodents in Manipur. Chandrasekar-Rao and Sunquist (1996) conducted studies on ecology of small mammals in tropical forest habitats of Southern India. They studied the species richness, diversity and macro and micro habitat selection of small mammals across three habitats namely, moist evergreen, moist deciduous and teak plantations at Indira Gandhi Wildlife Sanctuary in the state of Tamil Nadu, India. They found that the species richness and diversity was lower in the teak planatation and there was no significant difference in the habitat selection of the any of the species except *Rattus rattus wroughtoni* and *Funambulus tristriatus* in which the former showed a significant association with bamboo, and the latter one was associated with areas of higher canopy height and density in moist deciduous forest. Similarly Shanker and Sukumar (1998) studied the Community structure and demography of small-mammal populations in insular montane forests in southern India. Two indices of diversity, species richness and proportion of *R. rattus* were compared as measures of community structure. Seven habitat characteristics were measured; of these, canopy cover, canopy height and tree density were correlated with the size of the patch. Density and biomass of species other than *R. rattus* and proportion of *R. rattus* were correlated with canopy height. Density and biomass of species other than *R. rattus* were highest in smaller patches. While the population characteristics of *R. rattus* may be affected by patch size, the density of

rare species may be influenced by factors related to lower canopy height. According to them, the local migration between patches may be an important factor in maintaining populations in these patches.

Mudappa *et al.* (2001) studied the abundance and habitat selection of the Malabar spiny dormouse in the different altitudinal regions of Kalakad-Mundanthurai Tiger Reserve and the Anamalai hills of southern Western Ghats. A total of 9347 trap nights were carried out in different study locations. Twenty individuals of dormouse were reported during the study. They concluded that the dormouse trapping success was high during the southwest monsoon and their abundance is directly correlated with the climber density and thick forest vegetation. They also added that the species was totally absent in plantations and fragmented forests.

A study was conducted by Shanker (2002) about the ecology and natural history of small mammals in montane ecosystems of the Nilgiris, Southern India. A total of 35,000 trap-nights were sampled in various habitats including montane forests, grasslands and plantations. He found that the species richness and abundance of small mammals was high compared to other natural habitats in southern India. Kumar *et al.* (2002) studied the impact of rainforest fragmentation on small mammals and herpetofauna in the Western Ghats, South India. In the first phase of this project, they attempted to understand the distribution and ecology of the target taxa in the continuous stretch of rainforest in Kalakad-Mundanthurai Tiger Reserve and in the second phase, the study was conducted in the rainforest fragments in the Anamalai Hills for comparison. Shenoy and Madhusudan (2006) studied the species composition, population and micro habitat preference of small mammal communities in a rapidly developing southern Indian city. Four sites around the Bangalore city were selected for the study. *Cremnomys blanfordi* and *Rattus rattus wroughtoni* were the dominant species.

2.3.2.3 *Food and feeding behaviour*

The food and feeding behavior of small mammals varies from species to species. Considering the food preferences, some rodents have distinct food preferences while others are omnivorous. The majorities are herbivorous, but, some feed on invertebrates such as termites and the smaller vertebrates such as small birds. But reports say that rodents feed on some amount of animal matter also (Odend'hal, 1980). He reported *Rattus rattus* feeding on dying cattle affected with foot-and-mouth disease. The food habits and related behaviour patterns such as daily cycle, hoarding, etc. have been studied by Kumari and Khan (1985). One species, *Rattus manipulus*, in Manipur feeds largely on earthworms which are cut up in small pieces, swallowed and the rat's stomach was full of such pieces (Roonwal, 1949). In North-Eastern India, dramatic population increase of *Rattus rattus* have been correlated with the periodical flowering of bamboos (Seal *et al.*, 1951). After eating the flowers, huge population of rats poured into rice fields, causing famine. Ports are the favourite locations of some species such as *Rattus norvegicus*, *Rattus rattus* and some bandicoots because of the abundance of available food in ships, godowns and sewers (Deoras and Pradhan, 1975). Cannibalism is reported in *Funambulus pennanti*, where especially the young ones are the victims (Gupta and Agarwal, 1968).

2.4 BATS

Bats are the only true flying mammals that mastered flight. These hand winged flying machines are the most fascinating animals of the world because they "see" with their ears, hangs upside down to sleep by day and they can catch insects while flying even in the darkest of nights (Vanitharani, 1998). Bat fossils date back approximately fifty million years but surprisingly, the bats of the ancient period very closely resembled those we know today. The earliest known fossil record of the order Chiroptera is from an early eocene site in the South West Wyoming, USA. Here an almost complete skeleton of a bat (*Icaronycteris index*) was found in marble stone

from the Green river formation (Jespen, 1966). The evolution of flight and echolocation in bats was undoubtedly a prime factor in the diversification of feeding and roosting habitats, reproductive strategies and social behaviors and they have successfully colonized almost every continental region on earth, except Antarctica, as well as many oceanic islands and archipelagos (Kunz, 1982). Bats though constitute the largest mammalian order in India; very little studies have been done on them.

2.4.1 Studies across the world

The Order Chiroptera is divided into two suborders: the Megachiroptera and Microchiroptera. The Megachiropterans are all found in the old world tropics and subtropics, feed on fruits, nectar, pollen and roost mainly in trees (Hill and Smith, 1984). There is only one family in the suborder Megachiropetra, the Pteropodidae, containing 42 genera. The 57 species of the largest genus, Pteropus are mainly island species and levels of endemism are extremely high, 35 species out of this are found on only one, or on a small group of islands (Koopman, 1993). Mickleburgh *et al.* (1992) observed that the megachiropterans do not use high frequency echolocation but have large eyes and good vision, and use sight and smell as their major locational senses. Bates and Harrison (1997) reported that one megachiropteran genus, *Rousettus* has developed a crude form of echolocation, by producing clicks with the back of the tongue.

Microchiropterans use high frequency echolocation and rely on hearing as their major locational sense. According to Hill and Smith (1984), insectivorous bats feed on insects, fruits, nectar, pollen, fish, other vertebrates or blood and they roost in a great variety of sites including caves, buildings and trees. The largest family, the Vespertilionidae has around 300 species and an almost global distribution. The microchiropterans are found worldwide and there are 16 families and 135 genera (Koopman, 1993). Around 88 per cent of bat species are exclusively tropical. In the old world tropics, the pteropodids are the main fruit eating bats where as in the New

World tropics, the super family Phyllostomidae dominates (Findley, 1993). Haematophagous bats, popularly known as vampires exist only in Latin America, from Mexico to the Northern provinces of Argentina. They are represented by three species, Common Vampire Bat (*Desmodus rotundus*), Hairy-legged Vampire Bat (*Diphylla ecaudata*) and White-winged Vampire Bat (*Diaemus youngii*). While two species feed only on blood of wild birds, one species, *Desmodus rotundus*, causes losses by feeding on livestock and could be a vector for rabies virus (Mayen, 2003).

Humphrey (1975) has shown that species richness and diversity of colonial bats are strongly correlated with an index of physical structure of environment which includes contribution from topographic complexity, presence of trees and human constructions. High bat diversity characterises areas where all kind of roost structures occur, whereas places with low bat diversity are lacking one or more roost types. Many tropical forest bats roost in caves, but many others utilize tree hollows or foliage. Usman (1988) reported that light and temperature of the area is affecting the roosting behaviour of bats. According to Jung and Thompson (1999), bats use wide variety of habitats and many taxa are dependent to a great extent to the primary forest, whereas some species are very common in urban areas also. Granek (2000) stated that out of the total 41 genera in India, 29 roosts in trees, 11 roosts in caves and six in other sites whereas members of the genus *Pteropus* often form large aggregation on exposed tree branches. Different species of bats are known to occupy different altitudes (Hayes and Gruver, 2000). Roost site fidelity is generally high in those genera that roost communally. Thus, cave roosts of *Eonycteris*, *Notopteris* and *Rousettus* may be occupied for many years as may tree roosts of *Eiodolon, Epomophorus* and *Pteropus*. Those genera roosting singly or in small groups show less site fidelity but may use same perch for considerable periods. For some taxa, there can be dramatic seasonal changes in roost composition. Most colonies of *Eidolon helvum helvum* use same roosts for many years, but because of local

fluctuations in food availability, some colonies make regular seasonal migrations, returning after a few months to their former roosting sites (Marshall, 1983).

Diversity and abundance of bats can be regarded as an indicator of disturbance in neotropical rain forests (Medellin *et al.*, 2000). A comparison of the phyllostomid bat assemblages in undisturbed Neotropical forest and in forests fragments of the slash and burn farming mosaic in Guatemala prove that the relative abundance of large frugivores which feed on small-fruited plants occurring in early successors are an indicator of forest disturbance (Schulze *et al.*, 2000). A study conducted by Wikramasinghe *et al.* (2003) highlights that the position of bats as bio-indicators and victims of agricultural change. They found that greater habitat quality in terms of prey availability and better water quality on organic farm favoured higher foraging activity by bats.

2.4.2 Bat studies in India

2.4.2.1 *Ecological studies*

Studies on the bats of the Indian subcontinent are far and in between. Perhaps the only detailed ecological study on the bats of the country was by Brosset (1962a; 1962b; 1962c). He conducted extensive studies on the bats of the subcontinent, though it covered only the central and western region of India. Bhat (1968a; 1968b; 1974) studied the bats of Uttar Pradesh and West Bengal. Bates *et al.* (1994a; 1994b; 1994c) did a follow up study on bats of the same region. Bates and Harrison (1997) brought out a well illustrated field guide on the bats of the Indian subcontinent.

2.4.2.2 *Breeding habit studies*

Gopalakrishna (1947; 1954; 1969), Gopalakrishna *et al.* (1970), Gopalakrishna and Madhavan (1970a; 1970b; 1971; 1977), Madhavan (1971; 1978; 1980), Gopalakrishna and Karim (1972), Gopalakrishna *et al.* (1976), Gopalakrishna and Choudhari (1977), Gopalakrishna and Rao (1977), Madhavan *et al.* (1978),

Krishna and Dominic (1980; 1981; 1982; 1983; 1985), Gopalakrishna and Bhatia (1982), Gopalakrishna and Chari (1983), Gopalakrishna *et al.* (1985; 1991; 1992), Gopalakrishna and Badwaick (1989), were among the pioneers who carried out studies on breeding habits of many of the Indian bat species. Sinha (1980; 1981; 1999) studied the bats of Rajasthan, Gujarat and North East Hills. Bhat (1994) studied the bats of Pune, Bhat and Jacob (1990), studied the bats of Karnataka, Das (1986) has done studies on taxonomy and geographical distribution of species of bat obtained in Silent Valley National Park, Kerala. Bhat and Sreenivasan (1972; 1990) and Bhat *et al.* (1980) studied the bats of Karnataka.

2.4.2.3 *Behavioral studies*

Subbaraj and Chandrashekaran (1977; 1978), Marimuthu *et al.* (1978; 1981; 1998; 1995), Subbaraj (1981), Marimuthu and Selvanayagam (1981), Marimuthu and Chandrashekaran (1983a; 1983b; 1985), Marimuthu (1984; 1988; 1991; 1997), Marimuthu and Neuweiler (1987), Chandrashekaran (1992; 1994), Subbaraj and Balasingh (1996), Subbaraj *et al,* 1997 studied the various behavioural aspects of the bats of the Indian subcontinent.

2.5 STUDIES ON LESSER KNOWN MAMMALS OF KERALA

Studies on the lesser known mammals of Kerala are very scanty though the state has a fine distribution of these animals. Studies on the mammals of Kerala date back to the British period but comprehensive account on the mammals of Kerala is yet to be published. This is true especially in the case of small mammals as mammalian studies from Kerala were concentrated on large mammals like elephant, tiger, gaur, tahr etc. Most of the works pertaining to small mammals were based on captive breeding trials (Xavier and Balakrishnan, 1993). Since 2002, Department of Wildlife Sciences of Kerala Agricultural University has been conducting studies on this less known group of mammals.

A new description for field rat was given by Agarwal and Ghosal (1969). George and Joy (1981) studied the bioecology of Bandicoot rat in Kerala. Das (1986) has done studies on taxonomy and geographical distribution of species of bat obtained in Silent Valley National Park, Kerala. Jayson and Christopher (1995) had reported Spiny dormouse from Peppara Wildlife Sanctuary. Yoganand and Kumar (1999) conducted a study on the small carnivores of Western Ghats in which Silent Valley National Park was one of the study sites.

A survey of small mammals of Kerala was conducted by Easa *et al.* (2001) and reported 21 species of rodents and three species of insectivores. 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. Cyriac (2003) studied the bats of Kerala Agricultural University campus and reported nine species. Mathew (2004) studied the diversity and abundance of bats in Peechi-Vazhani wildlife sanctuary and reported 16 species. Easa and Ramachandran (2005) documented the biodiversity of Kerala and the Part 12 of their report deals with the mammalian fauna of the state. Radhakrishnan (2005) did a detailed study on diversity of bats in Peechi-Vazhani wildlife sanctuary while Shanid (2005) studied the diversity and abundance of rodents and insectivores in the same sanctuary. Abhilash (2005) conducted an ecological study on bats of Peechi-Vazhani wildlife sanctuary. Arun (2006) and Ali (2006) studied on the feeding behaviour of fruit bats and insectivorous bats respectively in Peechi-Vazhani Wildlife Sanctuary. Jayson (2006) studied the status, distribution, food and feeding habits of Malabar Spiny Dormouse in the Western Ghats of Kerala. Joy (2008) studied the diversity and abundance of bats in Chimmony wildlife sanctuary whereas Babu (2008) studied the diversity and abundance of rodents and insectivores in the same sanctuary. A survey of Indian Flying Fox exclusively in Thrissur district of Kerala state was done by Sreehari (2009). Recently Melite (2010) conducted a survey on small carnivores of Chimmony wildlife sanctuary while Mohan (2010) and Jayalakshmi (2010) studied about the

ecology of diurnal and nocturnal squirrels of the sanctuary respectively. The inadequacy of knowledge and information on the lesser known mammals in India in general and particularly in Kerala warrants immediate attention on the studies of these mammals in this region and hence the present study.

Materials and Methods

MATERIALS AND METHODS

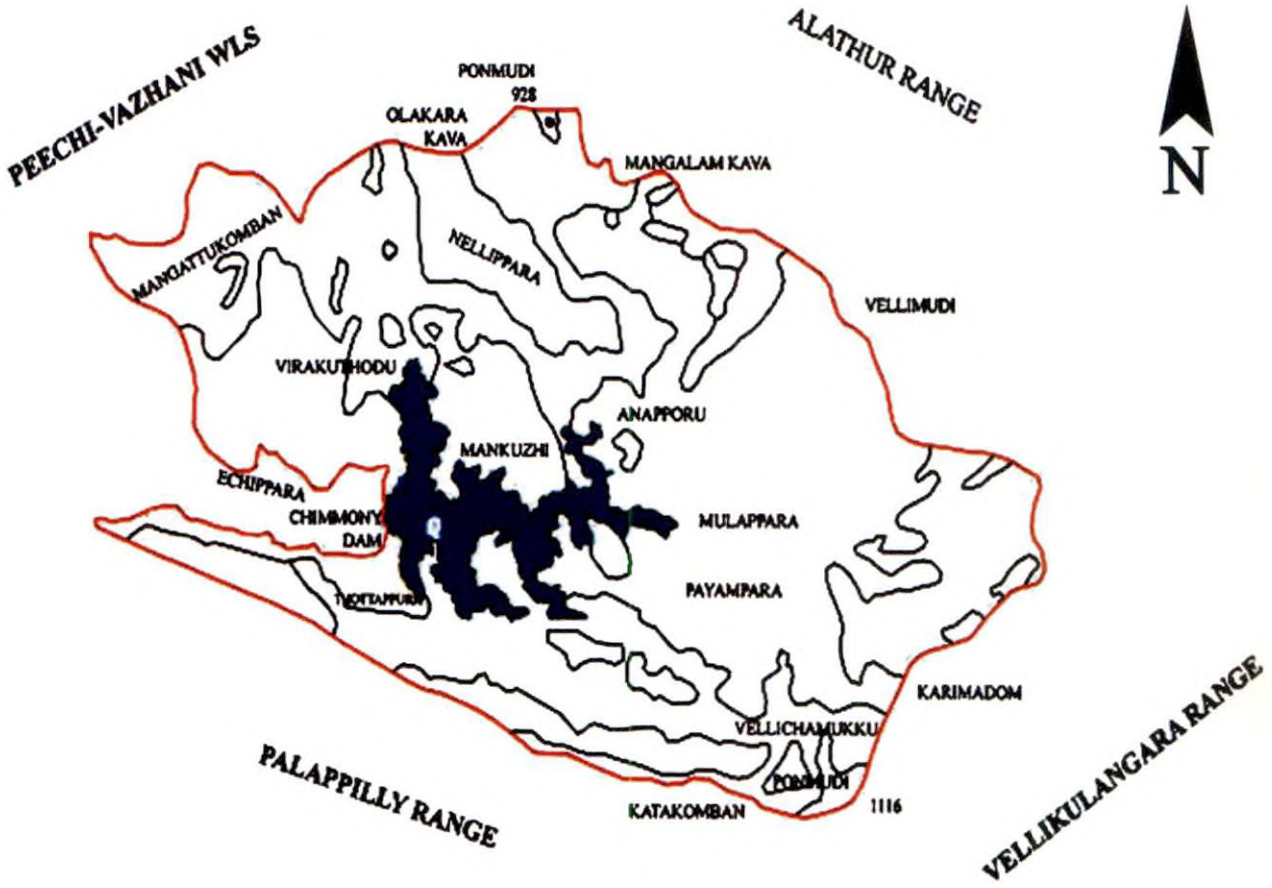
3.1 STUDY AREA

3.1.1 Name, location and extent

Chimmony Wildlife Sanctuary lies within the geographical extremes of latitudes 10° 26'N and 10° 26'N longitude 76° 31'E and 76° 37'E (Fig. 1) in Mukundapuram Taluk within the administrative jurisdiction of Northern Wildlife Circle, Thrissur District of Kerala State. It was established in 25th September 1984. Chimmony Sanctuary is about 45 km South-East of Thrissur town.

The sanctuary has an area of about 85 sq. km. The present boundaries of the sanctuary have been notified on the basis of naturally occurring physical barriers. Ecological continuity has not been considered when the legal boundaries were notified. There are extensive evergreen and semi-evergreen forest patches around the sanctuary harbouring several endangered species, which do not come within the limits of any protected areas.

Beyond the eastern boundary on the sanctuary lies large tract of evergreen forests; the area comes between the Parambikulam and Chimmony protected area. The south and southwest of the sanctuary has continuous evergreen forests of Vazhachal and Chalakudy Forest Divisions. These areas at present do not come under the legal protection of the sanctuary. The topography of Kerala creates suitable locations for one of the decisive factors helping the retardation of the best forest areas. Hence the deep valleys like Chimmony - Mupli valleys have a mosaic of forest types and edaphic and seral stages, which are ecologically fragile. Any disturbance to these crucial locations set off a chain reaction of widespread and often irreversible damage to the ecosystem.



Chimmony Wildlife Sanctuary

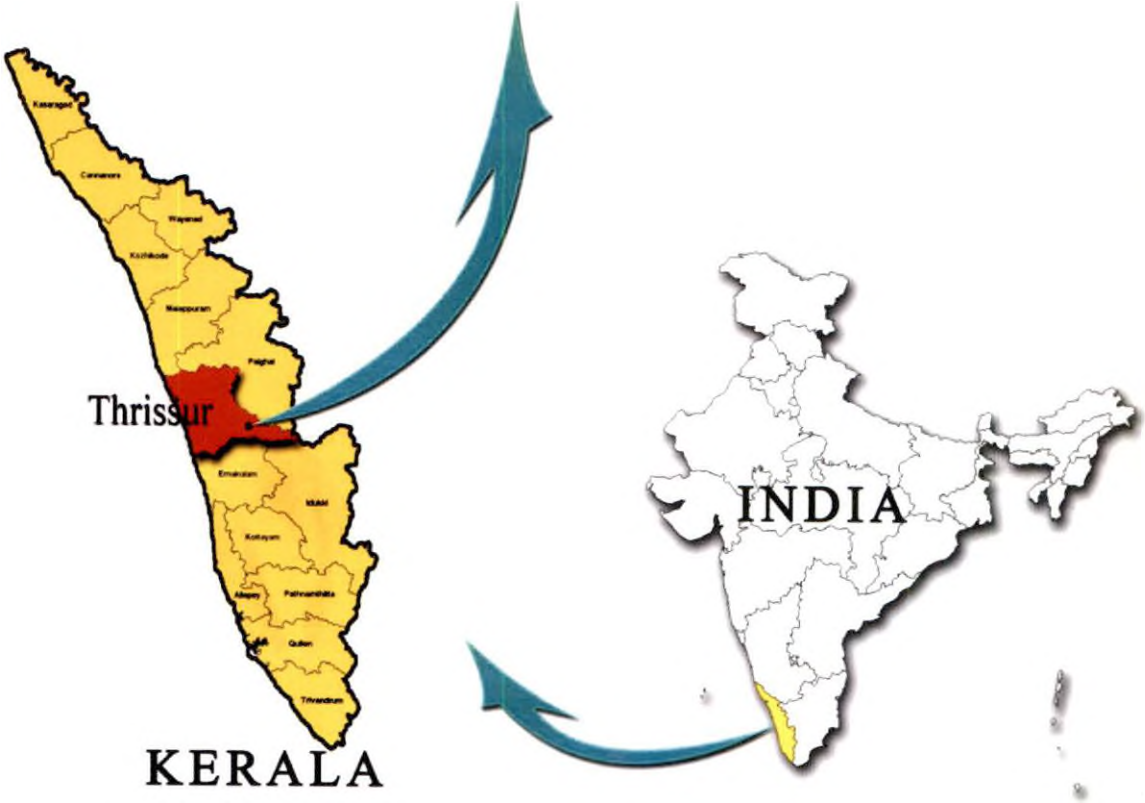


Fig 1. Location map of Chimmony Wildlife Sanctuary

3.1.2 Geology, rock and soil

Metamorphic Gneiss is the principal formation of the hills. On the lower slopes and on the hills, the rocks tend to become lateritic in nature. Small extents of rocky blanks, consisting of sheet rocks are seen scattered in the sanctuary.

The soil is originated from weathering of crystalline rocks like granite, gneisses and chamockites. Surface soil is generally sandy loam in texture while the subsurface soil is loamy. Initial stages of laterization are observed where the soil is devoid of vegetal cover and erosion is active.

3.1.3 Terrain

The terrain is hilly and the altitudinal range varies from 40 m above MSL at the dam site on the low margin of the sanctuary to 1,110 m above MSL in the eastern end. The highest peak in the sanctuary is the Pundimudi (1,116 m).

3.1.4 Climate

3.1.4.1 *Rainfall pattern and distribution*

The tract gets a few pre-monsoon showers in April. The bulk of the annual rainfall is from the southwest monsoon. The tract receives an average rainfall of about 2,980 mm annually. The sanctuary also receives the northeast monsoons during October-November. Heavy showers occur in the afternoons accompanied by thunder and lightning.

3.1.4.2 *Temperature*

The dry season is from December to May. The hottest months are March, April and May. The temperature varies between a maximum of 36^0C and a minimum of 24^0C in the hottest months. During December - January, the minimum temperature falls to 15^0C.

3.1.4.3 *Wind*

There are two prevailing winds in the tract blowing in the direction of two monsoon currents. No great injury is caused to the wildlife by these winds. But the northeast winds blowing through the Palakkad gap of Western Ghats have desiccating effect and cause heavy leaf fall resulting in accumulation of combustible materials on the ground inducing wild fires.

3.1.5 Water source

The sanctuary has more than 250 fingertip streams of which Chimmony river, Virakuthodu, Anapporu thodu, Payampara thodu, Nellipara thodu, Thachanakadavu thodu, Kodakallu thodu, Mulappara thodu, Chavarala thodu, Kanjiripara thodu and Vavala thodu are prominent. Most of these streams are seasonal and dry up during summer. All streams drain to Chimmony reservoir, having water spread area of 10.1 km^2. Chimmony dam is constructed across the Chimmony river, which is a tributary of the river Karuvannur. There are two manmade water pools in the sanctuary, one at Virakuthodu and the other at Nellipara.

3.1.6 Habitat and vegetation

The sanctuary provides a mosaic habitat by the presence of moist deciduous forests, semi-evergreen forests, riparian forests as well as evergreen forests (Fig. 2). The natural forests of the sanctuary are classified on the basis of Champion & Seth (1969) into the following types such as 14/C4 - West Coast Tropical Evergreen Forests, 24/C2 - West Coast Semi-evergreen Forests and 33/C - Southern Indian moist deciduous forests. There are four softwood plantations in the sanctuary having an extent of 157.83 ha. These plantations were raised as a mixture of teak and elavu (*Bombax malabaricum*). An overview of the sanctuary is shown in Plate 1.

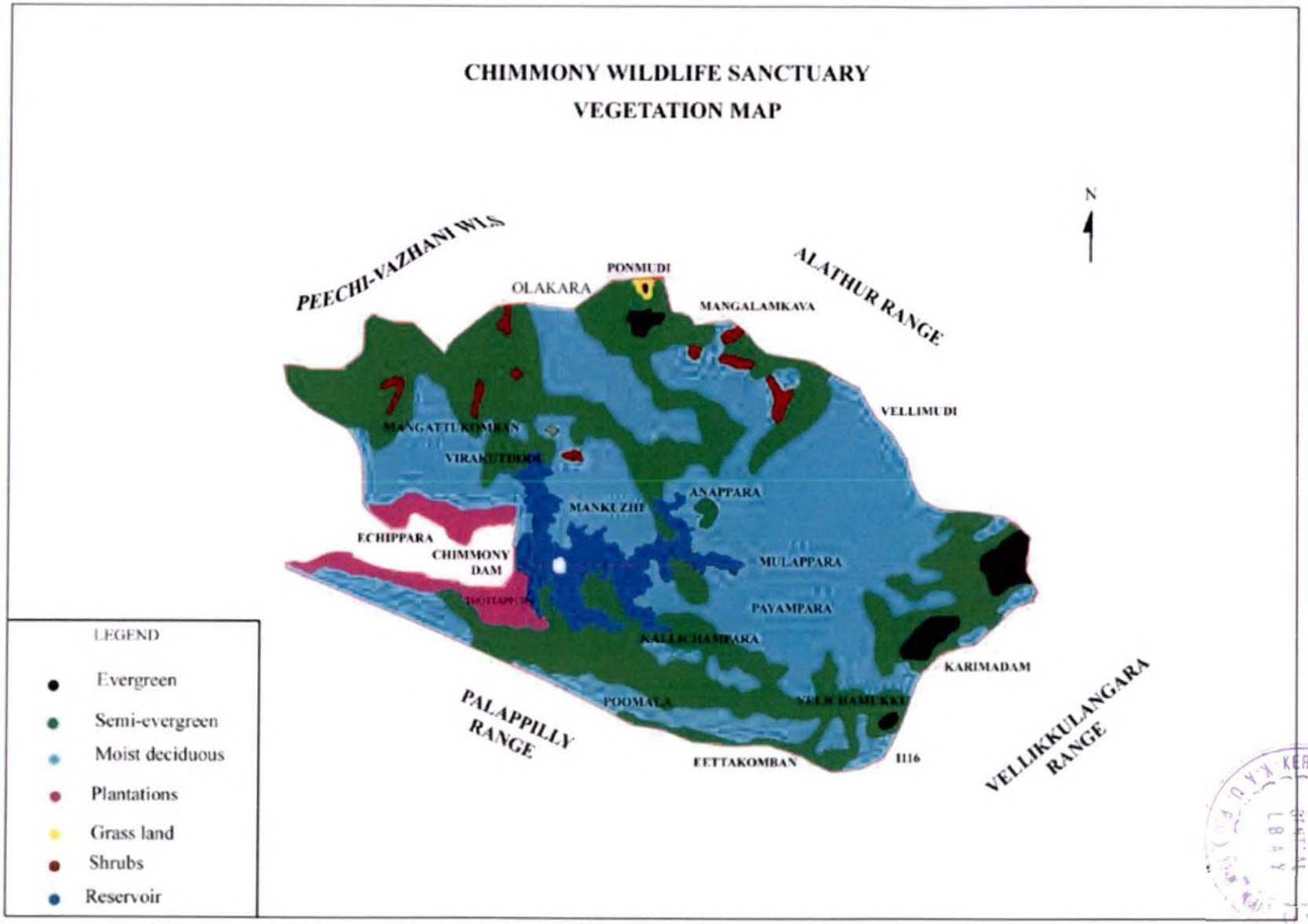
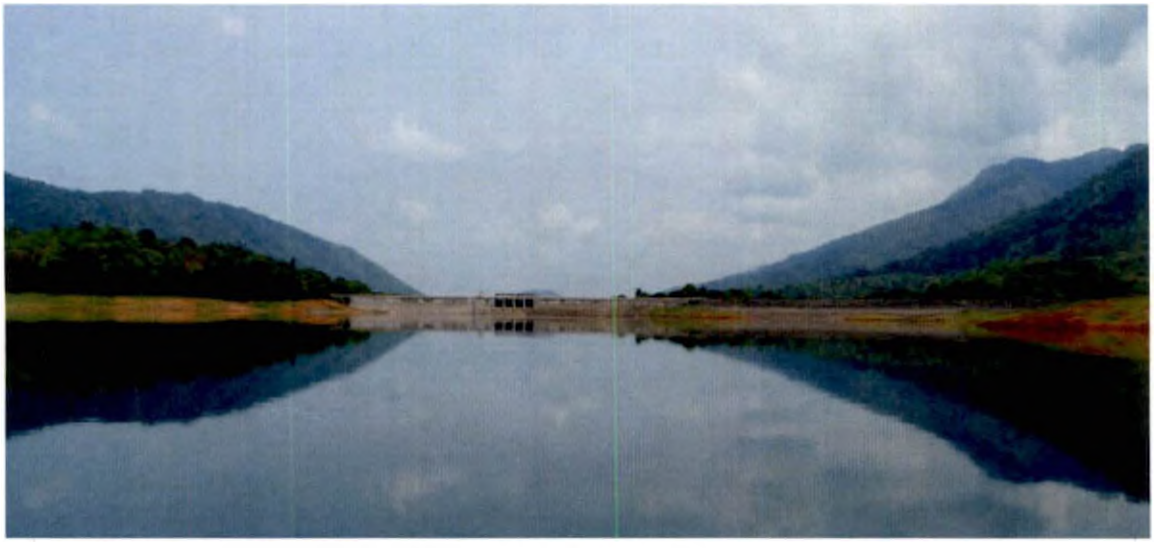


Fig 2. Vegetation map of Chimmony region



Chimmony Reservoir

Semi Evergreen Habitat

Moist Deciduous Habitat

Virakuthodu Stream

A manmade water hole

Plate 1. An overview of Chimmony Wildlife Sanctuary

3.1.6.1 *The forest types*

3.1.6.1.1 *Tropical evergreen forests*

Such forests are found in the higher reaches of the sanctuary. They are thickly wooded with lofty trees and have a closed canopy. High humidity and shade provide ideal habitats for variety of epiphytes and flowering plants. Canes and reeds are abundant. The ground flora normally consists of species like Strobilanthus, arrowroot, ferns etc. The trees are tall, cylindrical and some with buttresses. Some common trees found are *Palaquim ellipticum, Mesua ferrea, Cullenia exarillata, Dipterocarpus indicus, Hopea parviflora, Dysoxylum malabaricum, Canarium strictum, Melicope lunu-ankenda* and *Mallotus philippensis.*

3.1.6.1.2 *Semi-evergreen forests*

These forests appear where the moist deciduous forests merge with the evergreen forests. They contain elements of both the evergreen and moist deciduous forests; the ground floor receives more light than in evergreen forests. The dominant species in the top canopy are *Adina cordifolia, Bombax ceiba, Cedrella toona, Syzygium cumini* and *Lagerstroemia lanceolata.*

3.1.6.1.3 *Moist deciduous forests*

These forests occur in the lower elevation of the sanctuary. The canopy remains leafless from March to May. *Adina cordifolia, Albizzia procera, Alstonia scholaris, Dalbergia latifolia, Lagerstroemia lanceolata* and *Xylia xylocarpa* are the dominant species in the top canopy. Some other common species found are *Bridelia retusa, Careya arborea, Cassia fistula, Dillenia pentagyna, Helicteres isora, Hollarena antidysentrica, Lantana camara,* etc.

3.1.7 Habitat

It is a virgin trail for trekkers and those who love to camp in the wilderness. Common tree species are *Palaquium ellipticum, Mesua ferrea, Cullenia exarillata, Dipterocarpus indicus, Hopea parviflora, Dysoxylum malabaricum, Cedrella toona, Bombax ceiba, Syzigium cumini, Largerstroemia lanceolata, Adina cordifolia, Albizzia procera, Alstonia scholaris, Dalbergia latifolia, Xylia xylocarpa* etc.

There are 39 species of mammals, 160 species of birds, 25 species of reptiles, 14 species of amphibians, and 31 species of fishes reported from the sanctuary (George, 2002). The mammals found are Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Sloth Bear (*Melursus ursinus*), Elephant (*Elephas maximus*), Sambar (*Rusa unicolor*), Barking Deer (*Muntiacus muntjac*), Bonnet Macaque (*Macaca radiata*), Nilgiri Langur (*Trachypithecus johnii*), Slender Loris (*Loris lydekkerianus*), Indian Porcupine (*Hystrix indica*) etc. The Chimmony Wildlife Sanctuary also offers trekking paths for the adventure traveler while bird-lovers get a special treat with great views of over 160 species of birds.

3.2. METHODS

3.2.1. Period of observation

The field study was carried out from July 2009 to June 2010. Monthly observations were made during these periods. Though the time frame represented the retreating south-west monsoon, the north-east monsoon, winter, hot summer and the south-west monsoon, these were grouped into two seasons namely the wet season (June to November) and dry season (December to May) since the change in seasons was not so distinguishable.

3.2.2. Site selection

Stratified random sampling with equal allocation of sampling units was followed to select the study sites. Two strata, the semi-evergreen and the moist deciduous forests, were selected for studying the ecology of the lesser known mammals in the sanctuary. This method is used when same level of precision is required for each stratum. This also gives habitat-specific estimates, which may be of greater interest than a single estimate in the whole area. Though the area shows some evergreen patches, their clear-cut distinction from the semi-evergreen forests is very difficult. So the inclusion of these evergreen patches into the semi-evergreen forests was of special interest. Sites for all the methods such as camera trapping, transect survey, Sherman trapping, mist-netting etc. were selected randomly representing equally the semi-evergreen and moist deciduous forest habitats in the sanctuary.

3.2.3. Camera trap survey

Camera traps were used to survey the small carnivores in the study site in both the habitats. Since most of the small carnivores are nocturnal animals, camera trapping is one of the best methods to study them. Digital scout cameras having passive infra-red sensors for heat and motion detection (Wildview Xtreme 4 model no. STC-TGL4M) were used for this survey (Plate. 2). Total 270 trap-nights (nine cameras X three days X ten months) were carried out in the sanctuary during the study period. Trap stations were selected randomly with 200m distance between the stations. Cameras were active for 12 hours (1800h to 0600h) in three consecutive days for ten months and the locations were changed in every month.

3.2.4. Line-transect survey for both direct and indirect evidences

Line transects of one kilometer length were selected randomly in each habitat. Total 240 km (120 km in each habitat) transect walk was carried out in the sanctuary ie., four kilometer X five days X 12 months. Transects were surveyed from 0700h to

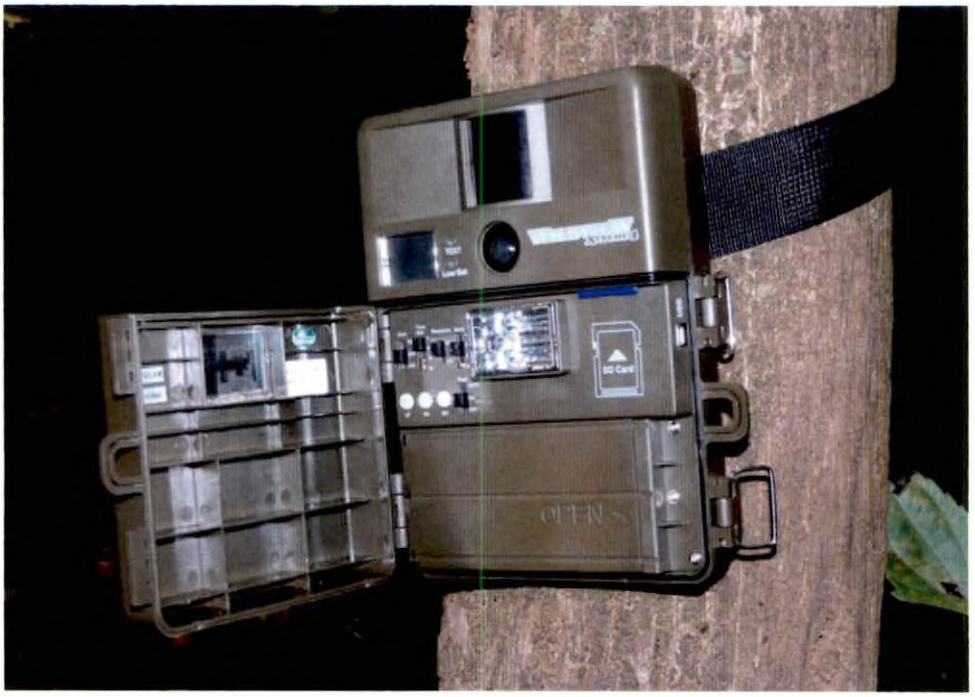


Plate 2. Camera-trap used for the study

Plate 3. Camera-trap set in the reservoir bank

1000h in the morning and 1500h to 1800h in the evening. The direct sightings of the animals as well as other indirect evidences which give the presence of the animals were recorded in the prescribed datasheets (Appendix I and II) during the transect walk.

3.2.5. Night spotlight survey

For some of the nocturnal mammals which are strictly arborial, the day transects and camera trapping are ineffectual. Night spotlight survey is an effective method for these animals. The same transect used for direct and indirect evidence in day time was used for spotlight survey also. A total of 120 km (two kilometer X five days X 12 months) was surveyed as night transect. It was carried out from 2000h to 2130h using High Beam LED torch. Animals directly sighted and calls heard were recorded.

3.2.6. Sherman traps for rodents

Most of the rodents are nocturnal and some are burrowing animals. Live trapping is the only method for studying these animals. Sherman traps were used for live trapping of rodents. Traps were set in 7 X 7 grids with 10m between the trap stations. Each station had a single Sherman trap 23cm X 9cm X 8cm in dimension (Plate 4), placed on ground giving a total of 49 traps per site covering an area of 0.49 ha (Fig.3). Additional ten traps were set on trees at five meter height from the ground. Trapping was carried out for five days consecutively in every month. This gave approaximately 5000 trap-nights (50 traps X five days X 10 months in both the semi-evergreen and moist deciduous habitats) during the study period. Traps were baited using peanut butter with fried coconut kernel, and checked and rebaited in every morning at 0700h. The rodents captured were removed immediately and placed in a cone (Plate 5), identified, measured and released. The morphological measurements such as the head to body length (HBL), tail length (TL) and weight (W) were

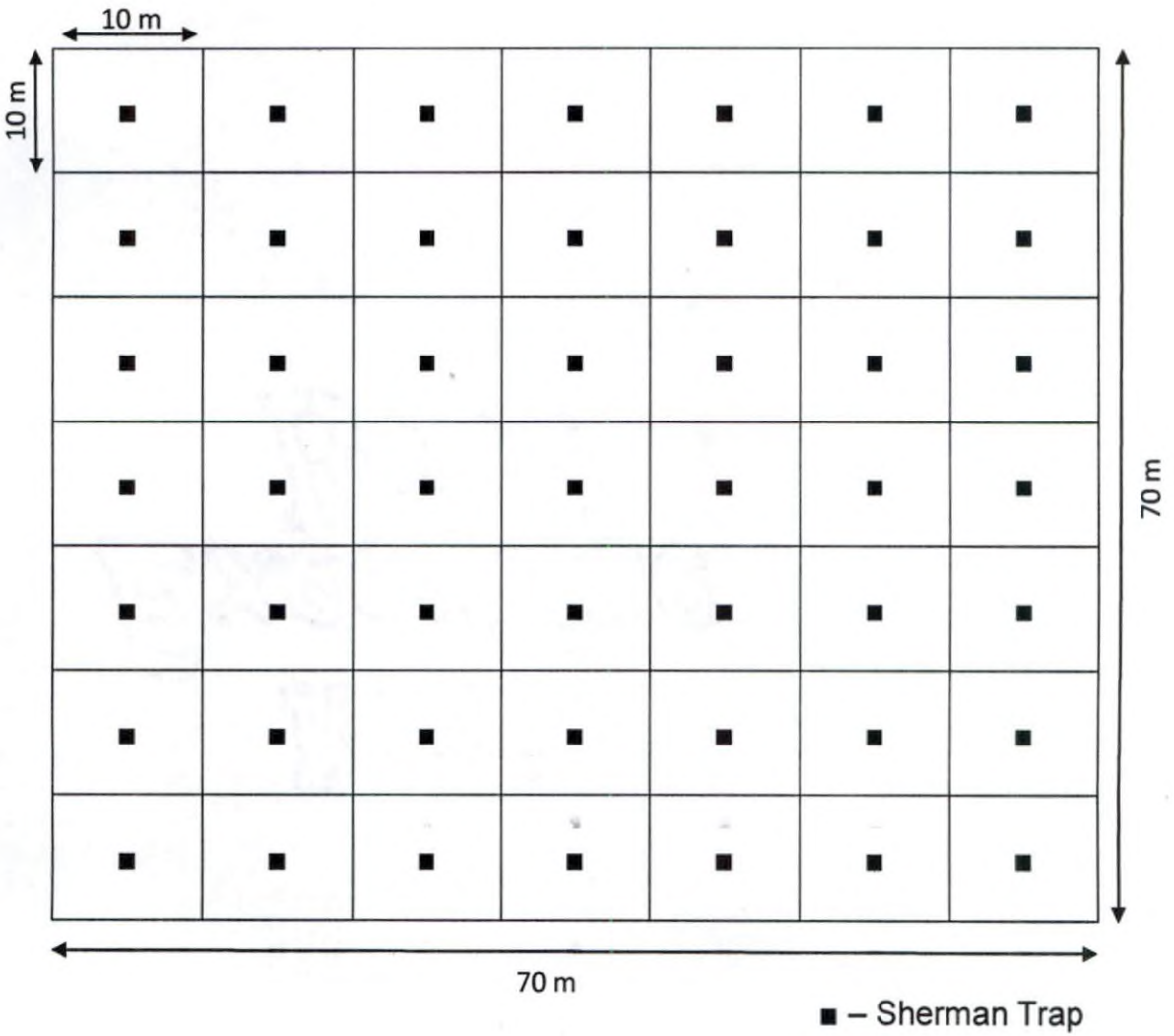


Figure 3. Alignment of Sherman-trap grid

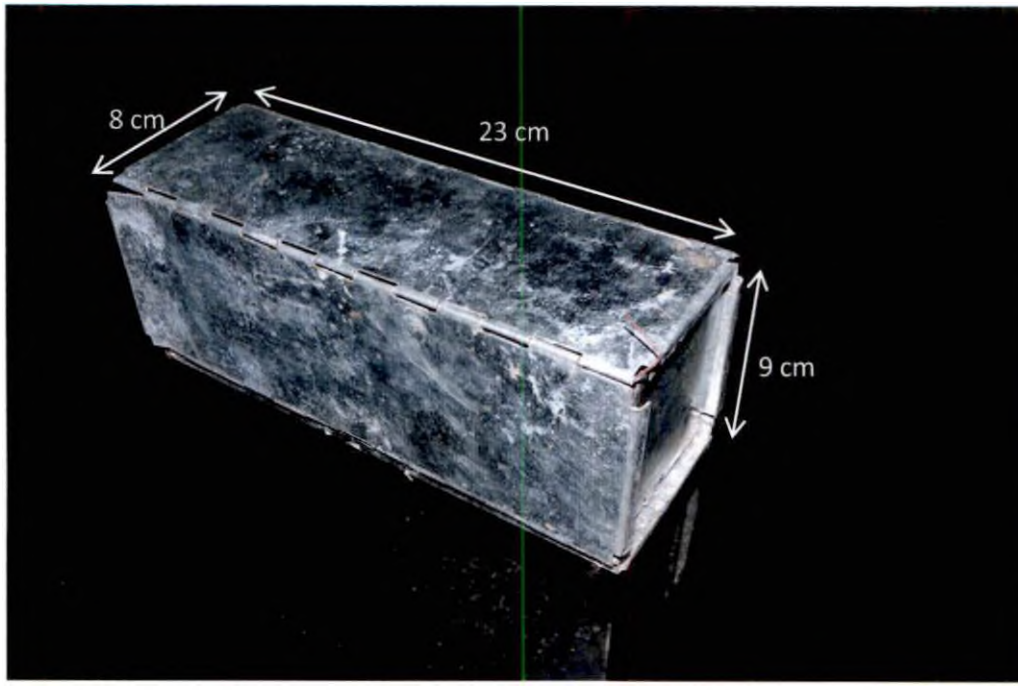


Plate 4. Sherman-trap used for capturing small mammals

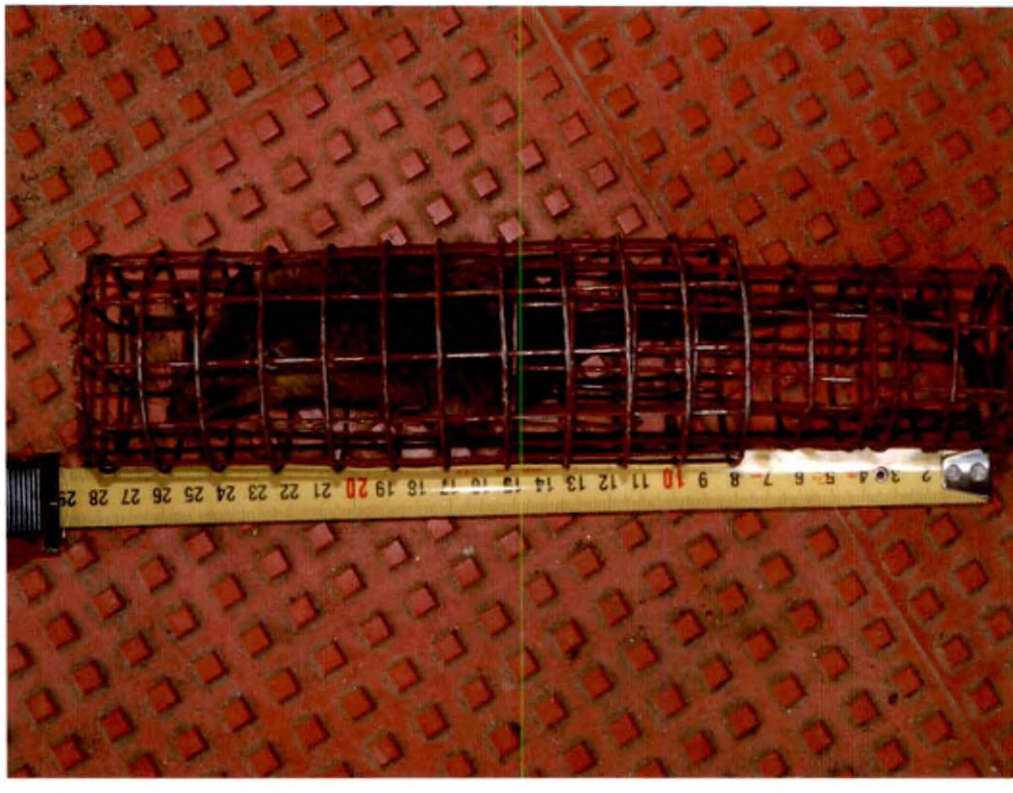


Plate 5. Cone used to transfer the rodents captured in the Sherman-trap

measured. In addition to this, other behavioural and habitat observations of the individuals captured were also recorded.

3.2.7. Survey for otters

Purposive samplings along the reservoir banks and stream shores were made for otter survey. One kilometer transects were laid around the dam within a distance of 10m from the water edge. This dimension was followed because the activity of the otters is seen within 10m distance from the shore line (Anoop and Hussain, 2004). Direct sightings as well as indirect evidences were recorded for present/absent survey.

3.2.8. Mistnet for bats

Mist nets are used most commonly for the small, volant mammals, because they are easily deployable and suitable in a variety of situations (Greenhall and Paradiso, 1968; Nagorson and Peterson, 1980; Kunz and Kurta, 1988). Mist nets made of monofilament nylon with a mesh size of 36 mm and an overall size of 10 x 1.5 m were used to capture bats during the study. The net was erected about half an hour before dusk and was kept open for two to four hours after dusk. Total 80 hours of mist-netting was carried out in the sanctuary during the study period. Nets were watched continuously. The bats, which were trapped in the mist net were removed immediately with gloved hands and placed in cloth bags, measured and released. Measurements such as forearm length (FL), ear length (EL), tail length (TL), were taken using digital calliper.

3.3. Data analysis

The ecology of a species can be expressed by various indices that show how much that particular species is related to other species in the area as well as with the different habitats in the area. In this study, the ecology of the various species

captured/observed was studied with the species richness, diversity, abundance, seasonal variation in use of different habitats, and macro and microhabitat selection.

The following indices which are commonly used for measuring species richness, diversity, evenness, abundance, similarity, habitat use etc. were used to analyse the ecology of the lesser known mammals in the sanctuary.

3.3.1 Margalef species richness index

Margalef index is calculated by the formula given below,

$$DMg = \frac{S-1}{\ln N}$$

Where, S is the total number of species recorded and N is the total number of individuals summed over all S species (Magurran, 1988).

3.3.2. Diversity indices

3.3.2.1. *Simpson's index, λ*

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

$$\lambda = \Sigma p_i^2$$

where, pi is the proportional abundance of the 'i' th species given by

$$p_i = \frac{n_i}{N}$$

Where, i = 1, 2, 3, 4, ...S, n_i is the number of individuals of the i^{th} species and N is the total known individuals for all S species in the population. Simpsons index, which varies from 0 – 1, gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated, if the

probability is high that both individual belong to the species, then the diversity of the community sample is low (Ludwig and Reynolds, 1988)

3.3.2.2. *Shannon-Wiener index, H'*

The Shannon-Wiener index (Shannon and 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,.....p_s.

3.3.3. Pielou's evenness index

In the present study evenness index was calculated using the Pielou's Evenness Index (Pielou, 1975).

$$J' = \frac{H'}{\ln S}$$

Where H' is Shannon-Weiner diversity index and S is the species richness. J' expresses H' relative to the maximum value that H' can obtain when all of the species in sample are perfectly even with one individual per species.

3.3.4. Berger-Parker index of dominance (d)

Berger-Parker index expresses the proportional importance of the most abundant species (Berger and Parker, 1970)

$$d = \frac{N_{max}}{N}$$

Where, N is the total number of individuals and N_{max} is the number of individuals in the most abundant species

3.3.5. Similarity indices

The similarity of the group of animals concerned between the study sites were worked out using Jaccard's index (qualitative) and Morista-Horn index (quanditative) (Magurran, 1988)

3.3.5.1. *Jaccard's similarity index*

Jaccard's similarity index () is given by the formula,

$$S_j = \frac{a}{(a+b+c)}$$

Where, a = number of species common in both sites 1 and 2

b = number of species in site 1 but not in site 2

c = number of species in site 2 but not in site 1

3.3.5.2. *Morisita-Horn index*

Morisita-Horn index of similarity (C_{mh}) on abundance of different species in habitats is given by;

$$C_{mh} = \frac{2\sum_{i=1}^{S}\left[(an_i)(bn_i)\right]}{(da+db)(aN)(bN)}$$

Where, S = total number of species at both sites

aN = total number of individuals of all species collected at site A

bN = total number of individuals of all species collected at site B

an_i = number of individuals of the i^{th} species collected at site A

bn_i = number of individuals of the i^{th} species collected at site B

and, in the denominator, there are two terms summed that are defined as:

$$da = \frac{\sum_{i=1}^{S} an_i^2}{aN^2} \quad \text{and} \quad db = \frac{\sum_{i=1}^{S} bn_i^2}{bN^2}$$

3.3.6. Estimation of abundance

Different measures were followed to assess the abundance of lesser known mammals in the sanctuary.

3.3.6.1 *Abundance of small carnivores*

The abundance of scats was used as an indicator of the abundance of the small carnivores since other measures such as camera traps and transect walk for direct sightings give inadequate data. Scat abundance was estimated as the number of scat encounter per kilometer surveyed with respect to a habitat or an area. Even this presented with many difficulties. Based on scat morphology, it was possible to identify the scats only to the family level - mongoose, civets, and otters - and not to species level. All scats seen were recorded and some scat samples were collected for detailed analysis.

$$\text{Abundance} = \frac{\text{Total number of scats obtained}}{\text{Total transect walk in kilometer}}$$

3.3.6.2 *Abundance of rodents*

In the case of squirrels, the encounter rate was used as a measure to calculate the abundance of the squirrels in the sanctuary. The abundance of squirrels as encounter rate is expressed as number of individuals seen per kilometer transect walk.

$$\text{Abundance of squirrels} = \frac{\text{Total number of individuals sighted}}{\text{Total transect walk in kilometer}}$$

Similarly the abundance of rodents captured using Sherman traps was measured as Trap Index, ie., the number of individuals captured per 100 trap-nights (Prakash and Singh, 1999). This is calculated by the formula;

$$\text{Trap Index} = \frac{\text{Total number of individuals of } i^{th} \text{ species captured}}{\text{No. of traps X No. of trapping nights}} \text{ X } 100$$

The abundance of Indian Porcupine was calculated as scat abundance using the same formula used for small carnivores.

3.3.6.3 *Abundance of bats*

The abundance of different species of bats was calculated as the number of individuals captured per hour of mist-netting. This was calculated using the formula given below

$$\text{Abundance of Bats} = \frac{\text{Total number of individuals captured}}{\text{Total hours of mist-netting}}$$

3.3.7 Habitat use assessment

3.3.7.1 *Habitat Use Index (HUI)*

This index was used to understand the habitat preference of a species in an area. This index was developed from the indirect evidences recorded from different habitats of the sanctuary. In this study, this index is used to analyse the habitat preference of small carnivores and porcupines since they gave only indirect evidences. The HUI is calculated by the formula given below,

$$\text{Habitat Use Index (HUI)} = \frac{N_{HI}}{N_H} \text{ X } 100$$

Where, N_{HI} = Total number of indirect evidences from one habitat (in a season or during the study period)

N_H = Total number of indirect evidences from all the habitats (in a season or during the study period)

3.3.7.2 *Microhabitat Selection*

Microhabitat variables such as canopy height in meter, canopy closure in 0 - 1 scale over a radius of two meter, herbaceous cover in two meter radius (0 – 1 scale), percentage rocky area in five meter radius and volume of coarse woody debris were collected at each trap station in the case of Sherman trapping. Line Intercept Method was used to estimate coarse woody debris (CWD), following the method outlined in Harmon and Sexton (1996). Two randomly chosen transects having five meter length that extended out from the trap location were selected. The length and diameter of each piece of CWD (> 10 cm diameter and minimum one m in length) encountered along the transects were recorded. Then the volume of CWD was estimated by the formula

$$V = \frac{1.234}{L} X \Sigma d_i^2$$

Where, V = total volume of CWD in cubic meter per hectare, L = transect length in meter, and, d = diameter of i^{th} element in centimeter.

Then the microhabitat use profile for each species captured was developed using the means of the habitat variables at all trap stations where an individual of that species was captured. Multivariate analysis (Mann-Whitney U test) was used to test the null hypothesis that there was no difference between the animal habitat use (captured plots) and availability of habitat (random plots or non-captured plots).

3.3.8. Statistical analysis

Various statistical packages including the Microsoft Office Excel (Version 2007), SPSS (Version 17), BiodiversityPro (McAleece *et al.*, 1997), and PAST (Hammer *et al.,* 2001) were used for statistical analysis of the data collected.

Results

RESULTS

4.1 SPECIES COMPOSITION OF LESSER KNOWN MAMMALS FROM CHIMMONY WILDLIFE SANCTUARY

The present study at Chimmony Wildlife Sanctuary recorded 22 species of mammals belonging to the rodents, small carnivores and bats which are considered as lesser known mammals (Table 2). It includes six species of small carnivores, eight species of rodents and eight species of bats. Each of these groups of mammals is explained in detail below.

4.1.1 Small carnivores from Chimmony Wildlife Sanctuary

Six species of small carnivores were identified from the sanctuary. They are represented in families such as viverridae, herpestidae, mustelidae and felidae. The six different species includes Jungle Cat (*Felis chaus),* Grey Mongoose (*Herpestes edwardsii*), Stripe-necked Mongoose (*Herpestes vitticollis*) Smooth-coated Otter (*Lutrogale perspicillata*), Asian Palm Civet (*Paradoxurus hermaphrodites*) and Small Indian Civet (*Viverricula indica*). The lists of small carnivores identified from Chimmony Wildlife Sanctuary along with their taxonomic position are given in Table 2.

4.1.1.1 *Results from direct sighting*

Day transects as well as the night spotlight survey resulted in eight sightings of five different species of small carnivores. These five species include *Herpestes edwardsii, Herpestes vitticollis, Lutrogale perspicillata, Paradoxurus hermaphrodites* and *Viverricula indica.* Among these, three sightings were that of *Lutrogale perspicillata* in which two sightings were from the semi-evergreen habitats of Kallichampara and Anapporu, and one sighting from the moist deciduous forests of Virakuthodu. All these sightings were near to the reservoir. *Herpestes edwardsii* gave two sightings from the moist deciduous forests of

Virakuthodu. A single sighting of *Herpestes vitticollis* was from the moist deciduous forests of Virakuthodu at noon time.

Table 2. Lesser known mammals from Chimmony Wildlife Sanctuary

Sl. No.	Common Name	Scientific name	Family
I	**Small carnivores**		
1	Small Indian Civet	*Viverricula indica*	Viverridae
2	Asian Palm Civet	*Paradoxurus hermaphroditus*	
3	Grey Mongoose	*Herpestes edwardsii*	Herpestidae
4	Stripe-necked Mongoose	*Herpestes vitticollis*	
5	Smooth-coated Otter	*Lutrogale perspicillata*	Mustelidae
6	Jungle Cat	*Felis chaus*	Felidae
II	**Rodents**		
7	Dusky Striped Squirrel	*Funambulus sublineatus*	Sciuridae
8	Jungle Striped Squirrel	*Funambulus tristriatus*	
9	Malabar Giant Squirrel	*Ratufa indica*	
10	Large Flying Squirrel	*Petaurista philippensis*	
11	White-tailed Wood Rat	*Cremnomys blanfordi*	Muridae
12	Black Rat	*Rattus rattus wroughtoni*	
13	Common Metad	*Millardia meltada*	
14	Indian Porcupine	*Hystrix indica*	Hystricidae
III	**Bats**		
15	Short-nosed Fruit Bat	*Cynopterus sphinx*	Pteropodidae
16	Lesser Dog-faced Fruit Bat	*Cynopterus brachyotis*	
17	Fulvous Fruit Bat	*Rousettus leschenaulti*	
18	Lesser Wooly Horseshoe Bat	*Rhinolophus beddomei*	Rhinolophidae
19	Rufous Horse-shoe Bat	*Rhinolophus rouxii*	
20	Dusky Leaf-nosed Bat	*Hipposideros ater*	
21	Schneider's Leaf-nosed Bat	*Hipposideros speoris*	
22	Lesser False Vampire Bat	*Megaderma spasma*	Megadermatidae

The two civets *Paradoxurus hermaphrodites* and *Viverricula indica* were seen only once during the night transect from the moist deciduous forests of Virakuthodu. *Paradoxurus hermaphrodites* was seen running across the road whereas *Viverricula indica* was seen feeding on *Ficus aspera.*

4.1.1.2 *Results from indirect evidences*

4.1.1.2.1 *Presence of scats*

A total of 17 scats pertaining to small carnivores were identified from 240 km transect walk (120 km in each semi-evergreen and moist deciduous habitat respectively). Existing trails, forest roads and streams which seemed to be used more frequently by the lesser carnivores were selected as transects. Among the 17 scats collected, nine were of civets (52.9%), five of mongoose (29.4%) and three of otters (17.6%). The proportion of the scats seen in various habitats in the sanctuary is shown in Figure. 4. In the moist deciduous habitat, civet scats (50%) were seen more, followed by mongoose (40%) and otters (10%) and in the semi-evergreen forests the civet scats were seen more (57.1 %), followed by otters (28.6%) and mongoose (14.3%).

Scat abundance (scats/kilometer) was calculated as a measure to represent the abundance of small carnivores in the sanctuary. Scat abundance was higher for the civets (0.04) followed by mongoose (0.02) and otters (0.01) in the whole sanctuary. Scat abundance in various habitats and in the whole sanctuary is given in Table 3. It shows that the civets and mongoose were abundant in the moist deciduous forests and the otters were abundant in the semi-evergreen forests. A stacked diagram of the abundance of small carnivores in various habitats and in the whole sanctuary is given in Figure. 5.

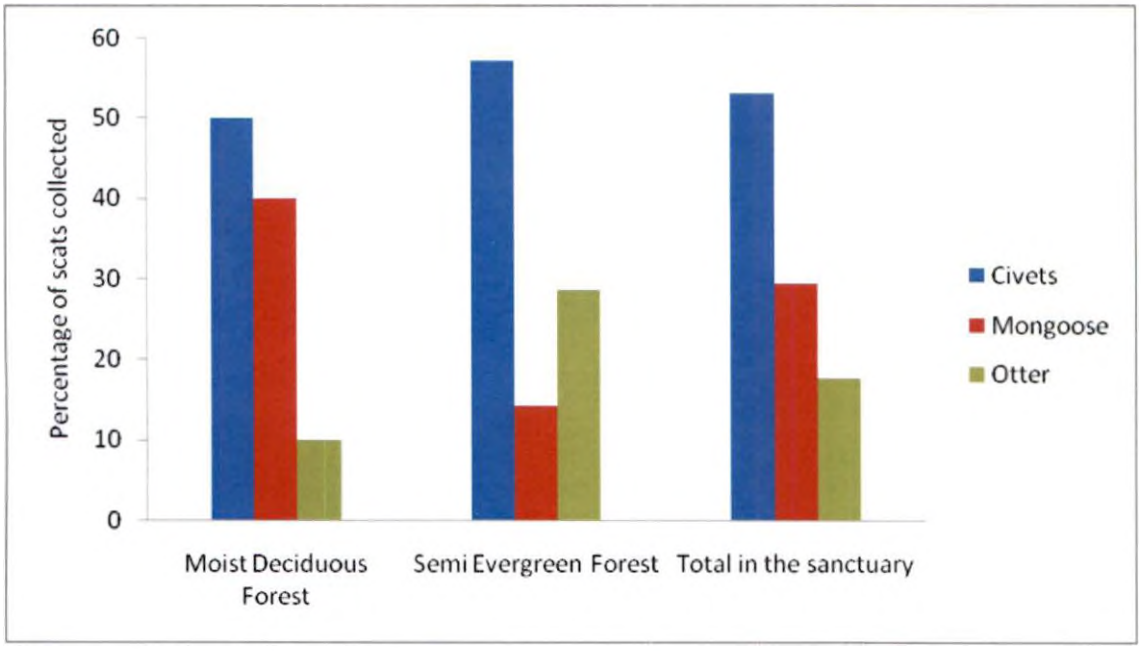


Figure 4. Proportion of small carnivore scats collected from Chimmony Wildlife Sanctuary

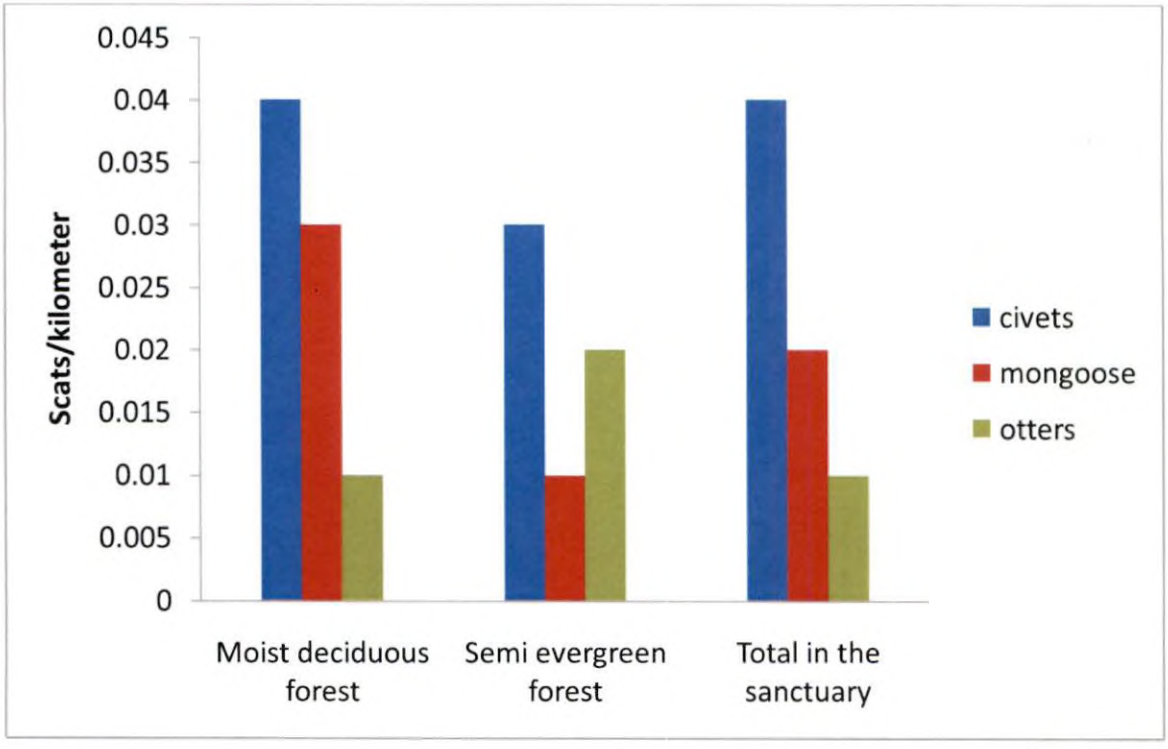


Figure 5. Abundance (scat encounter/kilometer) of small carnivores in Chimmony Wildlife Sanctuary

Table 3. Abundance (scat encounter/kilometer) of small carnivores in Chimmony Wildlife Sanctuary

Sl No.		Moist Deciduous Forests	Semi-evergreen Forests	Total in the Sanctuary
1	Civet	0.04	0.03	0.04
2	Mongoose	0.03	0.01	0.02
3	Otter	0.01	0.02	0.01

4.1.1.2.2 *Presence of footprints*

The foot prints of small carnivores observed in different parts of the sanctuary was taken and identified. The tracks of jungle cats and otters were confirmed from the sanctuary. A total of six tracks of jungle cat and two tracks of otters were recorded from the sanctuary. In the case of jungle cat, five tracks were recorded from the moist deciduous forests and only one track was seen in the semi-evergreen habitats. All the otter pugmarks were collected from the reservoir banks of moist deciduous forests in Virakuthodu. It was very difficult to make out the pugmarks from the reservoir banks since the constant water movement washes it away. Pugmarks of several other carnivores were also collected from the sanctuary which include Common Leopard (*Panthera pardus*), Tiger (*Panthera tigris*) and Wild Dog (*Cuon alpinus*).

4.1.1.2.3 *Presence of dens and small holes*

Several dens, small holes and other resting places were observed during the survey. But a typical den which was supposed to be that of the jungle cat was obtained from semi-evergreen forest of Vavala. The den also had the presence of pugmarks at the entrance. The observations also showed that the den is in use and

no vegetation was there at the mouth of the den which showed the presence of constant use of the den.

4.1.1.3 *Results from camera-trapping*

Digital scout cameras having passive infra-red sensors for heat and motion detection (Wildview Xtreme 4 model no. STC-TGL4M) were used for this survey. Total 270 camera-trap nights were carried out in the sanctuary. Among the lesser known mammals studied the camera-trap gave a single image of two Indian Porcupines from the Virakuthodu area of the sanctuary. However, no small carnivores could be captured in the camera traps. This could be due to the less abundance of the small carnivores in the study area. Moreover, some technical problems encountered with the camera-traps were also responsible for the fewer capture success. The camera traps, however, documented the presence of some large bodied animals such as common leopard (*Panthera pardus*), elephant (*Elephus maximus*), sambar deer (*Rusa unicolor*) and gaur (*Bos gaurus*) from the sanctuary. It was for the first time that the camera-trapping is conducted in the sanctuary. The images captured are shown in Plate 6.

4.1.1.4 *Presence of small carnivores in different habitats of Chimmony Wildlife Sanctuary*

A presence/absence profile of the small carnivore species recorded in various habitats of the sanctuary is presented in Table 4. It includes both the direct sightings as well as indirect evidences such as scats, foot prints, den, hole etc.

The *Herpestes vitticollis* was the only habitat specialist preferring the moist deciduous forests. All others were seen in both the moist deciduous as well as semi-evergreen habitats. All the direct sightings were from the moist deciduous habitats except *Lutrogale perspicillata* which was sighted from both the habitats.

Indian Porcupine

Elephant

Sambar Deer

Gaur

Common Leopard

Plate 6. Images captured using camera-traps

Table 4. Presence of small carnivores in different habitats of Chimmony Wildlife Sanctuary

Sl. No.	Species	Habitat	
		Moist Deciduous Forests	Semi-evergreen Forests
1	*Viverricula indica*	D/I	I
2	*Paradoxurus hermaphroditus*	D/I	I
3	*Herpestes edwardsii*	D/I	I
4	*Herpestes vitticollis*	D	NO
5	*Lutrogale perspicillata*	D/I	D/I
6	*Felis chaus*	I	I

D= Direct sightings, I = Indirect evidences, NO = Not observed

4.1.1.4 *Habitat Use Index (HUI) of small carnivores in Chimmony Wildlife Sanctuary*

Habitat Use Index (HUI) of small carnivore species in the moist deciduous and semi-evergreen habitats of Chimmony Wildlife sanctuary was developed from the indirect evidences observed in both the habitats. A tabular statement of the HUI of small carnivores in the sanctuary is given in Table. 5 and graphical representation of the same is shown in Figure 6.

The HUI of civets showed slight variation among the habitats and was higher in moist deciduous habitat (55.6) when compared to semi-evergreen habitat (44.4). There was a considerable difference in the habitat use of mongoose and it was higher in moist deciduous habitats (80.0) than semi-evergreen habitats (20.0). Similarly otters preferred moist deciduous habitats (60.0) than semi-evergreen

(40.0). HUI of Jungle Cat is notably much higher for moist deciduous forests (83.3) than semi-evergreen habitats (16.7).

Table 5 Habitat Use Index of small carnivores in Chimmony Wildlife Sanctuary

Sl. No.	Small carnivore group	Moist Deciduous Forest	Semi-evergreen Forest
1	Civets	55.6	44.4
2	Mongoose	80.0	20.0
3	Otters	60.0	40.0
4	Jungle cat	83.3	16.7

Seasonal variation in habitat use of small carnivores in both the moist deciduous as well as semi-evergreen habitats was also analysed and it is graphically shown in Figure 7. The seasonal HUI of different small carnivore species in both the habitats is given in Table 6.

Table 6. Seasonal Habitat Use Index of small carnivores from Chimmony Wildlife Sanctuary

Sl. No.	Small carnivores	Dry Season		Wet Season	
		Moist Deciduous	Semi-evergreen	Moist Deciduous	Semi-evergreen
1	Civets	50	50	60	40
2	Mongoose	75	25	100	0
3	Otters	50	50	100	0
4	Jungle cat	83.3	16.7	0	0

The HUI was equal for both the habitats (50) in dry season in the case of civets but they preferred moist deciduous forest (60) than semi-evergreen (40) in wet season. Mongoose used moist deciduous habitat (75) than semi-evergreen (25) in the dry season but in wet season it was totally confined to the moist

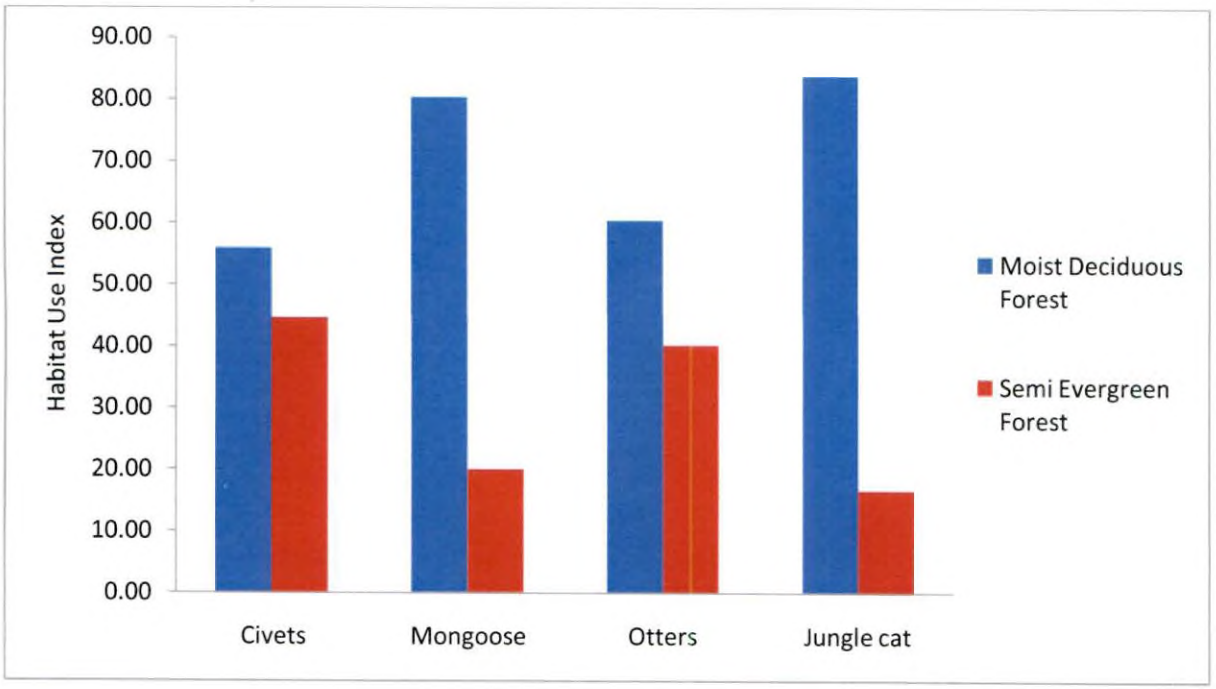


Figure 6. Habitat Use Index of small carnivores in Chimmony Wildlife Sanctuary

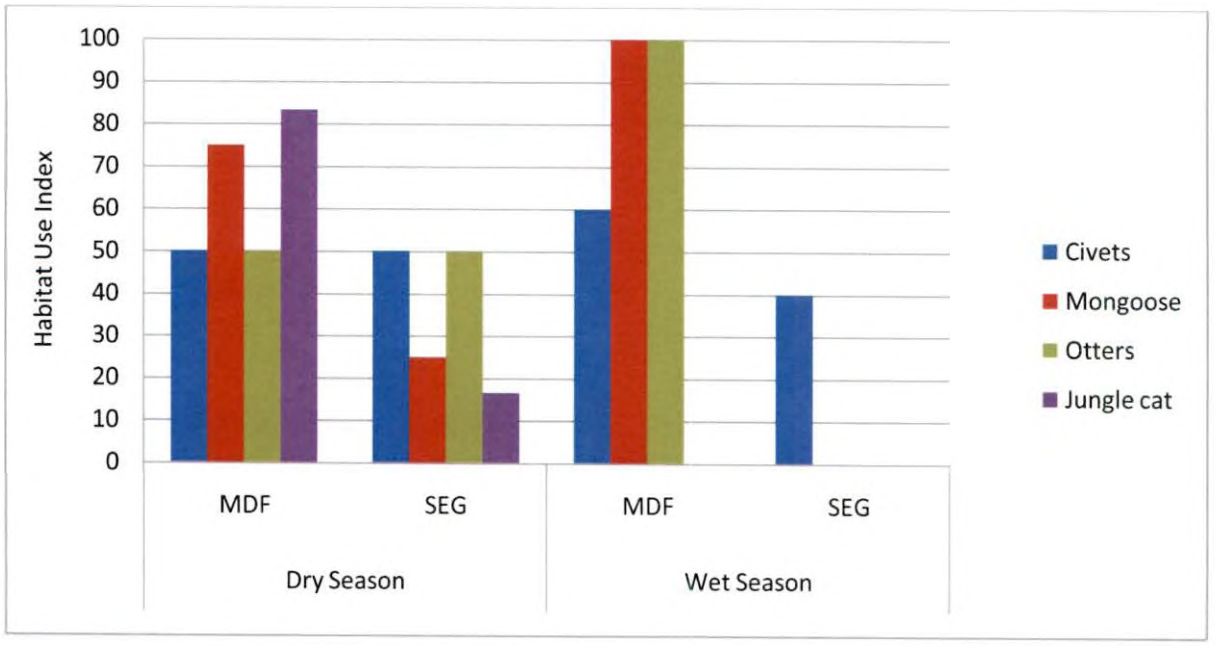


Figure 7. Seasonal habitat use of small carnivores in Chimmony Wildlife Sanctuary (MDF = Moist Deciduous Forest and SEG = Semi Evergreen Forest)

deciduous forest (100). Habitat use of otters in dry season was equal in both the habitats (50), while, in wet season it was found in moist deciduous habitats (100) only. Jungle Cats were seen only in the dry season with HUI much higher in moist deciduous forests (83.3) than in semi-evergreen forests (16.7).

4.1.1.5 *Similarity of small carnivores between different habitats of Chimmony Wildlife Sanctuary*

Jaccard's similarity index was used to analyse the similarity of distribution of small carnivores between the moist deciduous and semi-evergreen forest of the sanctuary. Jaccard's index of similarity was found 0.83 between the moist deciduous and semi-evergreen forests.

4. 1. 2 Rodents recorded from Chimmony Wildlife Sanctuary

The present study recorded a total of eight species of rodents from the Chimmony Wildlife Sanctuary. This includes four species of scuirine squirrels (Sciuridae), three species of rats (Muridae) and the Indian porcupine (Hystricidae). The list of rodents identified from Chimmony Wildlife Sanctuary along with their taxonomic position is given in Table 2.

4.1.2.1 *Results from direct sightings*

All the squirrels were directly sighted during the transect walk. Diurnal squirrels such as *Funambulus sublineatus*, *Funambulus tristriatus* and *Ratufa indica* were sighted during the day transects and the *Petaurista philippensis* was sighted in the night spotlight survey.

4.1.2.1.1 *Abundance of squirrels in Chimmony Wildlife Sanctuary*

The encounter rate of the squirrels was used as a measure to calculate the abundance of the squirrels in the sanctuary and the same is given in Table 7.

Table 7. Abundance of squirrels in Chimmony Wildlife Sanctuary

Sl. No.	Species	Number of sightings	Number of individuals	Abundance (individuals sighted / km)
1	*Ratufa indica*	56	77	0.32
2	*Funambulus tristriatus*	9	16	0.07
3	*Funambulus sublineatus*	10	14	0.06
4	*Petaurista philippensis*	5	5	0.02

Table 7 shows that among the squirrels *Ratufa indica* was the most abundant species (0.32) in the sanctuary with 56 sightings of 77 individuals. This is followed by *Funambulus tristriatus* (0.07) with nine sightings of 16 individuals. The abundance of *Funambulus sublineatus* (0.06) with 10 sightings of 14 individuals is almost similar to that of *Funambulus tristriatus.* The least abundant squirrel in the sanctuary is *Petaurista philippensis* (0.02) with only five sightings of five individuals.

The habitat wise abundance of squirrels in Chimmony Wildlife Sanctuary is given in Table 8 and the same is graphically shown in Figure 8. It shows that in moist deciduous forest, the abundance of squirrels is in the order *Ratufa indica* > *Funambulus tristriatus* > *Funambulus sublineatus* = *Petaurista philippensis* whereas, in semi-evergreen forest, it is in the order *Ratufa indica* > *Funambulus sublineatus* > *Funambulus tristriatus* > *Petaurista philippensis.*

Table 8 Abundance of squirrels in Chimmony Wildlife Sanctuary

Species	Moist Deciduous Forest			Semi-evergreen Forest		
	No. of sightings	No. of individuals	Abundance (individuals seen / km)	No. of sightings	No. of individuals	Abundance (individuals seen / km)
R. indica	30	43	0.36	26	34	0.28
F. tristriatus	7	12	0.10	2	4	0.03
F. sublineatus	3	3	0.03	7	11	0.09
P. philippensis	3	3	0.03	2	2	0.02

4.1.2.1.2 *Social habit of squirrels in Chimmony Wildlife Sanctuary*

The social habit indicates the social behaviour of the wild animals such as whether they are seen solitary, in pairs or in groups. The percentage of sightings of the squirrels as solitary, in pairs and the group with three individuals (the maximum cluster size observed was three individuals) is shown in Table 9.

Table 9 Social habit of squirrels in Chimmony Wildlife Sanctuary

Sl. No.	Species	% of sightings as		
		Solitary	In pairs	Group having three individuals*
1	*R. indica*	71.4	19.6	8.9
2	*F. tristriatus*	33.3	55.6	11.1
3	*F. sublineatus*	70	20	10
4	*P. philippensis*	100	0	0

* Maximum cluster size observed was three individuals

Table 9 shows that, all the species except *Funambulus tristriatus* was seen as solitary in most sightings, but, *Funambulus tristriatus* was seen in pairs in most of the sightings. A comparison of the social habit of these squirrels is graphically shown in Figure 9.

4.1.2.2 *Results from indirect evidences*

Apart from the direct sightings, indirect evidences also proved the existence of some rodents in the sanctuary. During the transect walk, efforts were made to record the scats, dens, small holes and other signs of the presence of rodents in various habitats of the sanctuary. From these observations, indirect evidences of rodents such as Indian Porcupine (*Hystrix indica*) and Malabar Giant Squirrel (*Ratufa indica*) were identified. Indian Porcupine was not directly sighted from the sanctuary, but their presence was seen throughout the sanctuary in all the habitats. Its abundance in the sanctuary was calculated as the scat encounter per kilometer. The scat encounter of Indian Porcupine was much higher than any of the scat encounter of other animals recorded in the present study (Table 10). Droppings of Malabar Giant Squirrel were also seen and its encounter rate was almost similar to that of civets in the sanctuary. A comparative expression of the abundance (scat encounter / km) of the lesser known mammals from the sanctuary is shown in Figure 10.

Table 10 Abundance (scat encounter / km) of lesser known mammals in Chimmony Wildlife Sanctuary

Sl No.		Moist Deciduous Forests	Semi-evergreen Forests	Total in the sanctuary
1	Porcupine	0.30	0.10	0.20
2	Civets	0.04	0.03	0.04
3	Malabar Giant Squirrel	0.04	0.01	0.03
4	Mongoose	0.03	0.01	0.02
5	Otters	0.01	0.02	0.01

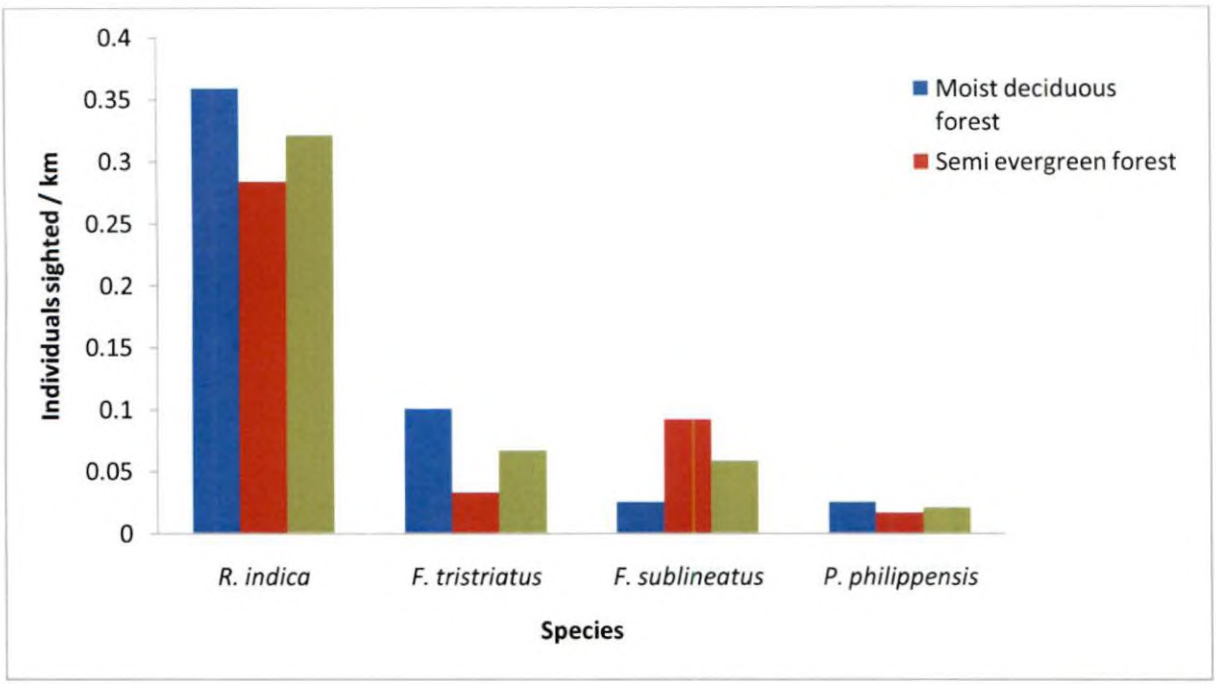


Figure 8. Abundance of squirrels in Chimmony Wildlife sanctuary

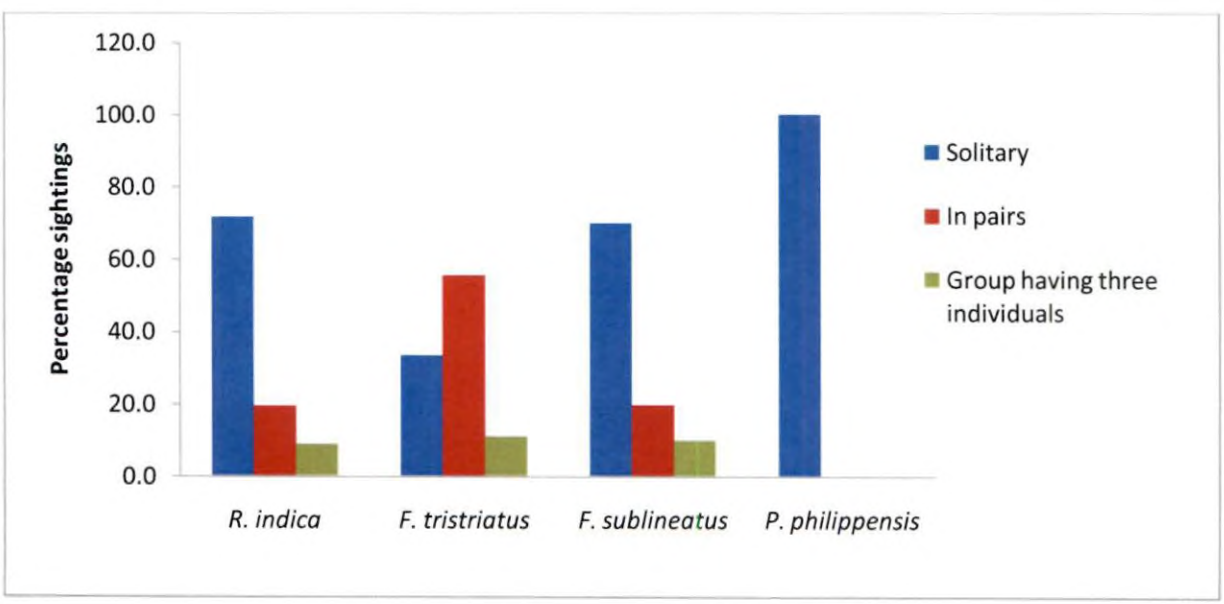


Figure 9. Social habit of squirrels in Chimmony Wildlife sanctuary

Table 10 also shows that the abundance of Indian Porcupine is almost three times higher in the moist deciduous forests than the semi-evergreen forest in the sanctuary. Similarly, the abundance of Malabar Giant Squirrel is much higher in the moist deciduous forests when compared to the semi-evergreen forests. The direct observation also supports the same.

4.1.2.2.1 *Habitat Use Index (HUI) of Indian Porcupine*

An HUI was designed from the indirect evidences recorded from various habitats of the sanctuary in various seasons to study the habitat preference of the Indian Porcupine in the sanctuary. Besides the scats, indirect evidences like the quills and dens were also used to design the HUI. The HUI of Indian Porcupine in two different habitats in two different seasons is shown in Figure 11. It shows that the animal prefers the moist deciduous habitat irrespective of seasons. In dry season, the activity was much higher in the moist deciduous habitat whereas in wet season, the difference in habitat use is very less.

4.1.2.3 *Results of the rodents captured using Sherman traps*

Four species of rodents were captured using Sherman traps in Chimmony Wildlife Sanctuary during the present study. The trap success was very poor in the sanctuary with only 20 successful trap-nights out of 5000 trap-nights. The four species captured include three species of rats (muridae) and one species of squirrel (scuiridae). Rat species captured include Black Rat (*Rattus rattus wroughtoni*), White-Tailed Wood (Blanford's) Rat (*Cremnomys blanfordi*) and Common Metad (*Millardia meltada*). The only squirrel species captured was the Jungle Striped Squirrel (*Funambulus tristriatus*). Number of individuals of various species of rodents captured and its abundance (capture/100 trapnights) with their sex ratio is given in Table 11. *Rattus rattus wroughtoni* was the most abundant species (0.48) in the sanctuary with a capture of 12 individuals. *Cremnomys blanfordi* is the second most abundant (0.24) species with a capture

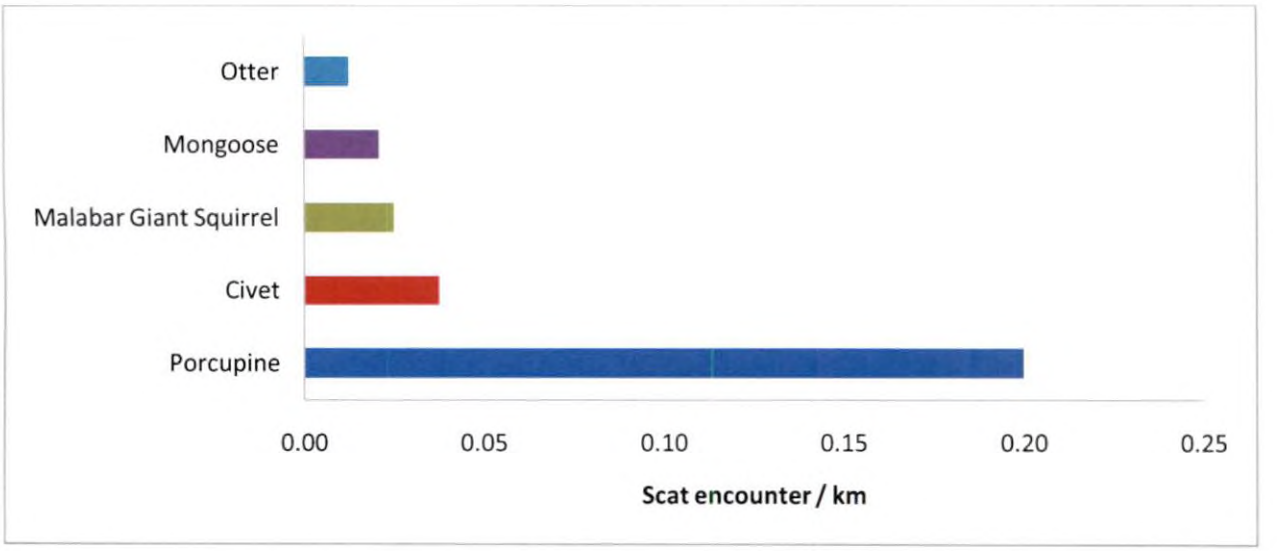


Figure 10. Abundance (scat encounter / km) of lesser known mammals in Chimmony Wildlife Sanctuary

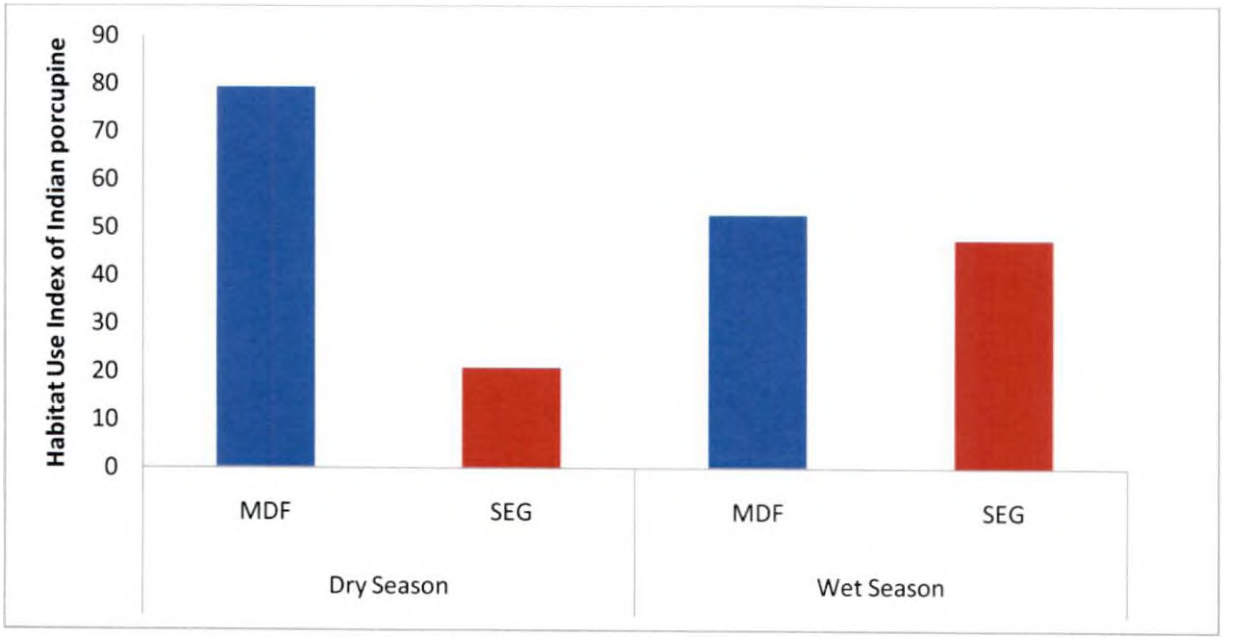


Figure 11. Seasonal habitat use of Indian Porcupine in Chimmony Wildlife Sanctuary (MDF = Moist Deciduous Forest and SEG = Semi Evergreen Forest)

of six individuals. Only one individual was trapped for both *Millardia meltada* and *Funambulus tristriatus.* The proportion of individuals of rodents trapped in the sanctuary is shown in Figure 12.

Table 11 Number of individuals of rodents trapped in Chimmony Wildlife Sanctuary

Sl. No.	Species	No. of Individuals	Abundance (capture/100 trapnights)	Male	Female	Sex Ratio
1	*R. r. wroughtoni*	12	0.48	9	3	3:1
2	*C. blanfordi*	6	0.24	3	3	1:1
3	*M. meltada*	1	0.04	1	0	1:0
4	*F. tristriatus*	1	0.04	1	0	1:0

Out of the 12 individuals of *Rattus rattus wroughtoni*, nine were males and three individuals were females, whereas, in the case of *Cremnomys blanfordi*, the sex ratio showed equal proportion. Only one individual was captured in the case of *Millardia meltada* and *Funambulus tristriatus* and both of them were males. A graphical representation of the proportion of male and female individuals among the rodents trapped is shown in Figure 13.

4.1.2.3.1 *Habitat selection of the rodents captured using Sherman traps*

Both macro and micro habitat selection of the species of rodents captured using Sherman traps were studied and described below. Macro habitats of the sanctuary include the moist deciduous and semi-evergreen forests. Micro habitats are the small regions within the macro habitats which are distinguished by various vegetative and topographic features.

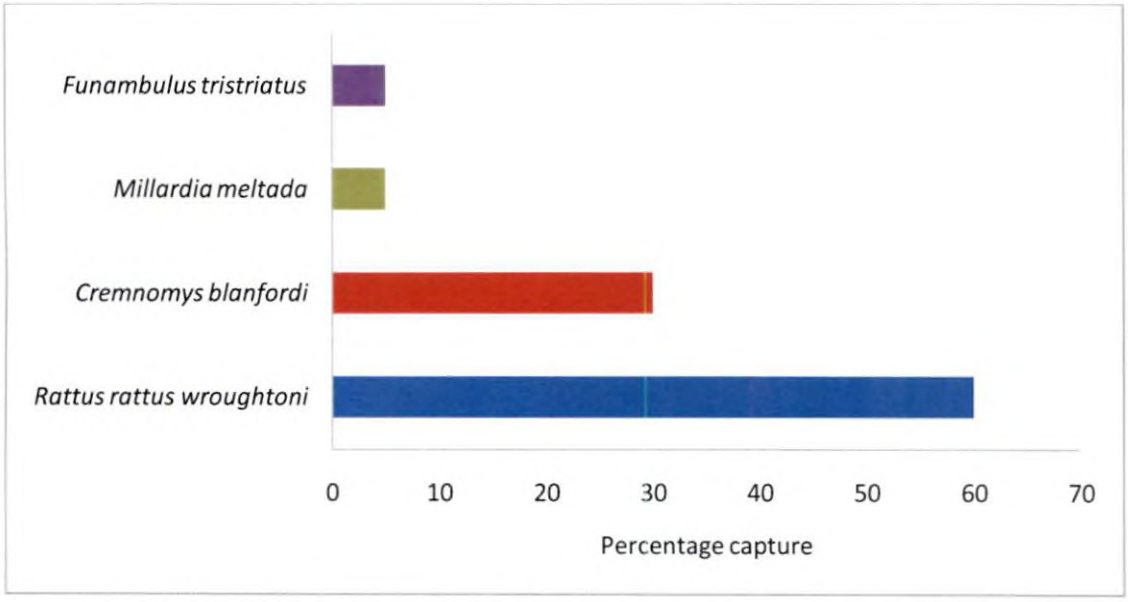


Figure 12. Proportion of individuals of rodents trapped in Chimmony Wildlife sanctuary

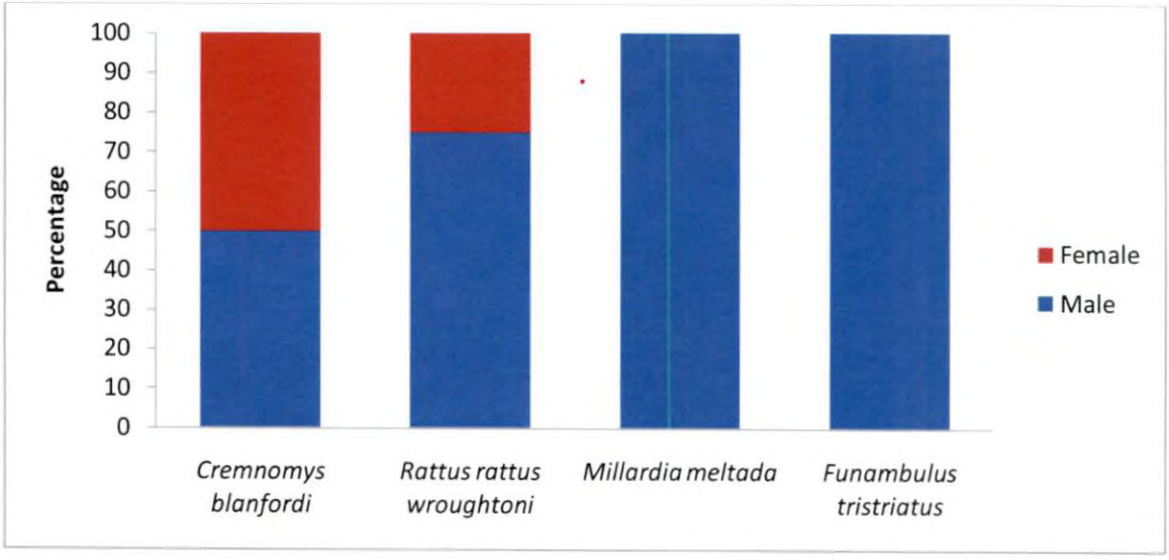


Figure 13. Proportion of male and female individuals among the rodents trapped in Chimmony Wildlife Sanctuary

4.1.2.3.2 *Macro habitat selection of the rodents captured using Sherman traps*

The details of the rodents trapped in different habitats of the sanctuary are given in Table 12. Total 13 individuals were trapped from the moist deciduous forests whereas only seven individuals were trapped from the semi-evergreen forests.

Table 12 Number of individuals of rodents trapped in different habitats of Chimmony Wildlife Sanctuary

Sl. No.	Species	Habitat	
		Moist Deciduous Forest	Semi-evergreen forest
1	*Cremnomys blanfordi*	6	0
2	*Rattus rattus wroughtoni*	6	6
3	*Millardia meltada*	0	1
4	*Funambulus tristriatus*	1	0
	Total	13	7

Among the rodents trapped, *Rattus rattus wroughtoni* was captured from both moist deciduous as well as semi-evergreen forests. Out of the 12 individuals trapped, six were from moist deciduous and the other six were from the semi-evergreen forests. It clearly shows that *Rattus rattus wroughtoni* is a habitat generalist in the sanctuary with equal preference to both the habitats. Unlike this, *Cremnomys blanfordi* is a habitat specialist in the sanctuary preferring only the moist deciduous habitat. All the captures were from the moist deciduous forests. The only one capture of *Millardia meltada* was from the semi-evergreen habitat of Anapporu, while the only one capture of *Funambulus tristriatus* was from the

moist deciduous habitat of Virakuthodu. Number of individuals of rodents trapped in various habitats of the sanctuary is shown in Figure 14.

4.1.2.3.3 *Microhabitat selection of the rodents captured using Sherman traps*

Microhabitat preference of the rodents within the macro habitat was studied by looking at various habitat parameters of the animal availability versus use sites. The animal captured site is the availability site and the random sites selected for capturing, from where the animals were not captured, are the animal use sites. Habitat parameters such as the canopy height (m), canopy closure (% in 5m radius), number of snags (number/plot), ground vegetation (% in 2m radius), rocks (% in 5m radius), litter (% in 2m radius), volume of coarse woody debris (m^3/ha) and tree density (number/plot) were compared between the capture and random plots to study the microhabitat selection of the species captured. Non-parametric Mann-Whitney U Test was used to examine differences in habitat variables between capture and random plots in the sanctuary. The microhabitat selection of *Millardia meltada* and *Funambulus tristriatus* were not studied since the capture rate was not sufficient to carry out the statistical analysis.

Results of the Mann-Whitney U Test to analyse the microhabitat selection of *Rattus rattus wroughtoni* in the moist deciduous forest is given in Table 13. It shows that the habitat variables such as snags, rock and coarse woody debris were significantly higher in the capture plots than in random plots. Among these the rock and coarse woody debris appeared to be particularly significant because it was almost five times greater in the capture plots than in random plots (Table 13).

Similarly the microhabitat selection of *Rattus rattus wroughtoni* in the semi-evergreen habitats of the sanctuary was analysed and the results of the same is given in Table 14. Here the number of snags, rock and coarse woody debris were significantly higher in the capture plots than the random plots whereas the ground vegetation was significantly lower in capture plots than random plots.

Table 13 Comparison of habitat parameters at *R. rattus wroughtoni* capture and random plots in moist deciduous habitats of Chimmony Wildlife Sanctuary

Variable	Capture plot N = 6 Mean (SE)	Random plot N = 37 Mean (SE)	Mann-Whitney *U* Test	
			z	*p*
Canopy height (m)	23.8 (6.5)	22.1 (1.7)	-0.07	0.943
Canopy closure (%)	65.0 (9.1)	52.4 (3.7)	-1.11	0.269
Snag (No./plot)	1.2 (0.5)	0.3 (0.1)	**-2.30**	**0.021**
Ground vegetation (%)	41.7 (10.5)	54.2 (2.9)	-1.19	0.236
Rock (%)	55.8 (12.5)	15.0 (4.3)	**-2.94**	**0.003**
Litter (%)	55.0 (8.2)	45.9 (2.7)	-1.19	0.233
Coarse woody debris (m^3/ha)	53.9 (25.1)	10.3 (2.2)	**-2.39**	**0.017**
Tree density (No./plot)	4.0 (0.8)	4.2 (0.3)	-0.29	0.775

Table 14 Comparison of habitat parameters at *R. rattus wroughtoni* capture and random plots in semi-evergreen habitats of Chimmony Wildlife Sanctuary

Variable	Capture plot N = 6 Mean (SE)	Random plot N = 30 Mean (SE)	Mann-Whitney *U* Test	
			z	*p*
Canopy height (m)	26.7 (4.0)	24.5 (2.0)	-0.71	0.478
Canopy closure (%)	74.2 (11.9)	75.1 (4.7)	-0.38	0.701
Snag (No./plot)	0.8 (0.3)	0.2 (0.1)	**-2.33**	**0.020**
Ground vegetation (%)	29.2 (4.2)	46.7 (3.7)	**-1.97**	**0.048**
Rock (%)	25.0 (12.9)	3.3 (2.0)	**-2.49**	**0.013**
Litter (%)	50.0 (6.5)	39.2 (2.9)	-1.54	0.125
Coarse woody debris (m^3/ha)	94.7 (38.1)	29.7 (6.8)	**-2.25**	**0.024**
Tree density (No./plot)	5.0 (0.7)	4.8 (0.4)	-0.35	0.728

Analysis of the microhabitat selection of *Cremnomys blanfordi* in the moist deciduous habitats of Chimmony Wildlife Sanctuary revealed that the canopy closure and coarse woody debris were significantly higher in the capture plots than the random plots whereas the canopy height and ground vegetation were significantly lower in the capture plots than the random plots (Table 15).

Table 15 Comparison of habitat parameters at *C. blanfordi* capture and random plots in moist deciduous habitats of Chimmony Wildlife Sanctuary

Variable	Capture plot N = 6 Mean (SE)	Random plot N = 37 Mean (SE)	Mann-Whitney *U* Test	
			z	*p*
Canopy height (m)	14.0 (2.8)	23.7 (1.8)	**-2.07**	**0.039**
Canopy closure (%)	87.5 (5.6)	60.4 (3.6)	**-2.71**	**0.007**
Snag (No./plot)	0.5 (0.3)	0.4 (0.1)	-0.26	0.794
Ground vegetation (%)	37.5 (5.6)	54.9 (3.1)	**-2.24**	**0.025**
Rock (%)	38.3 (17.2)	17.8 (4.5)	-1.17	0.240
Litter (%)	50.0 (0.0)	46.8 (3.0)	-0.59	0.557
Coarse woody debris (m^3/ha)	16.5 (1.9)	16.3 (5.1)	**-2.01**	**0.045**
Tree density (No./plot)	4.5 (0.2)	4.1 (0.3)	-0.59	0.556

4.1.2.3.4 *Seasonal variation in capture of rodents using Sherman traps at Chimmony Wildlife Sanctuary*

The overall capture success was higher in the dry season. Moist deciduous habitat showed more capture rate in dry season whereas semi-evergreen habitats showed more capture in wet season (Table 16). *Rattus rattus wroughtoni* was equally captured in both the seasons but in dry season, the capture rate was more in moist deciduous habitats and in wet season, capture was more in semi-evergreen habitat. All the captures of *Cremnomys blanfordi* was in dry season

from the moist deciduous habitats. The only capture of *Millardia meltada* was in wet season from semi-evergreen forest of Anapporu and the only one capture of *Funambulus tristriatus* was in dry season from the moist deciduous habitat of Virakuthodu (Figure 15).

Table 16 Seasonal variation in capture of rodents using Sherman traps at Chimmony WLS

Species	Dry Season			Wet Season		
	MDF	SEG	Total	MDF	SEG	Total
C. blanfordi	6	0	6	0	0	0
R. r. wroughtoni	5	1	6	1	5	6
M. meltada	0	0	0	0	1	1
F. tristriatus	1	0	1	0	0	0
Total	12	1	13	1	6	7

MDF = Moist Deciduous Forest, SEG = Semi-evergreen Forests

4.1.2.4 *Presence/absence profile of rodents in different habitats of Chimmony Wildlife Sanctuary*

A presence/absence profile of the rodents in various habitats at Chimmony Wildlife Sanctuary was prepared from all the results explained above and the same is shown in Table 17.

In this, *Petaurista philippensis* and *Cremnomys blanfordi* were habitat specialists seen only in moist deciduous forest, whereas, *Millardia meltada* was observed only in the semi-evergreen forest. All other species of rodents were observed in both the habitats.

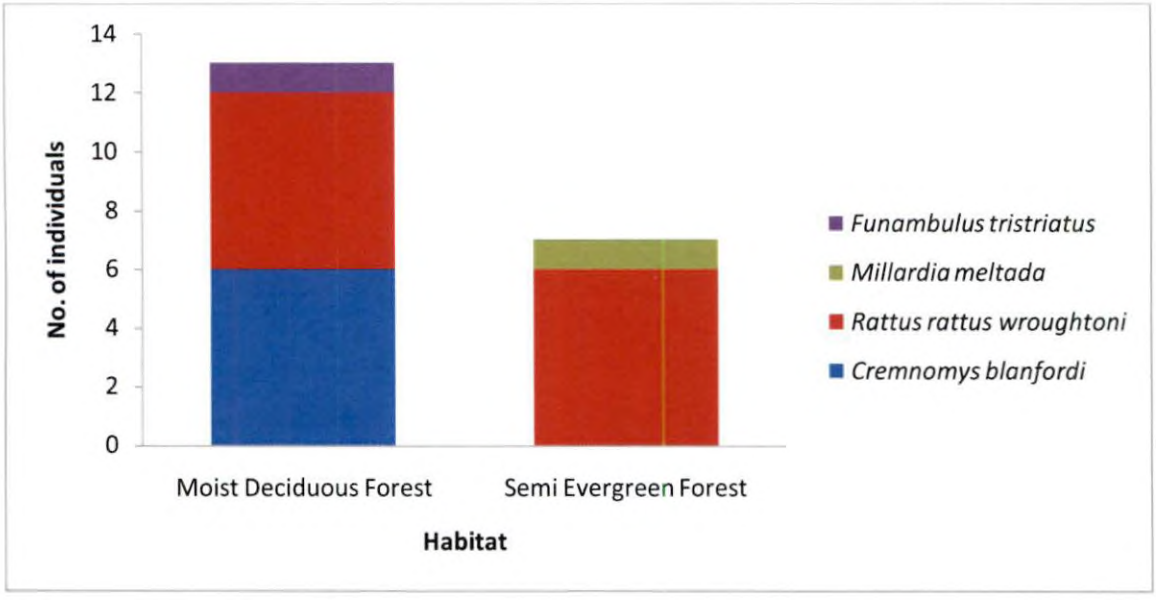


Figure 14. Number of individuals of rodents trapped in different habitats of Chimmony Wildlife Sanctuary

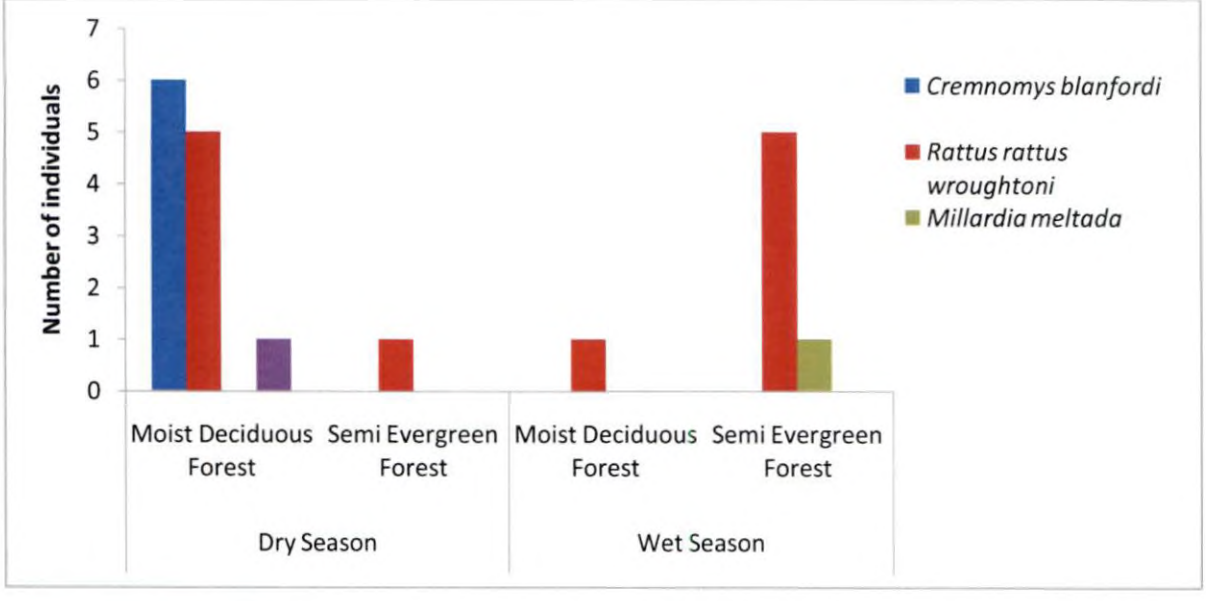


Figure 15. Seasonal variation in capture of rodents using Sherman traps at Chimmony Wildlife Sanctuary

Table 17 Presence of rodents in different habitats of Chimmony Wildlife Sanctuary

Sl. No.	Species	Moist Deciduous Forest	Semi-evergreen Forest
1	*Funambulus sublineatus*	O	O
2	*Funambulus tristriatus*	O/C	O
3	*Ratufa indica*	O	O
4	*Petaurista philippensis*	O	NO
5	*Cremnomys blanfordi*	C	NO
6	*Rattus rattus wroughtoni*	C	C
7	*Millardia meltada*	NO	C
8	*Hystrix indica*	I	I

O = Observed, C = Captured, I = Indirect evidences, NO = Not observed

4.1.2.5 *Similarity of rodents between different habitats of Chimmony Wildlife Sanctuary*

Jaccard's similarity index was used to analyse the similarity of distribution of rodents between the moist deciduous and semi-evergreen forests of the sanctuary. Jaccard's index of similarity was found as 0.63 between the moist deciduous and semi-evergreen forests.

4.1.2.6 *Morphometrics of the rodents captured in Chimmony Wildlife Sanctuary*

The basic morphometric measurements of the rodents captured in the sanctuary in comparison with Ellerman (1961) is given in Table 18.

Table 18 Morphometrics of the rodents captured in Chimmony Wildlife Sanctuary

Species	Variable (All in mm)	Present Study				Ellerman (1961)			
		Male		Female		Male		Female	
		Mean (SE)	Range	Mean (SE)	Range	From nearest locality	Range	From nearest locality	Range
Rattus rattus wroughtoni	HBL	144.6 (7.2) *(N = 9)*	113 - 177	156.7 (14.2) *(N = 3)*	140 - 185	154	140 - 201	164	146 - 195
	TL	193 (12.4) *(N = 9)*	140 - 263	192.7 (20.2) *(N = 3)*	170 - 233	199	160 - 250	228	177 - 258
Cremnomys blanfordi	HBL	160 (5) *(N = 3)*	150 - 165	156.7 (3.3) *(N = 3)*	150 - 160	155	149 - 195	162	155 - 180
	TL	198.3 (4.4) *(N = 3)*	190 - 205	205 (7.6) *(N = 3)*	190 - 215	208	179 - 212	215	215 - 225
Millardia meltada *	HBL	95	-	-	-	97	97 - 146	-	-
	TL	100	-	-	-	110	92 - 135	-	-
Funambulus tristriatus *	HBL	150	-	-	-	180	155 - 210	-	-
	TL	140	-	-	-	160	137 - 168	-	-

* = Only one individual captured, HBL = Head and body length, TL = Tail length

4. 1. 3 Bats recorded from Chimmony Wildlife Sanctuary

The present study recorded a total of eight species of bats belonging to three different families from the Chimmony wildlife sanctuary. The list of bats identified from Chimmony wildlife sanctuary along with their taxonomic position is given in Table 2. The survey method followed was mist-netting and the details of the mist-netting in the sanctuary is given in Table 19.

Table 19 Details of mist-netting in Chimmony Wildlife Sanctuary by the present study

Habitat	Place	Mist net hours	Species	No. of individuals
MDF	Verakuthodu	22	*Rhinolophus rouxii*	11
			Megaderma spasma	1
			Rousettus leschenaulti	1
			Hipposideros ater	1
	Mankuzhi	6	*Rhinolophus rouxii*	3
	Teak plantation	12	*Rhinolophus rouxii*	3
SEG	Anapporu	10	*Cynopterus sphinx*	6
			Cynopterus brachyotis	2
	Ponmudi	4	*Rhinolophus rouxii*	2
			Rousettus leschenaulti	1
	Vavala	16	*Rhinolophus rouxii*	4
			Rhinolophus beddomei	1
	Pazhayavellam	4	*Megaderma spasma*	2
			Cynopterus sphinx	1
	Mulappara	4	*Rhinolophus rouxii*	5
			Hipposideros speoris	4
Total		**80**		**48**

4.1.3.1 *Abundance of bats in Chimmony Wildlife Sanctuary*

The abundance of the species of bats captured in the sanctuary was calculated as number of individuals captured per hour of mist-netting (Table 20). By this,

Rhinolophus rouxii is the most abundant species (0.35) with 28 individuals out of the total 48 individuals captured. The second most abundant species was *Cynopterus sphinx* (0.09) with seven individuals. *Hipposideros ater* and *Rhinolophus beddomei* were the least abundant species with capture of only one individual. The percentage abundance of bats in Chimmony Wildlife Sanctuary is shown in Figure 16.

Table 20 Abundance of bats in Chimmony Wildlife Sanctuary

Sl. No.	Species	No. of individuals	Abundance (capture/hour)
1	*Rhinolophus rouxii*	28	0.35
2	*Cynopterus sphinx*	7	0.09
3	*Hipposideros speoris*	4	0.05
4	*Megaderma spasma*	3	0.04
5	*Cynopterus brachyotis*	2	0.03
6	*Rousettus leschenaulti*	2	0.03
7	*Hipposideros ater*	1	0.01
8	*Rhinolophus beddomei*	1	0.01
	Total	**48**	**0.6**

4.1.3.2 *Habitat preference of bats in Chimmony Wildlife Sanctuary*

There was a considerable variation among the bat species and individuals captured between the habitats of Chimmony Wildlife Sanctuary (Table 21). *Rhinolophus rouxii* is present in both the habitats with slight preference to the moist deciduous forests. *Cynopterus sphinx*, *Hipposideros speoris*, *Cynopterus brachyotis* and *Rhinolophus beddomei* were present only in semi-evergreen forests whereas *Hipposideros ater* is the only habitat specialist preferring the moist deciduous forest. *Megaderma spasma* and *Rousettus leschenaulti* are the

other habitat generalists in the sanctuary observed in both the habitats. A stacked diagram of the abundance of various species of bats in different habitats of Chimmony Wildlife Sanctuary is shown in Figure 17.

Table 21 Abundance of bats in different habitats of Chimmony Wildlife Sanctuary

Sl. No.	Species	Habitat			
		Moist Deciduous Forest		Semi-evergreen Forest	
		No. of individuals	Abundance	No. of individuals	Abundance
1	*R. rouxii*	17	0.43	11	0.28
2	*C. sphinx*	0	0	7	0.18
3	*H. speoris*	0	0	4	0.10
4	*M. spasma*	1	0.03	2	0.05
5	*C. brachyotis*	0	0	2	0.05
6	*R. leschenaulti*	1	0.03	1	0.03
7	*H. ater*	1	0.03	0	0
8	*R. beddomei*	0	0	1	0.03
	Total	**20**	**0.52**	**28**	**0.72**

4.1.3.2 *Diversity and similarity of bats between different habitats of Chimmony Wildlife Sanctuary*

Different indices widely using in ecological studies were used to measure the diversity and similarity of bats in different habitats of Chimmony Wildlife Sanctuary.

4.1.3.2.1 *Diversity of bats between different habitats of Chimmony Wildlife Sanctuary*

The present study showed variations in bat diversity indices between habitats in Chimmony Wildlife Sanctuary. The various indices used and the results obtained are given in Table 22. Species richness and the number of individuals

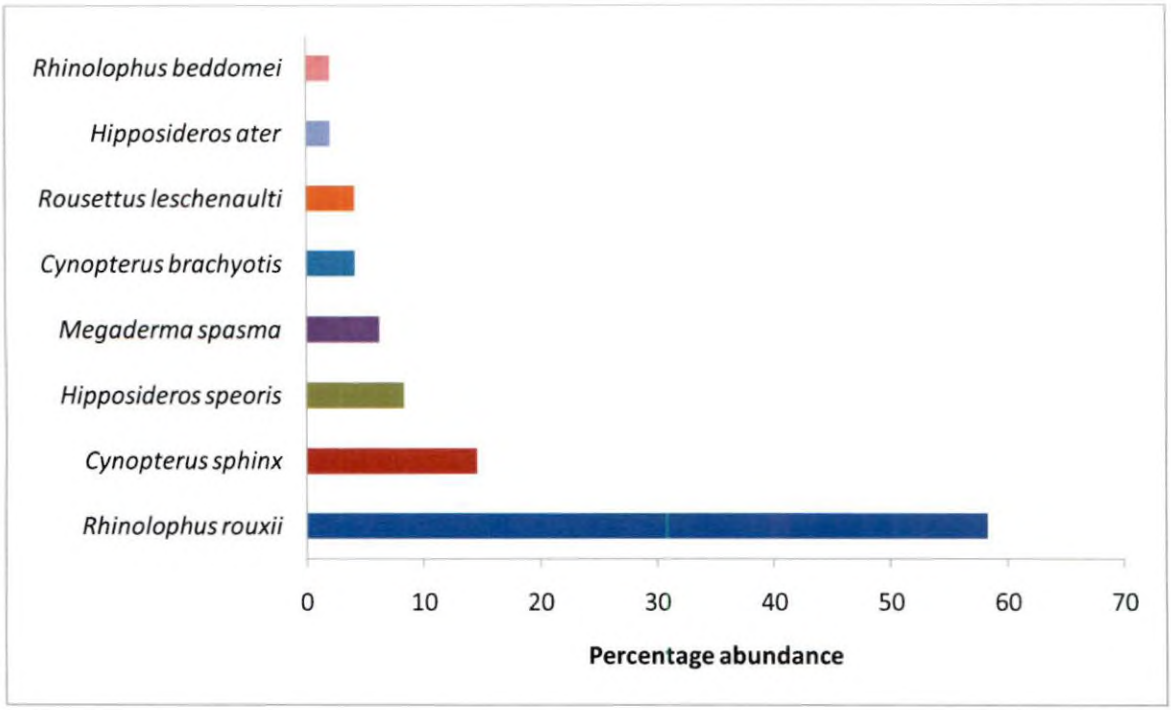


Figure 16. Percentage abundance of bats in Chimmony Wildlife Sanctuary

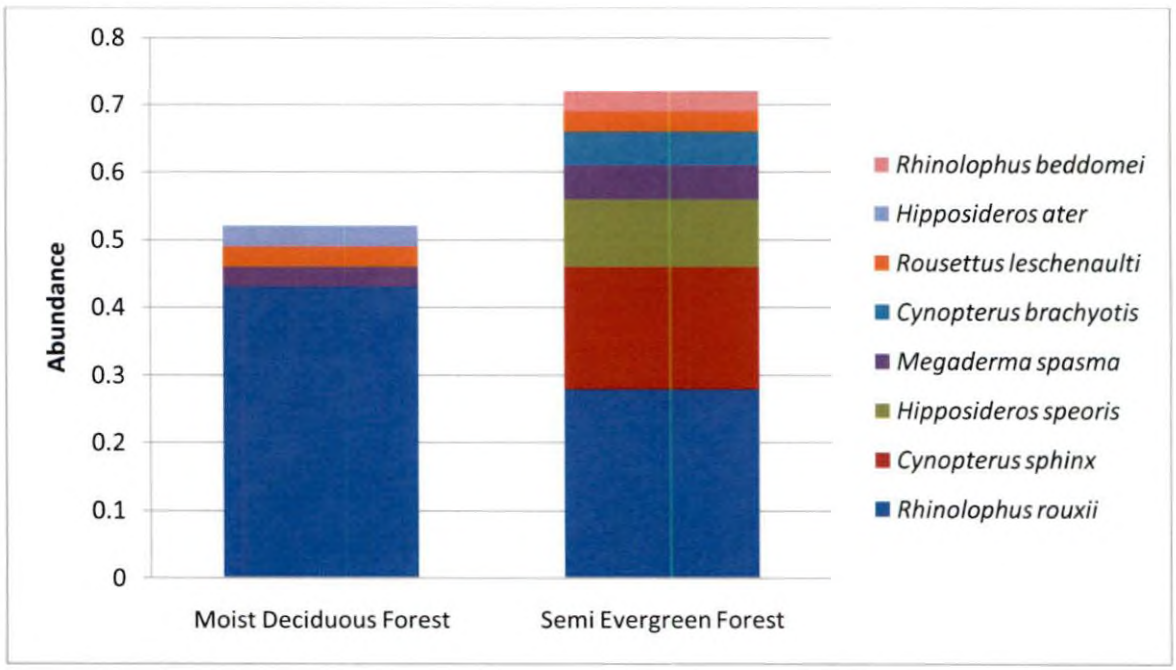


Figure 17. Abundance (no. of capture/hour) of bats in different habitats of Chimmony Wildlife Sanctuary

were more in semi-evergreen habitat than in moist deciduous forests. Diversity indices like the Shannon-Wiener Diversity index, Simpson's index, Pielou's Evenness index and Margalef species richness index were highest for the semi-evergreen when compared to moist deciduous habitats. The Berger-Parker index showed highest for moist deciduous as expected.

Table 22 Diversity indices of bats in different habitats of Chimmony Wildlife Sanctuary

Measures of Diversity	Moist Deciduous Forest	Semi-evergreen Forest	For the whole sanctuary
Species richness	4	7	8
No. of Individuals	20	28	48
Shannon-Wiener diversity index (H)	0.59	1.61	1.4
Simpson's index (1-D)	0.27	0.75	0.62
Pielou's Evenness index (E)	0.45	0.71	0.51
Margalef richness index	1.0	1.8	1.81
Berger-Parker Dominance	0.85	0.39	0.58

Shannon diversity t test of bat species between the moist deciduous and semi-evergreen habitats of Chimmony Wildlife Sanctuary showed that the two habitats are significantly different in the diversity of bats ($t = -3.508$, $df = 36.47$ and $p = 0.0012$).

4.1.3.2.2 *Similarity of bats between different habitats of Chimmony Wildlife Sanctuary*

Similarity indices of bats in different habitats of the sanctuary are given in Table 23. Two indices were measured, namely, the Jaccard's index of similarity for the qualitative expression on presence/absence of species and the Morisita-

Horn index for the quantitative expression of similarity in species abundance between the two different habitats in the sanctuary.

Table 23 Similarity indices of bats between moist deciduous and semi-evergreen habitats of Chimmony Wildlife Sanctuary

Similarity index	Moist deciduous v/s Semi-evergreen
Jaccard's index	0.38
Morisita-Horn index	0.69

4.1.3.3 *Morphometrics of the bats collected from Chimmony Wildlife Sanctuary*

The basic morphometrics of the bats captured from Chimmony Wildlife Sanctuary is given in Table 24 as comparison against Bates and Harrison (1997).

Table 24. Morphometrics of the bats collected from Chimmony Wildlife Sanctuary

Species	Present study			Bates and Harrison (1997)		
	FAL (mm)	EL (mm)	TL (mm)	FAL (mm)	EL (mm)	TL (mm)
C. sphinx (n= 7)	66.6	18.2	10.1	70.2	20.6	10.9
C. brachyotis (n=2)	61.4	16.1	7.3	60.3	16.7	7.2
R. leschenaulti (n=2)	82.4	22.6	12.7	80.6	20.8	15.6
M. spasma (n=3)	57.4	37.8	Tail-less	56.9	36.9	Tail-less
R. rouxii (n=28)	48.2	16.2	24.8	49.3	19.0	27.1
R. beddomei (n=1)	64.1	32.5	43.3	62.7	31.2	45.7
H. speoris (n= 4)	53.2	11.1	29.5	50.7	16.9	25.2
H. ater (n= 1)	34.3	16.0	23.8	36.3	17.6	24.7

FAL = Forearm Length, EL = Ear Length, TL = Tail Length

4.2 COMMUNITY STRUCTURE OF LESSER KNOWN MAMMALS IN CHIMMONY WILDLIFE SANCTUARY

The lesser known mammals of Chimmony Wildlife Sanctuary include a total of 22 species belonging to 10 families. Six species of small carnivores, eight species of rodents and eight species of bats form the lesser known mammal community in the sanctuary. The species richness and similarity of the lesser known mammals in different habitats of the sanctuary were analysed to study the community structure of lesser known mammals in the sanctuary.

4.2.1 Species richness of lesser known mammals in different habitats of Chimmony Wildlife Sanctuary

The species richness of the lesser known mammals in different habitats of the sanctuary is given in Table 25. Though there are variations among some of the families, the overall species richness was differed with only one species which was seen in semi-evergreen forest. The species composition of various families of lesser known mammals in different habitats of the sanctuary is shown in Figure 18.

4.2.2 Similarity of lesser known mammals in different habitats of Chimmony Wildlife Sanctuary

Jaccard's similarity index was used to analyse the similarity of species composition of lesser known mammals between the moist deciduous and semi-evergreen forests of the sanctuary. The number of species common in both the habitats is 13, number of species seen only in moist deciduous forest is four and the number of species present only in semi-evergreen forests is five. Jaccard's index of similarity was found as 0.60 between the moist deciduous and semi-evergreen forests.

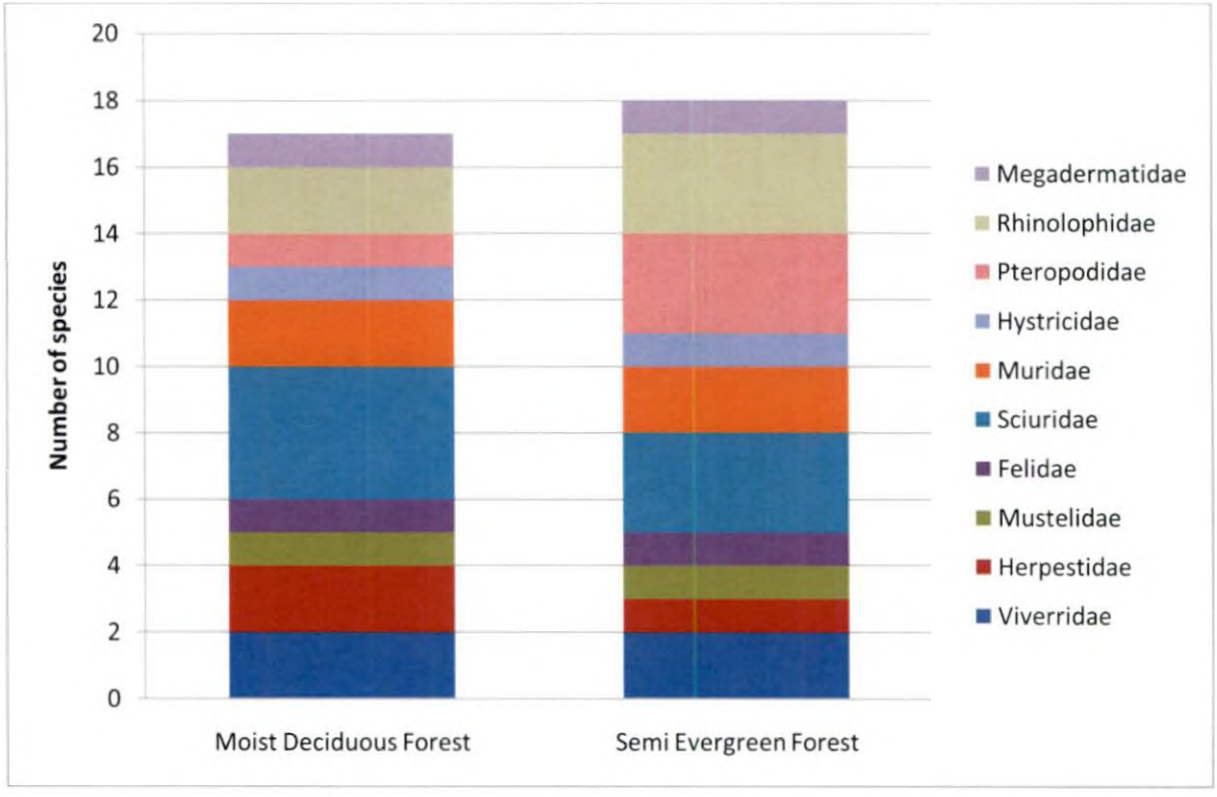


Figure 18. Species richness of various families of lesser known mammals in different habitats of Chimmony wildlife sanctuary

Table 25. Species richness of various families of lesser known mammals in different habitats of Chimmony wildlife sanctuary

Sl No.	Family	Number of Species	
		Moist Deciduous Forest	Semi-evergreen Forest
1	Viverridae	2	2
2	Herpestidae	2	1
3	Mustelidae	1	1
4	Felidae	1	1
5	Sciuridae	4	3
6	Muridae	2	2
7	Hystricidae	1	1
8	Pteropodidae	1	3
9	Rhinolophidae	2	3
10	Megadermatidae	1	1
	Total	**17**	**18**

4.3 CONSERVATION STATUS OF LESSER KNOWN MAMMALS OBSERVED IN CHIMMONY WILDLIFE SANCTUARY

The conservation status of the lesser known mammals that have been recorded from Chimmony sanctuary is given in Table 26. Among the 22 species, *Lutrogale perspicillata* and *Funambulus sublineatus* are vulnerable species as per the IUCN red list criteria (Rajamani *et al.*, 2008; Hussain *et al.*, 2008) and *Funambulus tristriatus* is endemic to Western Ghats.

Table 26. Conservation status of the lesser known mammals recorded from Chimmony sanctuary

Sl. No.	Species	Conservation status
1	*Lutrogale perspicillata*	Vulnerable
2	*Funambulus sublineatus*	Vulnerable
3	*Viverricula indica*	Least Concern
4	*Paradoxurus hermaphroditus*	Least Concern
5	*Herpestes edwardsii*	Least Concern
6	*Herpestes vitticollis*	Least Concern
7	*Felis chaus*	Least Concern
8	*Funambulus tristriatus*	Least Concern
9	*Ratufa indica*	Least Concern
10	*Petaurista philippensis*	Least Concern
11	*Cremnomys blanfordi*	Least Concern
12	*Rattus rattus wroughtoni*	Least Concern
13	*Millardia meltada*	Least Concern
14	*Hystrix indica*	Least Concern
15	*Cynopterus sphinx*	Least Concern
16	*Cynopterus brachyotis*	Least Concern
17	*Rousettus leschenaulti*	Least Concern
18	*Rhinolophus beddomei*	Least Concern
19	*Rhinolophus rouxii*	Least Concern
20	*Hipposideros ater*	Least Concern
21	*Hipposideros speoris*	Least Concern
22	*Megaderma spasma*	Least Concern

Discussion

DISCUSSION

5.1 SPECIES COMPOSITION AND COMMUNITY STRUCTURE OF THE LESSER KNOWN MAMMALS IN CHIMMONY WILDLIFE SANCTUARY

During the present study a total of 22 species belonging to small carnivores, rodents and bats were identified from the sanctuary, which are considered as lesser known mammals. Out of the 22 species recorded six were belonging to small carnivores, eight species were rodents and another eight species were bats (Table 2). The community of small carnivores includes two species of civets, two species of mongoose, one species of otter and one species of small cat. The rodent community includes three species of rats, four species of squirrels and the Indian Porcupine. Similarly the bat community in the sanctuary is represented by three species of fruit bats and five species of insectivorous bats. Each of these groups of lesser known mammals is further explained below.

5.2 SMALL CARNIVORES OF CHIMMONY WILDLIFE SANCTUARY

The small carnivores of Chimmony Wildlife Sanctuary were represented by four families namely Viverridae, Herpestidae, Mustelidae and Felidae under the order Carnivora. The various species of these families which were recorded from the sanctuary and their description are given below.

5.2.1 Family Viverridae

5.2.1.1 *Common Palm Civet (Paradoxurus hermaphroditus)*

This is the most common civet in India. The un-patterned throat and tail help to distinguish Common Palm Civet from other civets. Its body colour varies from a rich cream to brownish black or even jet black. Dark spots coalesce into stripes on the sides. It has three longitudinal stripes on its back, which are visible on close

inspection. It is basically an omnivore and is very much fond of the fruits of palms and honey, thus earning its reputation for having a 'sweet tooth' (Prater, 1971; Menon, 2003).

The Common Palm Civet plays a major role as a seed disperser. The palm civets use prominent sites such as rocks and fallen logs along the trails in forest to defecate. Like most other civets, this species is also a nocturnal animal. The Common palm civet is mostly a terrestrial frugivore and it is highly tolerant to disturbances. It is mostly confined to moist and dry deciduous forest and drier habitats at lower altitudes (Yoganand and Kumar, 1999). During the present study only one sighting of the Common Palm Civet was obtained which was from the moist deciduous habitat of Virakuthodu. It was sighted during a night transect survey at around 7:30 PM on 22nd November 2009. It was seen crossing the road and moved towards the reservoir area. Besides these the indirect evidences were recorded from both the moist deciduous as well as semi evergreen forests.

5.2.1.2 *Small Indian Civet (Viverricula indica)*

The Small Indian Civet is buff coloured with spots all over its body. The coat can vary from brown to grey. The black and white ringed tail has 8-10 dark bands. This civet lacks a spinal crest and has a cream throat with two dark bands across it. Its ears are small, rounded and set close to each other on top of the head, more like a cat's, while its legs are dark and long. It is not very arboreal and prefers thick grass and scrub. It dens in burrows or under rocks. This species occurs in almost all kinds of habitats, including the arid zones of western India. They are omnivorous in diet and are known to feed largely on insects. Secretions from their perineal glands are used to mark territories. Despite being good climbers, they have been observed to forage largely on the ground (Prater, 1971; Menon, 2003).

The Small Indian Civet prefers scrub and dry forests or grasslands and is relatively rare in undisturbed rainforests. Garbage dumps near settlements are known

to attract these civets. The present study recorded a single sighting of Small Indian Civet from the moist deciduous habitat of the Virakuthodu area near to the Inspection Bungalow of Chimmony Wildlife Sanctuary during a night trail at around 9:30 PM on 7th June 2010. It was seen feeding on the fruits of *Ficus aspera*. Besides this the scats were seen throughout the sanctuary but it was difficult to differentiate from the scats of other civets. One laboratory analysis showed the presence of insect body parts and seeds of *Cassia fistula* in a civet scat obtained from Virakuthodu area (Plate 7) and it is assumed to be that of Small Indian Civets because unlike other civets it is known to feed largely on insects (Yoganand and Kumar, 1999).

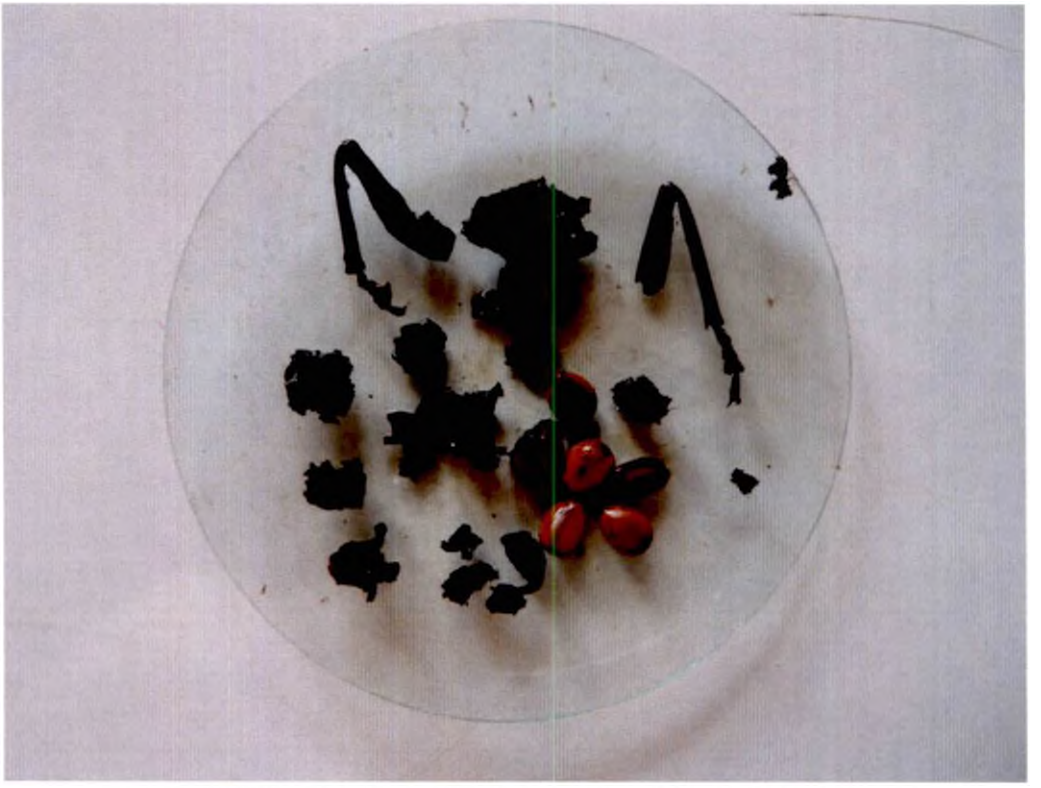
5.2.2 Family Herpestidae

5.2.2.1 *Grey Mongoose (Herpestes edwardsii)*

Grey Mongoose is also called as Common Indian Grey Mongoose. It is a famed animal used in snake-mongoose shows. Its tawny-grey fur is much more grizzled and coarse than that of other mongooses and individual hairs have ten alternate dark and light bands. Its legs are darker than its body and its tail is as along as its head and body put together. The desert subspecies is more reddish, the southern Indian one is more brownish and the northern Indian one is more greyish. It is a very bold and inquisitive animal and often lives near human habitation. It is commonly found in open scrub, cultivated land, rocky patches and forest edges all over India. The species is more popular for its enmity with snakes, particularly cobras (Prater, 1971; Menon, 2003).

Two individuals were sighted during the present study and both of them were from the moist deciduous habitat of Virakuthodu area. One was seen in noon time at 12:47 PM on 22nd Nonember 2009 and the other was in the evening at 4:05 PM on 31st January 2010.

Civet scat in the field



Civet scat showing insect body parts and *Cassia fistula* seeds

Plate 7. Images of civet scat in the field and laboratory

5.2.2.2 *Stripe-necked Mongoose (Herpestes vitticollis)*

It is restricted to the Western Ghats in India and Sri Lanka. In the Western Ghats, it is found south from North Kanara in Karnataka. The species has a distinct black stripe with a white border on the sides of the neck. Its fur is a reddish brown, being more reddish in the southern populations. The Stripe-Necked Mongoose occurs in well-wooded habitats, particularly in the dry and moist deciduous forests. It is known to prefer streams and rivers and is believed to feed extensively on crabs. There are reports of it hunting small mammals such as mouse deer in Sri Lanka (Prater, 1971).

There was a solitary sighting of this species from the sanctuary at the reservoir bank near to the moist deciduous habitat of Virakuthodu area. It was seen in noon time at 1:15 PM on 20th June 2010. Rompaey and Jayakumar (2003), recorded this species from the deciduous and evergreen forest, swampy clearings, plantations, open scrub and along watercourses.

5.2.3 Family Mustelidae

5.2.3.1 *Smooth-coated Otter (Lutrogale perspicillata)*

This is the most common otter in India. It is easily identified by its well-groomed chocolate brown coat. Its underside is lighter and its paws are dark brown but lighter than the body. It differs from the other otters in having V-shaped nostrils and its tail is flatter towards the tip. The Smooth-coated Otter is active by day. It is also widespread in the Western Ghats. It is commonly found in plains, including arid areas. These animals are often seen in groups in large rivers, lakes and reservoirs. They are more diurnal or crepuscular in their habit. The species is known to readily adapt to hunting in forests, when water sources dry up (Menon, 2003).

Total three sightings were obtained from the sanctuary. Two of these were from the semi evergreen habitats of Kallichampara and Mulappara. The other sighting

was near to the moist deciduous habitat of Virakuthodu. All these three sightings were from the reservoir bank.

5.2.4 Family Felidae

5.2.4.1 *Jungle Cat (Felis chaus)*

Jungle Cat is the most common wild cat in India. It is buff or grey-brown in colour with reddish ears. The ears have short black tufts. It has two black stripes on its lanky forelegs, and its tail, which is shorter than that of a domestic cat, is black tipped. Its coat is unmarked except for faint red stripes running across the forehead and on the outer surface of the legs. Its eyes are ringed with white, with a dark tear stripe running down each cheek. The Jungle Cat found in Southern India is greyer and lightly speckled on the back. The Jungle Cat is frequently found near the human habitations. It can also hunt animals much larger than itself such as the porcupines. It usually inhabits small dens and also under rocks. It is commonly found in grasslands, scrub jungle, dry deciduous and evergreen forests, semi urban areas and villages (Menon, 2003). The main conservation threat for the animal includes poaching and habitat destruction.

Jungle Cat showed its presence in both the moist deciduous and semi evergreen forests of the sanctuary through the indirect evidences like the pugmarks, dens and resting places. No individuals were directly sighted during the study period.

5.3 RODENTS OF CHIMMONY WILDLIFE SANCTUARY

The rodents of Chimmony Wildlife Sanctuary were represented by three families such as Scuiridae, Muridae and Hystricidae under the order Rodentia. The various species of these families which were recorded from the sanctuary and their description are given below.

5.3.1 Family Scuiridae

5.3.1.1 *Dusky Striped Squirrel (Funambulus sublineatus)*

The Dusky Striped Squirrel has a coat speckled with dull greenish grey (Plate 8). This is the smallest of the *Funambulus* genus. It has four dark brown longitudinal stripes with three intervening pale ones. It is found in the south Indian hill ranges. It is a shy and secretive creature keeping to damp gullies in densest forest where it is most difficult to discover among the tangled creepers and dense undergrowth which are its hunting ground (Prater, 1971). It was sighted 14 times during the study period. Out of these 11 were from the semi evergreen forests and three sightings were from the moist deciduous forests of the sanctuary.

5.3.1.2 *Jungle Striped Squirrel (Funambulus tristriatus)*

This is the largest species of the *Funambulus* genus. There are clear light stripes on the back, three in number, and the under parts are light or whitish. The tail is most often shorter than the head and body (Plate 8). Fourth finger is usually dominant in the hand. The species is endemic to Western Ghats (Prater, 1971; Menon, 2003). Total 16 sightings were recorded during the present study. Out of these 12 were from the moist deciduous forests and four were from semi evergreen forests of the sanctuary.

5.3.1.3 *Malabar Giant Squirrel (Ratufa indica)*

It is also called the Indian Giant Squirrel. This is an endemic squirrel to India. It consists of varying bright pelages. The back is a mixture of maroon and black and the under parts are cream or buff (Plate 8). In the northern Western Ghats, this squirrel is brownish maroon in appearance with an all brown or brown and white tail (Prater, 1971; Menon, 2003). In the south it is black and dark maroon with a black and brown tail. Its presence is marked well in the moist deciduous forests of the sanctuary and is less distributed in the evergreen patches. The present study recorded

56 sightings of 77 individuals. Out of these 43 individuals were seen in 30 sightings from the moist deciduous forests and 34 individuals were seen in 26 sightings from the semi evergreen forests.

5.3.2 Family Muridae

5.3.2.1 *Black Rat (Rattus rattus wroughtoni)*

This species is the wild form of Common House Rat (*Rattus rattus*) which has wide distribution throughout the forests. The species has it's under parts completely white and upper deep grey to black (Plate 8). The tail is usually longer than the head and body (Prater, 1971; Menon, 2003). This was the most abundant species during the study. Among 11 individuals captured six were from the moist deciduous forests and five were from the semi evergreen forests.

5.3.2.2 *White-tailed Wood Rat (Cremnomys blanfordi)*

It is a rare species of rodent and is a typical forest species. The rat is about 150-180 mm long, its tail is little longer. Very distinctive in this species is the colour of the tail. It is brown for three quarters of its length, but the terminal portion is clothed with longer white hairs. Its soft long fur is grey brown above, and white on the underside (Plate 8). This wood rat inhabits dry or moist deciduous and evergreen forest zones in southern, central, and eastern India as far north as Bengal. In southern India this is found only in the forest. (Prater, 1971; Menon, 2003). This was the second most abundant rodent captured during the present study. Total six individuals were trapped and all of them were from the moist deciduous forests of the sanctuary.

5.3.2.3 *The Soft Furred Field Rat or Common Metad (Millardia meltada)*

It is a nocturnal and fossorial species. Head and body length usually over 100 mm. and up to 156 mm. Tail usually a little shorter than head and body. Ears are shorter than hind foot (Plate 8). Tail is moderately to poorly haired (Ellerman, 1961).

Dusky Striped squirrel

Jungle Striped squirrel

Malabar Giant squirrel

Black Rat

White-tailed Wood Rat

Soft Furred Field Rat

Plate 8. Some of the rodents recorded from Chimmony Wildlife Sanctuary

It occurs in tropical and sub tropical dry deciduous forests, tropical grasslands, irrigated croplands and grasslands with gravel. Agriculture lands, water courses, embankments, dry rocky hills. It has been found to occupy gravelly areas, bunds of fields and largely cultivated areas (Molur *et al.*, 2005). Only one species was captured during the study and that was from an open area near to a semi evergreen habitat at Anapporu on 11th June 2010. It was captured from a fallen, partially decayed tree and the area showed thick growth of wild turmeric *Curcuma aromatica.*

5.3.3 Family Hystricidae

5.3.3.1 *Indian Crested Porcupine (Hystrix indica)*

The common and largest porcupine of India. This rodent is covered with long black and white quills with a long crest of spines flowing from the forehead to the middle of the back. Its tail ends in a bunch of thick white quills. In southern India sub-species often referred to as the "Red Porcupine" have quills with a rusty tinge on its back (Prater, 1971; Menon, 2003).

Indian Porcupine was not directly sighted from the sanctuary but their presence was seen throughout the sanctuary in all the habitats, through indirect evidences. However the camera-trap showed a single image of two individuals from the moist deciduous habitat of Virakuthodu area (Plate 6). The scat encounter of Indian Porcupine was much higher than any of the scat encounter of other animals recorded by the present study.

5.4 BATS OF CHIMMONY WILDLIFE SANCTUARY

The bats of Chimmony Wildlife Sanctuary were represented by three families such as Pteropodidae, Rhinolophidae and Megadermatidae under the order Chiroptera. The various species of these families which were recorded from the sanctuary and their description are given below.

5.4.1 Family Pteropodidae

5.4.1.1 *Short-nosed Fruit Bat (Cynopterus sphinx)*

This is a medium sized fruit bat with an average forearm length of 70.2mm (64-79mm). The membrane is dark brown throughout, but with pale fingers on the wing. The medial part of interfemoral membrane is hairy, above and below (Plate 9). The muzzle is short, broad and covered with hairs as far as the nostrils, which project well forwards. The ears are simple and essentially naked; mocha brown in colour but with well defined pale anterior and posterior borders. The pelage is soft and silky in texture. This species is found in a wide variety of habitats from rural areas, primary and secondary forested habitats to urban landscapes. It is found as small colonies consisting of 3-7 individuals, sometimes more; it roosts underside leaves, in flower and fruit clusters and is known to build tents in the roosting trees. It feeds on a variety of fruits both wild and cultivated. It has a low but fast flight (Bates and Harrison 1997). During the present study, seven individuals captured from the sanctuary and all of them were from moist deciduous habitats.

5.4.1.2 *Lesser Dog-faced Fruit Bat (Cynopterus brachyotis)*

This species averages smaller than *Cynopterus sphinx* with a forearm length of 60.3mm (57.3-63.3mm). It can be distinguished by its smaller ears, which do not exceed 18mm in length. In comparison with *Cynopterus sphinx* the pale borders of the ears are narrow or absent (Plate 9). The finger bones of the wings tend to be darker than *C. sphinx*. In all other external characters, the two species are similar. This species can be found from habitats ranging from orchards, gardens to forested tracts. It roosts in palms especially seed clusters of palms either solitary or in small groups of a few individuals in rural and urban landscapes and in forested areas (Bates and Harrison 1997). In South Asia, the species is believed to be more restricted to

Cynopterus sphinx

Cynopterus brachyotis

Rousettus leschenaultii

Rhinolophus beddomei

Rhinolophus rouxii

Hipposideros ater

Hipposideros speoris

Megaderma spasma

Plate 9. Images of bats captured from Chimmony Wildlife Sanctuary

higher elevations when compared to *C. sphinx*, making it specifically a hill forest species. Two individuals were obtained during the study period both from semi evergreen habitats of Anapporu. The study conducted by Joy (2008) reported the species from the Chimmony Wildlife Sanctuary. This was the first report of the species from the sanctuary. The other studies in Kerala which reported the species include Das (1986) from Silent Valley National Park, Nameer (2001) from Periyar Tiger Reserve and Nelliampathies, and Radhakrishnan (2005) from Peechi-Vahani Wildlife Sanctuary.

5.4.1.3 *Fulvous Fruit Bat (Rousettus leschenaultii)*

This species is having an average forearm length of 80.6mm (75-86mm). The muzzle is relatively short and slender. The pelage is soft, fine and silky. It is fulvous brown on the crown of the head, back, flanks and throat; the belly is more greyish in the median area (Plate 9). This species is found in a variety of habitats ranging from tropical moist forest to urban environments. Roosts in colonies ranging from a few to several thousands of individuals in caves, old and ruined buildings, forts and disused tunnels. It feeds on fruits and flowers. It has two breeding cycles in a year and bears a single young (Bates and Harrison 1997). Only two individuals were captured during the present study, one from the moist deciduous habitat of Virakuthodu and the other from the semi evergreen habitat of Ponmudi at an altitude of 900 m above MSL.

5.4.2 Family Rhinolophidae

5.4.2.1 *Lesser Wooly Horseshoe Bat (Rhinolophus beddomei)*

This is smaller in size with a forearm length ranges from 54.9-64.3 mm. The horseshoe is prominent. The pelage is dark, long and of a noticeable woolly texture; it is usually blackish (Plate 9). This species is primarily a found in dense dry and tropical moist forests. It roosts either as solitary animals or in pairs in caves, dilapidated buildings, large trees with hollows, wells, old and unused tunnels (Molur

et al., 2002). This is a low flyer and feeds on a variety of insects especially beetles and termites (Bates and Harrison, 1997). Only one individual was captured during the present study and it was from the semi evergreen forests.

5.4.2.2 *Rufous Horse-shoe Bat (Rhinolophus rouxii)*

This species is very variable in size. The forearm length of this species varies from 44.4-52.3mm. The pelage is soft and silky. There is a considerable variation in pelage colour ranging from orange to russet brown to buff brown to grey (Plate 9). This species is found in caves, hollows of large tree in moist evergreen forests, unused wells, old dilapidated buildings and temples in South Asia (Molur *et al.* 2002). This was the most abundant bat species in the sanctuary. Twenty eight individuals were captured during the present study. Out of these 17 were from the moist deciduous forests and 11 were from the semi evergreen forests.

5.4.2.3 *Dusky Leaf-nosed Bat (Hipposideros ater)*

This is a small species of Hipposideros superficially similar to *Hipposideros fulvus* with a significantly shorter forearm (average 36.3mm; 34.9-38mm) and smaller ears. The breadth of the ears is sub equal to their height and the tips are broadly rounded off; each ear has a well-defined antitragus (Plate 9). The nose-leaf has a width of about 4.0-4.5mm. Its anterior leaf is without supplementary lateral leaflets or a median emargination. The feet are small. In the wing, the fourth metacarpal exceeds the fifth in length whilst the third is the shortest. The tail is long and is enclosed, all except the extreme tip, with in the well-developed interfemoral membrane. The wings and the interfemoral membrane are naked, above and below, and are a uniform dark brown or black. The pelage is variable in colour ranging from dull yellow, golden orange or pale grey to dark brown on the dorsal aspect. The hair bases are paler than the tips. The ventral aspect is also variable in colour but is usually paler than the back. In South Asia, this species roosts in small colonies in lofts of old thatched houses, old disused buildings, disused areas of buildings, mines, tunnels, culverts,

wells, hollows of large trees in forested areas, large crevices in walls, caves on sea shores. It is a late flyer with a low, fast and fluttering flight and feeds on small sized coleopterans and mosquitoes (Bates and Harrison 1997). Only one individual was captured during the study period and it was from the moist deciduous habitat of Virakuthodu near to an abandoned building.

5.4.2.4 *Schneider's Leaf-nosed Bat (Hipposideros speoris)*

Although the forearm length averages 50.7 mm (45.6-54.0mm), which significantly exceeds that of *Hipposideros fulvus*, the ears are markedly smaller (Plate 9). The nose leaf has three supplementary leaflets, of which the outer is distinctly smaller than the other two. The narial lappets are well developed. The intermediate leaf has a slightly concave upper edge. The posterior leaf is divided into four cells by three vertical septa, its upper edge is slightly thickened and without processes. A frontal sac is present in males where as in females it is represented by a tuft of hairs. The pelage colour is variable. Some individuals are grey, palest on the ventral surface, and between the shoulders on the upper back; they are darker on the flanks. Others are yellowish brown or bright orange colour. This species is found in dry plains to forested hillsides in caves, caverns, underground cellars, old forts, palaces, under bridges, old disused buildings, temples, tunnels. It roosts in colonies ranging from a few to several hundreds of individuals (Bates and Harrison 1997, Molur *et al.* 2002). Four individuals were captured from the semi evergreen habitat of Mulappara in the sanctuary. A cave roost having more than 500 individuals was also observed at Mulappara (Plate 10).

5.4.3 Family Megadermatidae

5.4.3.1 *Lesser False Vampire Bat (Megaderma spasma)*

A smaller species than *Megaderma lyra* with an average forearm length of 56.9mm (54.0-62.0mm). The interfemoral membrane larger than *Megaderma lyra.*

Cave at Mulappara

Hipposideros speoris inside the cave

Plate 10. A cave roost at Mulappara

The face differs in the shape of the vertical nose-leaf, which is shorter than that of *Megaderma lyra*; it has convex rather than straight sides and its longitudinal ridge has a characteristic heart shaped base (Plate 9). The pelage is deep grey on the upper surface; it is paler grey on the belly. In South Asia, this species is found in humid areas and dense tropical moist forest. It roosts in small colonies in caves, old and disused buildings, temples, lofts of thatched huts, tiled roofs, hollows in large trees and disused mines Rarely occurs in the same location with *M. lyra* (Molur *et al.*, 2002). Three individuals were captured from the sanctuary, among that one was from the moist deciduous habitat and two were from the semi evergreen forest.

5.4 ECOLOGY OF THE SMALL CARNIVORES OF CHIMMONY WILDLIFE SANCTUARY

5.4.1 Diversity of small carnivores in Chimmony Wildlife Sanctuary

The present study revealed the presence of six species small carnivores in the sanctuary. This includes two species of civets (Viverridae) viz *Viverricula indica* and *Paradoxurus hermaphroditus*, two species of mongoose (Herpestidae) namely *Herpestes edwardsii* and *Herpestes vitticollis*, one species of otter (Mustelidae) the *Lutrogale perspicillata* and one species of small cat (Felidae) the *Felis chaus*. The study conducted by Jayson and Easa (1996) listed only three species of small carnivores from the sanctuary. This includes two species of civets of the same species recorded in the present study and one species of mongoose, the Ruddy Mongoose (*Herpestes smithi*) was not observed in the present study. The management plan of the Chimmony Wildlife Sanctuary, reports eight species of small carnivores, though the source of the information was not given (George, 2002). Besides the six species of small carnivores listed by the present study the management plan of the sanctuary contains Brown palm civet (*Paradoxurus jerdoni*) and Brown mongoose (*Herpestes fuscus*). The otter listed in the management plan is *Lutra lutra* that may be a wrong identification and the possible species from the sanctuary is *Lutrogale perspicillata*.

A recent study conducted by Nameer *et al.* (2009) showed five species of small carnivores and all of these five species were observed in the present study as well.

5.4.2 Abundance of small carnivores in Chimmony Wildlife Sanctuary

The abundance of scats was used as a measure of the abundance of the small carnivores in the sanctuary. Scat abundance was estimated as the number of scat encounter per kilometer surveyed in different habitats of the sanctuary. Based on scat morphology, it was possible to identify the scats only to the family level - mongoose, civets, and otters - and not to species level. Another constraint was the assumption that the scat abundance is proportional to animal abundance. This implies that defecation rates, scat decay rates and seasonal and habitat differences in these were not considerable. Moreover, these assumptions are questionable; for example, it is very likely that fruit eaters such as civets would have a higher defecation rate than meat eaters such as cats (Yoganand and Kumar, 1999).

Based on the scat morphology the scats identified were grouped into civets, mongoose and otter scats. Scats of the small cats were not identified from the sanctuary, but the animal's presence was seen throughout the sanctuary as pugmarks, tracks, den and resting places. The analysis revealed that the scat abundance was higher for civets followed by mongoose and otters. This shows that in the small mammal community of the sanctuary, civets were the abundant ones, followed by the mongoose and the least abundant small carnivore in the sanctuary was otter. There was a notable variation in the scat abundance between the two habitats of the sanctuary. The overall scat abundance of the small carnivores was seen more for the moist deciduous forests than semi evergreen forests. The abundance of civets and mongoose were higher in the moist deciduous forests whereas the otters were abundant in the semi evergreen habitats. The direct sighting also supports the same that all sightings of civets and mongoose were from the moist deciduous forests of Virakuthodu whereas out of the three sightings of otters two were from the semi

evergreen habitats of Kallichampara and Anapporu, and one sighting from the moist deciduous forests of Virakuthodu. Similar results were obtained in the study conducted by Yoganand and Kumar (1999) in the Nilgiri Biosphere Reserve.

5.4.3 Habitat Preference of small carnivores in Chimmony Wildlife Sanctuary

The Habitat Use Index (HUI) was worked out for each group of small carnivores and it showed remarkable variations between the various habitats of the sanctuary. Habitat Use Index shows the habitat preference of small carnivores in the sanctuary. The analysis showed that the habitat use of civets was slightly higher in moist deciduous habitat when compared to semi evergreen habitat. The two civets *Paradoxurus hermaphroditus* and *Viverricula indica* were seen only once during the night transect from the moist deciduous forests of Virakuthodu. *Paradoxurus hermaphroditus* has been found in a wide range of habitats including evergreen and deciduous forest (primary and secondary), plantations and near human habitations, in habitats up to 2,400 m (Duckworth, 1997; Azlan, 2003; Su, 2005). In Chimmony it was seen running along the road near to the disturbed sites of Virakuthodu area. In Lao PDR it occurs commonly deep within old-growth evergreen and semi-evergreen forest (Duckworth, 1997) but it seems to avoid such habitat in the Western Ghats (Mudappa, 2002a). *Viverricula indica* was rarely seen in the undisturbed rainforests of Kalakad-Mundanthurai Tiger Reserve (KMTR) in India, and was mostly seen near garbage dumps (Mudappa, 2002a). In Chimmony it was seen near to the Inspection Bungalow of the sanctuary. In KMTR they were not camera-trapped frequently in rainforest, but were the most camera-trapped species in grasslands and in a riverine habitat (Mudappa, 2002a). The temporal difference in the habitat use of civets in the sanctuary was not remarkable. In dry season HUI was seen equal for both the habitats whereas in wet season it was slightly more in the moist deciduous forest.

The HUI of mongoose was seen four times higher in moist deciduous habitat when compared to semi evergreen habitat. The direct sightings of both the *Herpestes*

vitticollis and *Herpestes edwardsii* were from the moist deciduous forests. *Herpestes vitticollis* showed only a single sighting at the reservoir bank near to the moist deciduous habitat of Virakuthodu area. In deciduous forests it is usually found in swampy clearings, along watercourses, and in open scrub (Krishnan, 1972). *Herpestes edwardsii* was sighted two times from the moist deciduous forests near to the Inspection Bungalow of the sanctuary which is also near to the abandoned buildings of Water Authority. It was seen running across the road. The habitat and ecology of the *Herpestes edwardsii* is known from few studies, however, it has been recorded in disturbed areas, in dry secondary forests, and thorn forests (Shekhar, 2003), but seems to be a commensal with humans as well. This species was often recorded near human settlements by Shekhar (2003) in a survey in central India during 2002-03, where it was seen near garbage bins, garbage dumps, scavenging on carrion, and on roads. The species seems to be most common in disturbed areas, in dry secondary forests and thorn forests. The present study noticed that in dry season almost 75 per cent of the activities of the species were seen in moist deciduous forests and in wet season 100 per cent of the habitat use was confined to the moist deciduous forests.

HUI of otters in the sanctuary was also seen higher in the moist deciduous forests than the semi evergreen habitats. The only otter species identified from the sanctuary, *Lutrogale perepicillata*, was observed more in the rocky and open areas than the areas having vegetation in the both the habitats sighted. Similar results can be seen in previous studies on the species and all the observations showed that otters prefer to use habitats where food is plentiful and anthropogenic disturbances low (Shenoy *et al.*, 2006; Hussain and Choudhury, 1997; Anoop and Hussain, 2004). The habitat selection of the species changes in temporal basis rather than spatial (Shenoy *et al.*, 2006). The same was observed in Chimmony also. In dry season the HUI was seen equal for both the habitats but in wet season it used only the moist deciduous habitat.

The only small cat from the sanctuary, *Felis chaus*, showed noteworthy variation in habitat use in the sanctuary. The HUI of the species was seen much higher in the moist deciduous forests when compared to the semi evergreen forests. It is probably absent from all closed canopy forests, including rainforest. The species may make use of agricultural areas with a low intensity of human use and which retain patches of scrub (Duckworth *et al.*, 2005). The presence of the animal was observed only during the dry season. It may be due to the movement of the individuals to the adjacent forest areas like Parambikulam and Peechi forests or most probably due to the frequent rain that washed away the indirect evidences such as foot prints, scats etc.

Jaccard's index of similarity of small carnivores in Chimmony Wildlife Sanctuary was found 0.83 between the moist deciduous and semi evergreen forests.

5.5 ECOLOGY OF THE RODENTS OF CHIMMONY WILDLIFE SANCTUARY

5.5.1 Diversity of rodents in Chimmony Wildlife Sanctuary

The present study recorded a total of eight species of rodents from the Chimmony Wildlife Sanctuary. This includes four species of scuirine squirrels (Sciuridae), three species of rats (Muridae) and the Indian porcupine *Hystrix indica* (Hystricidae). The scuirids include *Funambulus sublineatus*, *Funambulus tristriatus*, *Ratufa indica* and *Petaurista philippensis*. The murids recorded from the sanctuary include *Rattus rattus* wroughtoni, *Cremnomys blanfordi* and *Millardia meltada*. The study conducted by Jayson and Easa (1996) listed only two species of squirrels from the sanctuary namely *Ratufa indica* and *Funambulus palmarum*. The latter one was not observed in the sanctuary during the present study period. The race of the Indian Giant Squirrel identified from the sanctuary is *Ratufa indica maxima* (Abdulali and Daniel, 1952). The Management Plan of the Chimmony Wildlife sanctuary reports 12 species of rodents including four species of squirrels, seven species of rats and the Indian Porcupine (George, 2002). But this doesn't include *Funambulus sublineatus*,

Cremnomys blanfordi and *Millardia meltada* which were observed in the present study. The recent study conducted by Nameer *et al.* (2009) showed 12 species of rodents which includes all the species listed by the present study except the *Millardia meltada.*

5.5.2 Abundance of rodents in Chimmony Wildlife Sanctuary

The encounter rate (number of individuals seen per kilometer transect walk) was used as a measure to calculate the abundance of squirrels in the sanctuary. *Ratufa indica* showed maximum encounter which means that it is the most abundant squirrel in the sanctuary. Jayson and Easa (1996) also reported the same from the sanctuary. The second most abundant squirrel was *Funambulus tristriatus.* This was followed by *Funambulus sublineatus.* The least abundant squirrel in the sanctuary was the *Petaurista philippensis.* When compared to the other squirrels the population of *Ratufa indica* in the sanctuary is very high. It was seen solitary in most of the sightings. Similarly *Funambulus sublineatus* was also seen as solitary in most of the sightings whereas *Funambulus tristriatus* was observed in pairs in most of the sightings. In some occasions a group having three individuals was observed in *Ratufa indica, Funambulus tristriatus* and *Funambulus sublineatus.* Jayson and Easa (1996) also reported the sighting of squirrels in group having three individuals from the sanctuary. *Petaurista philippensis* was always seen solitary.

Among the rats captured in the Sherman traps *Rattus rattus wroughtoni* was the abundant species. The same was observed in most of the studies in the South India (Molur and Singh, 2009; Chandrasekar-Rao and Sunquist, 1996; Shanker and Sukumar, 1998; Shenoy and Madhusudan, 2006; Kumar *et al.*, 2002). The second most abundant rat species was *Cremnomys blanfordi.* A good population of *Cremnomys blanfordi* was observed in the moist deciduous habitats of Virakuthodu area. Only one individual of *Millardia meltada* was captured from the sanctuary. The overall trapping success was very poor in the sanctuary. In most of the previous

studies in the Western Ghats the trapping success was very less (Chandrasekar-Rao and Sunquist, 1996; Molur and Singh, 2009; Shanker and Sukumar, 1998). It may be due to factors such as weather, temperature, ants etc. (Molur and Singh, 2009) or may be due to the improper functioning of the traps.

Hystrix indica was not directly sighted during the study but its presence as scats and quills was seen throughout the sanctuary. It was also captured in the camera trap. The abundance was calculated as scat abundance and was much higher than any of the scat encounter of other animals recorded by the present study. This indicates that the sanctuary holds a good population of this species. Indian Porcupine is a common species in the Chimmony Wildlife Sanctuary, though the sighting was very rare, faecal matters were collected from most of the places. The same was observed by Jayson and Easa (1996) in the sanctuary.

5.5.3 Habitat preference of rodents in Chimmony Wildlife Sanctuary

The present study observed noteworthy difference in the use of different habitats by the rodents in the sanctuary. Among the squirrels *Ratufa indica* was observed mainly in the moist deciduous forests though the difference is not so remarkable. Study conducted by Kumara and Singh (2006b) also observed that the encounter rate of *Ratufa indica* was more in the dry forests than the wet forests of Karnataka state. In most of the sightings the animal was seen feeding on *Melicope lunu-ankenda* and also observed that the animal prefers *Lagerstroemia lanceolata* for building nests in the sanctuary. Both these tree species are mainly seen in deciduous forests. Similarly *Funambulus tristriatus* was also seen preferring the moist deciduous forest. A majority of the sightings of *Funambulus tristriatus* was from the moist deciduous habitats of Virakuthodu and one individual was captured in the Sherman trap (the trap was kept on the buttress of a *Tetrameles nudiflora*) because it is a semi-arboreal species (Molur *et al.*, 2005) and that too was from Virakuthodu. It occurs in tropical evergreen forest, moist deciduous forests, plantations and

pasturelands. It is found to occupy tea, cardamom and coffee estates, and is endemic to Western Ghats (Molur *et al.* 2005). *Funambulus sublineatus* was observed mainly in the semi evergreen forests of the sanctuary. The encounter rate was remarkably higher in the semi evergreen forests when compared to the moist deciduous forests of the sanctuary. The species was primarily observed in the typical semi evergreen habitats of Vavala and Eettakomba area in the sanctuary. The vegetation of these areas include wet bamboo and reedbrakes and this species is restricted to riparian habitats, especially reedbeds, in tropical evergreen and moist deciduous forest and in the Western Ghats it is associated with *Ochlandra* sp. and bamboo jungles (Molur *et al.*, 2005). *Petaurista philippensis* was seen as a habitat generalist in the sanctuary though there is a negligible variation in the abundance between the habitats which is slightly more in the moist deciduous forests. In South Asia it occurs in dry deciduous forests and evergreen forests (Molur *et al.*, 2005).

Among the rats captured *Rattus rattus wroughtoni* did not show any habitat preference. It was equally captured from both the moist deciduous and semi evergreen forests. But within the habitat it showed significant difference in selection of micro habitats. In moist deciduous forests it was captured from the sites were the snags, rock and coarse woody debris were more. Similarly in the semi evergreen forests the species showed a special affinity towards the sites were snags, rock and coarse woody debris are more but the ground vegetation is less. But similar study by Chandrasekar-Rao and Sunquist (1996) in the Western Ghats showed that it has preference to ground vegetation in the evergreen forests in dry season. In the present study it was equally captured in both the seasons but in dry season the capture rate was more in moist deciduous habitats and in wet season capture was more in semi evergreen habitat. The second most abundant species in the sanctuary *Cremnomys blanfordi* was captured only from the moist deciduous habitats. Similar study in Indira Gandhi Wildlife Sanctuary by Chandrasekar-Rao and Sunquist (1996) also showed the similar result that the species was captured only from the moist deciduous

forests. They concluded that this may be due to the competitive interaction with the *Rattus rattus wroughtoni*. All the captures of *Cremnomys blanfordi* in the present study was in dry season. In micro habitat selection within the moist deciduous habitats *Cremnomys blanfordi* showed preference to the sites having more canopy closure and coarse woody debris but less canopy height and ground vegetation. This may be due to the fact that this species is more ground dwelling than arboreal *R. rattus wroughtoni* is, on the other hand, believed to be highly arboreal, and may be more dominant in habitats with greater canopy height. The density of species other than *Rattus rattus wroughtoni* on small patches is probably determined by the lower canopy height and this lower canopy height may be related to diversity of forest floor niches (Shanker and Sukumar, 1998). *Millardia meltada* was captured from the semi evergreen habitat of Anapporu in wet season. This is the second report of the species from the sanctuary after Jayson (2006). The site from the animal captured showed thick growth of wild turmeric (*Curcuma aromatica*). It has been found to occupy gravelly areas, bunds of fields and largely cultivated areas (Molur *et al.*, 2005).

Jaccard's index of similarity of rodents in Chimmony Wildlife Sanctuary was found 0.63 between the moist deciduous and semi evergreen forests.

5.6 ECOLOGY OF THE BATS OF CHIMMONY WILDLIFE SANCTUARY

5.6.1 Diversity of bats in Chimmony Wildlife Sanctuary

The present study recorded a total of eight species of bats from the Chimmony Wildlife Sanctuary. This includes three species of fruit bats (Pteropodidae) and five species of insectivorous bats. The insectivorous species include four species of horseshoe bats (Rhinolophidae) and the Lesser False Vampire Bat *Megaderma spasma* (Megadermatidae), while the fruit bats include *Cynopterus sphinx*, *Cynopterus brachyotis* and *Rousettus leschenaultii*. The horseshoe bats recorded from the sanctuary include *Rhinolophus beddomei*, *Rhinolophus rouxii*, *Hipposideros ater* and *Hipposideros speoris*. The Management Plan of the Chimmony Wildlife

sanctuary reports only three species of bats namely *Pteropus giganteus*, *Megaderma lyra* and *Cynopterus sphinx* (George, 2002). Among these three species, the present study could identify only *Cynopterus sphinx* and the other two species were not observed in the sanctuary. The recent study conducted by Nameer *et al.* (2009) showed 18 species of bats which include all the species listed by the present study.

The Simpson's index of the diversity of the bats in the sanctuary was seen higher (0.62) when compared to the similar study by Radhakrishnan (2005) in Peechi-Vazhani Wildlife Sanctuary (0.24) which shares its border with the present study area whereas the Shannon-Wiener diversity index was less for the Chimmony Wildlife Sanctuary (1.4) when compared to Peechi-Vazhani Wildlife Sanctuary (1.94). This decreased value of Shannon index (H') indicates an increase in the magnitude of dominance of a few adapted species like *Rhinolophus rouxii*, the most abundant species in the sanctuary (58%). Similarly the Margalef richness index and Pielou's Evenness index were less as 1.81 and 0.51 respectively in Chimmony Wildlife Sanctuary compared to the observations of Radhakrishnan (2005) in Peechi-Vazhani Wildlife Sanctuary which followed 3.26 and 0.66 respectively.

5.6.2 Abundance of bats in Chimmony Wildlife Sanctuary

Rhinolophus rouxii was the most abundant species in the sanctuary as per the number of individuals captured per hour of mist-netting. The second most abundant species in the sanctuary was *Cynopterus sphinx*. Similar study in Peechi-Vazhani Wildlife Sanctuary showed *Cynopterus sphinx* as the most abundant species followed by *Rhinolophus rouxii* (Radhakrishnan, 2005). *Hipposideros ater* and *Rhinolophus beddomei* were the least abundant species with capture of only one individual.

5.5.3 Habitat preference of bats in Chimmony Wildlife Sanctuary

The present study observed the habitat preference of various species of bats in the sanctuary. *Rhinolophus rouxii*, the most abundant bat species in the sanctuary is

almost equally seen in both the moist deciduous as well as semi evergreen habitats with slight preference to the moist deciduous forests. This species is found in caves, hollows of large tree in moist evergreen forests, unused wells, old dilapidated buildings and temples in South Asia (Molur *et al.*, 2002). *Cynopterus sphinx*, *Hipposideros speoris*, *Cynopterus brachyotis* and *Rhinolophus beddomei* were strictly present only in semi evergreen forests. *Cynopterus sphinx* is found in a wide variety of habitats from rural areas, primary and secondary forested habitats to urban landscapes (Bates and Harrison, 1997). *Hipposideros speoris* roosts in colonies ranging from a few to several hundreds of individuals but in India, individuals do not usually congregate in clusters and tend to be scattered, while in Sri Lanka they tend to be in close contact in roosts (Bates and Harrison, 1997). In contrast to this a good population of *Hipposideros speoris* was observed in a cave at Mulappara having more than five hundred individuals. *Cynopterus brachyotis* was collected only from the semi evergreen habitat of Anapporu. The only one individual of *Rhinolophus beddomei* captured was from the semi evergreen habitats of Vavala. *Hipposideros ater* was observed as the only habitat specialist preferring the moist deciduous forest in the sanctuary. In South-East Asia, the species has been recorded from lowland and montane primary and secondary forest, over or associated with limestone (Molur *et al.*, 2002). *Megaderma spasma* and *Rousettus leschenaulti* are the other habitat generalists in the sanctuary observed in both the habitats.

The overall abundance of bats in the sanctuary was higher in the semi evergreen forests (0.7/hour of mistnet) with seven species when compared to the moist deciduous habitats (0.5/hour of mistnet) which showed the presence of only four species. Diversity indices like the Shannon-Wiener Diversity index, Simpson's index, Pielou's Evenness index and Margalef Species Richness index were highest for the semi evergreen when compared to moist deciduous habitats. This is because of the fact that some species are seen dominant in the moist deciduous habitats and it is seen with the Berger-Parker Dominance index which is more for the moist deciduous

habitat (0.85) than the semi evergreen forests (0.39). Shannon diversity t test of bat species between the moist deciduous and semi evergreen habitats of Chimmony Wildlife Sanctuary showed that the two habitats are significantly different in the diversity of bats (t = - 3.508, df = 36.47 and p = 0.0012).

The Jaccard's index of similarity for the qualitative expression on presence/absence of bat species between the moist deciduous and semi evergreen habitats was calculated as 0.38 whereas the Morisita-Horn index for the quantitative expression of similarity in species abundance was seen 0.69.

5.7 CONSERVATION STATUS OF LESSER KNOWN MAMMALS IN CHIMMONY WILDLIFE SANCTUARY

Among the 22 species of lesser known mammals observed in the sanctuary, *Lutrogale perspicillata* and *Funambulus sublineatus* are vulnerable species as per the IUCN red list criteria (Rajamani *et al.*, 2008; Hussain *et al.*, 2008). Major global threats to *Lutrogale perspicillata* population are loss of wetland habitats due to construction of large-scale hydroelectric projects, reclamation of wetlands for settlements and agriculture, reduction in prey biomass, poaching and contamination of waterways by pesticides. In most Asian countries increased human population during the last century, inadequate and ineffective rural development programmes have not been able to address the problems of poverty, forcing people to be more and more dependent on natural resources (Badola, 1997). Consequently, most of the wetlands and waterways do not have adequate prey base for sustaining otter populations. The important prey base of the species in Chimmony Wildlife Sanctuary is not yet studied and their population trend is also unknown. Since 1977, the smooth-coated otter is listed on Appendix II CITES. However, most range countries are not able to control the clandestine trade leading to extensive poaching. Nevertheless, it is a protected species in almost all the range countries which prohibits its killing (Hussain *et al.*, 2008). Similarly in the case of *Funambulus sublineatus,* habitat loss

and degradation due to selective logging, collection of non-woody vegetation (reeds), and forest fires have been observed to be the major threats (Molur *et al.* 2005). But Chimmony is free from most of these threats except the fact that the reedbeds are very less in the sanctuary. This species is endemic to southern India and Sri Lanka and it is not protected by any legislation. Survey, limiting factor research and captive breeding for species recovery are recommended as conservation actions for this species (Molur *et al.*, 2005).

Out of these 22 species *Funambulus tristriatus* is the only species endemic to Western Ghats. Other species such as *Herpestes vitticollis*, *Cynopterus brachyotis*, *Rhinolophus beddomei* and *Hipposideros speoris* are restricted to southern parts of India.

Summary

SUMMARY

Most of the mammalian studies in India are focused on the fascinating large bodied animals such as elephant, rhino, tiger, leopard, bear etc. Mammals such as small carnivores, rodents, insectivores and bats constitute almost 75% of Indian mammals and 66% of mammals of Kerala. Very little is known about these creatures. These animals play very crucial role in the ecosystem functioning.

The present study was carried out to understand the ecology of these lesser known mammals of the Chimmony Wildlife Sanctuary. This is the first ever study of its kind not only in the Chimmony Wildlife Sanctuary but also in Kerala. The various methods followed are; transect survey for the direct and indirect evidences, camera-trap survey, Sherman traps for small mammals and mist-netting for bats. A total of 240 kilometres transect walk, 270 camera-trap nights, 5000 Sherman trap nights and 80 hours of mistnet were carried out in the sanctuary during the present study period from July 2009 to June 2010. The salient findings are summarised below.

1. A total of 22 species belonging to 10 families were recorded from the sanctuary during the present study. This includes six species of small carnivores, eight species of rodents and eight species of bats. Small carnivores include two civets, two mongooses, one otter and one small cat. Rodents recorded include four species of squirrels, three species of rats and the Porcupine. Similarly, the bats include three species of fruit bats and five species of insectivorous bats.
2. Among the small carnivores civets were abundant followed by mongoose. Among the rodents, Malabar Giant Squirrel was the abundant squirrel and *Rattus rattus wroughtoni* was the abundant rat species. The overall scat abundance was highest for Indian Porcupine. Among the bats, *Rhinolophus rouxii* was the abundant species in the sanctuary.
3. Camera trapping gave images of large bodied mammals such as elephant, gaur, sambar deer and common leopard but it gave only a single image of Indian Porcupine among the lesser known mammals studied.

4. Total 17 species were recorded from the moist deciduous forests whereas 18 species were recorded from the semi evergreen forests.
5. *Herpestes vitticollis*, *Petaurista philippensis*, *Cremnomys blanfordi*, and *Hipposideros ater* were the habitat specialists preferring the moist deciduous forests whereas *Millardia meltada*, *Cynopterus sphinx*, *Hipposideros speoris*, *Cynopterus brachyotis* and *Rhinolophus beddomei* were the habitat specialists preferring only the semi evergreen forests. All other species recorded were habitat generalists seen in both the moist deciduous and semi evergreen forests.
6. Among the rodents captured, *Rattus rattus wroughtoni* showed a special affinity towards the microhabitats having more snags, rock and course woody debris in the moist deciduous and semi evergreen habitats whereas it showed less preference to ground vegetation in the semi evergreen forests. Similarly the *Cremnomys blanfordi* was seen preferring the microhabitats having more canopy closure and course woody debris but avoiding areas of low canopy height and ground vegetation.
7. In the case of bats the diversity indices like the Shannon-Wiener Diversity index, Simpson's index, Pielou's Evenness index and Margalef Species Richness index were highest for the semi evergreen when compared to moist deciduous habitats. The Berger-Parker index of dominance showed highest for moist deciduous habitat. The Morisita-Horn index of similarity was obtained as 0.69 between the moist deciduous and semi evergreen habitats.
8. The Jaccard's Similarity index between the moist deciduous and semi evergreen forests was observed as 0.83, 0.63 and 0.38 for small carnivores, rodents and bats respectively.
9. Species such as *Lutrogale perspicillata* and *Funambulus sublineatus* are vulnerable species as per the IUCN red list criteria which were identified from the sanctuary. Similarly *Funambulus tristriatus* recorded from the sanctuary is endemic to Western Ghats.

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Appendices

APPENDIX – I

Data sheet for direct sightings - Line transect method

Transect No: **Date:** **ST time:** **End time:**

Habitat Type: **Terrain Type:** **Weather:**

Season: **Geo Coordinates: N:** **E:**

Alt: **Observer Name:**

Sl.No	Time	Species	No. of Ind	Age			Sex	Dist. Band	Remark
				J/Y	SA	A			

Note: J/Y = Juvenile , SA = Sub Adult, A = Adult, M = Male, F = Female, A = 0-5m, B = 5-10m, C = 10-20m, D = 20-30m, E = 30 m and above'

APPENDIX – II

Data sheet for indirect evidences - Line transect method

Transect No: **Date:** **ST time:** **End time:**

Habitat Type: **Terrain Type:** **Weather:**

Season: **Geo Coordinates: N:** **E:**

Alt: **Observer Name:**

Sl.No	Species	S/P/D	Track	Den/Hole	Remark

Note: S = Scat, P = Pellet, D = Dung

ECOLOGY OF THE LESSER KNOWN MAMMALS OF CHIMMONY WILDLIFE SANCTUARY

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Studying the lesser known mammals such as the small carnivores, rodents, insectivores and bats is always a challenging one for the wildlife researchers because these mammals are nocturnal or crepuscular, small bodied and inhabit inaccessible areas. This makes these groups of mammals least studied and hence less information is available regarding their ecology, behaviour and habits. In this study, an attempt was made to understand the ecology of the lesser known mammals of Chimmony Wildlife Sanctuary. The techniques employed include line transect survey for direct and indirect evidences, camera trapping, Sherman trapping for rodents and insectivores, and mistnet for bats. A total of 240 kilometres transect walk, 270 camera-trap nights, 5000 Sherman trap-nights and 80 hours of mistnet were carried out in the sanctuary. A total of 22 species belonging to 10 families of lesser known mammals studied were recorded from the sanctuary. These include six species of small carnivores, eight species of rodents and eight species of bats. Small carnivores include two civets, two mongooses, one otter and one small cat. Rodents recorded include four species of squirrels, three species of rats and the Porcupine. Similarly, the bats studied include three species of fruit bats and five species of insectivorous bats. Among the small carnivores civets were abundant followed by mongoose. *Ratufa indica* and *Rattus rattus wroughtoni* were the abundant species of squirrels and rats respectively among the rodents. *Rhinolophus rouxii* was the abundant species of bats in the sanctuary. *Herpestes vitticollis*, *Petaurista philippensis*, *Cremnomys blanfordi* and *Hipposideros ater* were observed only in the moist deciduous forests whereas *Millardia meltada*, *Cynopterus sphinx*, *Hipposideros speoris*, *Cynopterus brachyotis* and *Rhinolophus beddomei* were observed only in the semi-evergreen forests. All other species recorded were habitat generalists observed in both the moist deciduous and semi-evergreen forests. Small mammals with smaller area requirements would have been the last one to be affected due to the changes in the landscape and habitat degradation. Smaller mammals are susceptible to the alterations in the habitat and thus could be a good indicator of the habitat health. Conservation strategies may be improved if information on species ecology is taken into account.