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**STATUS, DISTRIBUTION AND HABITAT
PREFERENCES OF SMALL CARNIVORES IN
ERAVIKULAM NATIONAL PARK, KERALA**

By

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(2013-17-102)**

THESIS

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

Master of Science in Forestry

**Faculty of Forestry
Kerala Agricultural University**



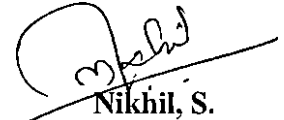
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2015

DECLARATION

I hereby declare that the thesis entitled “**Status, distribution and habitat preferences of small carnivores in Eravikulam National Park, Kerala**” 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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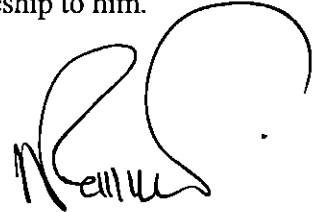
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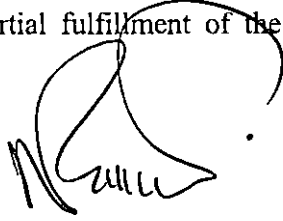
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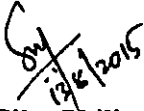
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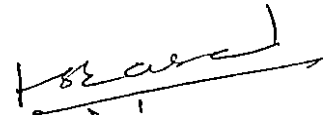
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Introduction

INTRODUCTION

The Western Ghats, also known as the Sahyadri Hills, are well known for their richness and uniqueness of flora and fauna. It is one amongst the 25 biodiversity hot-spots identified in the world. The Western Ghats extend from the Satpura Range in the north, go south past Goa, through Karnataka and into Kerala and Tamil Nadu end at Kanyakumari embracing Indian ocean. The major hill range starting from the north is the Sahyadhri range. High diversity of plants and animals makes the Western Ghats one of the global biodiversity hotspots of the world (Myers *et al.*, 2000). About 60 genera and 2,100 species are endemic to the Western Ghats. The southern Western Ghats lying between 8^o and 11^o N is the important ecological subunit of the Western Ghats (Myers *et al.*, 2000). The region harbors higher levels of biodiversity and endemism than the rest of the Western Ghats (Vasudevan *et al.*, 2001).

Mammals are air breathing vertebrate animals under the class mammalian characterised with the possession of mammae or teats. They give birth to young ones and nourish them with milk from the mammary glands. Mammals are the only animals having hair on the body. They evolved from reptiles nearly 180-220 million years ago and they have got rampant growth on earth after the extinction of dinosaurs (Wilson and Reeder, 2005). 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, frugivores, insectivores and omnivores among the mammals. They are considered to be the most successful animals on earth. Mammals encompass approximately 5416 species, distributed in about 1,135 genera, 136 families, and 26 orders (Wilson and Reeder, 2005). Four hundred and ten species of mammals (8.865% of the world's mammals) are known from India (Nameer, 2008). Around 123 species of mammals have been reported within the political boundaries of Kerala state.

The order carnivora is represented by nine families in India (Wilson and Reeder, 2005; Schipper *et al.*, 2008). Carnivores less than about five kilogram in body weight belonging to the order carnivora are generally called the small carnivores (Yoganand and Kumar, 1999). In terms of number of genus and species, these groups constitute more than 50% of the order Carnivora. There are 195 species of small carnivores, including the small cats known from the world in ten different families. Out of these, India has 43 species in six families (Appendix I). The families of small carnivores represented in India are Ailuridae, Felidae, Herpestidae, Mustelidae, Prionodontidae and Viverridae (Nayerul and Vijayan, 1993; Wozencraft, 2005; Schipper *et al.*, 2008). Western Ghats support 16 species of small carnivores in four families. The details of small carnivores of India, Western Ghats and Kerala in relation to the world over are given in Table. 1.

Table. 1 A comparison of small carnivores of India, Western Ghats and Kerala

Family	India	Western Ghats	Kerala	World
Ailuridae (Red Panda)	1	-	-	1
Eupleridae (fossa)	-	-	-	9
Herpestidae (mongoose)	7	4	4	34
Mephtidae (skunk)	-	-	-	12
Mustelidae (otters, martens)	16	5	3	59
Nandinidae (African Palm-civet)	-	-	-	1
Prionodontidae (linsangs)	1	-	-	2
Procyonidae (olingo)	-	-	-	14
Felidae (small cats only)	10	4	3	30
Viverridae (civets)	7	3	3	33
Total	42	16	13	195

Source: Nayerul and Vijayan (1993); Mudappa (1999); Nameer (2008); Schipper et al (2008)

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 largest 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).

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. 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.

The species of small carnivores known from Western Ghats and Kerala along with their IUCN conservation status are given in Table 2. These include the four felids (Jungle Cat *Felis chaus*, Leopard Cat *Prionailurus bengalensis*, Fishing Cat *Prionailurus viverrinus* and Rusty-spotted Cat *Prionailurus rubiginosus*), four herpestids (Indian Grey Mongoose *Herpestes edwardsii*, Brown Mongoose *Herpestes fuscus*, Ruddy Mongoose *Herpestes smithii* and Stripe-necked Mongoose *Herpestes vitticollis*), three viverrids (Brown Palm Civet *Paradoxurus jerdoni*, Common Palm Civet *Paradoxurus hermaphrodites* and Small Indian Civet *Viverricula indica*) and five mustelids (Honey Badger *Mellivora capensis*, Nilgiri Marten *Martes gwatkinsii*, Asian Small-clawed Otter *Aonyx cinerea*, Smooth-coated Otter *Lutrogale perspicillata* and Common Otter

Lutra lutra). Out of the 16 small carnivores of Western Ghats, eight species (50%) are at different levels of threats such as critically endangered (1), endangered (1), vulnerable (5) and one near threatened. The small carnivore community shows a high degree of endemism in the Western Ghats. The Brown Palm Civet and the Nilgiri Marten are endemic to species level while Stripe-necked Mongoose and the Brown Mongoose are endemic to sub-species level. Honey Badger is the only small carnivore which is present in Western Ghats and absent in Kerala. Among the various small carnivores of Western Ghats, the taxonomic status of Malabar Civet has been questioned by Nandini and Mudappa (2010).

1.1 MUSTELIDAE

The members of the family Mustelidae are the most diverse group and may be paraphyletic (Wozencraft, 1989a and b). The mustelids are highly adaptive, terrestrial, arboreal or aquatic in nature and primarily flesh eaters. They are mainly solitary, with males and females getting together only for the purpose of reproduction (Kruska, 1990). In south India, otters are represented by three species *viz.* the Eurasian otter, the small-clawed otter and the smooth-coated otter (Nagulu, 1996). All the three species of otters are becoming increasingly rare outside Protected Areas and are threatened in many areas because of the reduction in prey biomass, poaching and reduction of habitat (Foster- Turley, 1992). They differ from Felidae by the absence of retractile claws and from the family Canidae by having a well developed first digit on the forefoot, well developed anal glands and by not having a deep chested body (Pocock, 1941). The family Mustelidae is subdivided into four subfamilies, Lutrinae, Melinae, Memphitinae and Mustelinae (Wozencraft, 1989a and b). They occur throughout the world except Australia and Antarctica. In India the Mustelidae is represented by three subfamilies, Mustelinae, Melinae and Lutrinae with 16 species.

Table. 2 IUCN Red List status of small carnivores of Western Ghats

Species	Scientific name	Family	IUCN threat category
Brown Palm civet	<i>Paradoxurus jerdoni</i>	Viverridae	LC
Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	Viverridae	LC
Small Indian civet	<i>Viverricula indica</i>	Viverridae	LC
Indian Grey Mongoose	<i>Herpestes edwardsii</i>	Herpestidae	LC
Brown Mongoose	<i>Herpestes fuscus</i>	Herpestidae	VU
Ruddy Mongoose	<i>Herpestes smithii</i>	Herpestidae	LC
Stripe-necked Mongoose	<i>Herpestes vitticollis</i>	Herpestidae	LC
Jungle Cat	<i>Felis chaus</i>	Felidae	LC
Leopard Cat	<i>Prionailurus bengalensis</i>	Felidae	LC
Rusty-spotted Cat	<i>Prionailurus rubiginosus</i>	Felidae	VU
Fishing Cat	<i>Prionailurus viverrinus</i>	Felidae	EN
Eurasian Otter	<i>Lutra lutra</i>	Mustelidae	NT
Smooth-coated Otter	<i>Lutrogale perspicillata</i>	Mustelidae	VU
Asian Small-clawed Otter	<i>Aonyx cinerea</i>	Mustelidae	VU
Nilgiri Marten	<i>Martes gwatkinsii</i>	Mustelidae	VU
Honey Badger	<i>Mellivora capensis</i>	Mustelidae	LC

Source: Nameer (2014); Schipper *et.al.* (2008)

1.2 VIVERRIDAE

The members of the family Viverridae are characterised by the presence of scent glands external to the anal region (Wozencraft, 1989a and b). They differ from the family Herpestidae in the sense that their anus is not enclosed in the glandular pouch and they have a penial gland in the genital region (Pocock, 1941). Most of the members have retractile claws. Their ears are comparatively larger with well developed bursa on the external margin. They are distinguished

from the members of the family Felidae by the hind foot being five toed, the retention of the inter-ramal tuft of facial vibrissae and typically elongated muzzle. Many of the members have spots or stripes on the body and the tail has ring like marks (Pocock, 1939). They are either terrestrial or arboreal in nature and have wide variety of diet including small mammals, birds, insects and fruits. Viverrids are mostly solitary and nocturnal.

The family viverridae is divided into four subfamilies Cryptoproctinae, Hemigalinae, Paradoxurinae and Viverrinae (Wozencraft, 1989a and b). They are found only in tropical and subtropical Africa and Asia. Of the six subfamilies, the viverrids in India are represented by eight species. Earlier Spotted Linsang was coming under Viverridae but now it is classified under a new family Paradoxurinae (Schipper *et al.*, 2008).

1.3 HERPESTIDAE

The members of the family Herpestidae are characterised by the uniquely derived nature of their anal sac and the structure of the auditory bulla (Wozencraft, 1989a and b). They are distinguished from Viverrids by the presence of a naked glandular pouch around the anus, with the anal glands opening into the pouch. They have long non-retractile and fossorial claws. The ears have no marginal bursa. The penis, which although short as compared to viverrids, has a well developed baculum and is without penial glands (Pocock, 1939). The stripe-necked mongoose *Herpestes vitticollis* is the largest of the Asiatic mongoose. The mongoose is terrestrial in nature and has a diverse diet including small mammals, birds, reptiles, crabs, fish and insects. They are mostly gregarious and a few are solitary too. The family Herpestidae is divided into three subfamilies Galiidinae, Herpestinae and Mungotinae (Wozencraft, 1989a and b). They occur in most of Africa and Asia. In India, the family is represented by subfamily Herpestinae with seven species.

1.4 FELIDAE (SMALL CATS ONLY)

The members of the family Felidae varies considerably in size and colour, but all have slender graceful bodies with round head shortened muzzle and erect ears. Based on their body size they are classified into two, big cats and small cats. The color of felids is also highly variable. It varies from brown to golden. Fur is common in most species and also usually marked with distinctive spots, stripes, or rosettes (Prater, 1971). All felids have retractable claws. The claws are retracted when the animal is relaxed. Unlike canids many of which hunt by running flat out their prey, most cats hunt by stealth, aided by pads on the soles of their feet (Pocock, 1941). The small cats cannot roar like big cats because of completely ossified hyoid apparatus which in big cats is elastic in nature.

1.5 ROLE OF SMALL CARNIVORES IN ECOSYSTEM SERVICES

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 and pollination agents in tropical forests (Fleming, 1975). Many of them play a major role in seed dispersal and thereby in the vegetation dynamics of their habitat. They also form an important prey base for medium sized carnivores and raptors.

The small carnivores use large variety of habitats ranging from rain forests to arid deserts, high altitude ecosystems, wetlands, and coastal and marine ecosystems for their sustained reproduction. Conservation of natural habitats at a landscape level should therefore be the highest priority for ensuring survival of the small carnivores and also other wildlife. India has a large network of Protected Areas representing different biogeographic zones and habitat types, which ensure survival of a wide range of wildlife. With increasing human population and associated development activities in the last century, it is not known what is happening to small carnivore populations.

There are several constraints in studying the small carnivores. Most of these animals besides being small are also rare, nocturnal, 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. Because of these reasons, camera-trapping is preferred for observational studies to document species richness and assess status. However, very few studies have used this method specifically to survey small carnivores (Mudappa, 1998). Apart from the camera trapping method, line transect method for collecting indirect evidences and night transect using vehicles for estimating encounter rates or densities can also be used.

The need to undertake biodiversity studies is accentuated by the rapid destruction of forests, particularly in the tropics. This holds true for the Western Ghats also. The conservation and ecological studies of small carnivores have therefore attracted considerable attention in recent year. The introduction of new technologies such as radio-telemetry made ecological studies of this community feasible and most of the people are not aware of the existence of many of the species occurring in Western Ghats.

Most of the Protected Areas of the country in general and Kerala in particular do not have a comprehensive inventory of the small carnivores. Even basic information such as the distributional range of these species is not known (Nameer, 2000). Easa and Ramachandran (2005) made a biodiversity documentation of mammals of Kerala. No studies have been done on the small carnivores of Eravikulam National Park (henceforth ENP), except for the studies on the Small-clawed Otter (Perinchery, 2011); (Aneesh, 2012). Madhusudhan (1995) had reported a sighting of Nilgiri Marten at ENP. But studies focussing on the small carnivores have not been conducted in ENP. Hence, the present study focused on these small carnivores and it is obvious that it will help to bolster the management and conservation of the biodiversity of ENP.

The objectives of the present investigation were,

1. To document the diversity of small carnivores of ENP
2. To assess the status and distribution of small carnivores of ENP
3. To study the habitat preference of small carnivores of ENP

Review of literature

REVIEW OF LITERATURE

Small carnivores excluding small cats are not uniformly distributed around the world. They are concentrated more in Ethiopian/Afro-tropical region with 57 species. The other zoogeographic regions support the small carnivores in the following manner, the Indo-Malayan region: 47 species; Neotropics: 33 species; Palaearctic: 16 species and Nearctic, 18 species each. No native small carnivores are known from the Antarctic, Australasian or Oceanic realms (Schipper *et al.*, 2008).

2.1 STUDIES ON THE SMALL CARNIVORES OF THE WORLD

Majority of the studies on the order Carnivora are focused on the large carnivores. Little attention is given to the small carnivores like herpestids, viverrids, mustelids and small cats. However, Zielinski (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. A detailed account on the small carnivore group called 'Genets' was given by Powell and Rompaey (1998) from the Niger Delta. Engel (1998) studied the process of seed dispersal by small carnivores. 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. Su (2005) studied the small carnivores and their threats in Myanmar. Duckworth and Robichaud (2005) studied on the species range in small carnivores of South-East Asia. The small carnivores of Central Sumatra were surveyed by Holden (2006). Long and Hoang (2006) reported the conservation status of small carnivores in Central Vietnam. Belden *et al.* (2007) studied about the small carnivores in mixed-use forests of Malaysia. However, Low (2011) did a detailed study on the small carnivores of peninsular Malaysia and reported 13 species of small carnivore. McDonald (2000) studied the

small carnivores of Arunachal Pradesh and Assam and reported 23 species including Red Panda *Ailurus fulgens* and Spotted Linsang *Prionodon pardicolor*. The study also reported various threats being faced by the small carnivores in the north-eastern region. Choudhury (2004) gave detailed account on the small carnivores of different sanctuaries in Assam. Nandini and Karthik (2007) reported on the Yellow-throated Martens *Martes flavigula* of northeast India. More recently, the status of Red Panda *Ailurus fulgens* of West Bengal was studied by Mallick (2010). The study also identified various threats faced by the species and suggested some recommendations for the conservation of Red Panda. Lyngdoh *et al.* (2011) observed that the Spotted Linsang is widely hunted in Arunachal Pradesh for its fur and meat and thus the species is uncommon. Kumara *et al.* (2014) studied the status of small carnivores in Biligiri Rangaswamy temple Tiger Reserve recording nine species.

2.2.1 Studies on Viverrids

2.2.1.1 Studies on Malabar civet

Malabar civet *Viverra civettina* is endemic to Western Ghats and is as large as the large Indian Civet *Viverra zibetha* (Pocock, 1933). The original description about the Malabar civet *Viverra civettina* was given by Blyth (1862). The next published information about Malabar Civet was by Jerdon (1874), who reported the species as common throughout the Malabar coast.

Concern about this species began early this century as several expeditions failed to obtain specimens (Pocock, 1939). The last (and perhaps only) live specimen of the Malabar Civet in a zoo was at the Thiruvananthapuram Zoo in 1929. In 1987, after a gap of 58 years, two skins of recently killed animals were obtained by the Zoological Survey of India, Calicut of a species long suspected extinct (Kurup, 1989). In recent times only two possible sightings have been reported: Karanth (1986) in Bhagavathy Valley, Karnataka and Kurup (1989) in Tiruvalla, Kerala.

Most of the past records of the species are from the coastal tracks of the Western Ghats (Jerdon, 1874; Pocock, 1939; Prater, 1971) and from Kanyakumari in the extreme south to Honnavar in the Karnataka in the north. There are also two reports of its occurrence in the higher elevations of the Western Ghats in the high wavy mountains (Hutton, 1949), and in Kudremukh (Karanth, 1986). But for these reports, the Malabar Civet has remained unknown to the scientific community (Rai and Kumar, 1993).

Ashraf *et al.*, (1993) obtained two skins of the animals near Nilambur, an area dominated by cashew and rubber plantations. But, Rai and Kumar (1993) who surveyed the Nilambur and adjoining forests of Kerala could not get any evidence of the species. They however, suggested the presence of Malabar Civets in few locations in Kerala and Karnataka based on indirect evidences. The most recent survey on Malabar Civet by Rao *et al.*, (2007) and Ashraf *et al.*, (2009), could not get any direct evidence to prove the presence of Malabar Civet in south India. Jayson (2007) also did a status study of Malabar Civet in the southern Western Ghats under Kerala Forest Research Institute which also failed to obtain any direct evidences. Nandini and Mudappa (2010), after reviewing the history of its collection, published and unpublished literature on this species has proposed a novel possibility that the genus *Viverra* does not occur in the wild in South India and Malabar Civet is not a valid taxon.

2.2.1.2 Studies on Brown Palm Civet

The Brown Palm Civet or Jerdon's Palm Civet *Paradoxurus jerdoni* is an endemic carnivore restricted to the rainforest tracts of the Western Ghats, a 1,600km long hill chain along the west coast of India. The species has been reported from an altitudinal range of 500-1,300m, being more common in higher altitudes (Mudappa, 2001). They are known to occur in tropical rainforests of the Western Ghats and in areas such as Coorg they are known to use coffee estates as well (Report of G.C. Shortridge in Riely, 1913; Ashraf *et al.*, 1993).

Recent reports include photographs or sight records from Anamalais, Nilgiris, Coorg (Schreiber *et al.*, 1989), Silent Valley (Ramachandran, 1990), and Kalakad- Mundanthurai Tiger Reserve (Ganesh, 1997; Mudappa, 2001). Ashraf *et al.*, (1993) stated that the Brown Palm Civet probably occurs in low densities throughout its range. However, the species appears to be fairly common in Kakachi-Upper Kodayar (Ganesh, 1997) and other areas above 1,000m within the KMTR in the Agasthyamalai hills and also in the Anamalai hills (Mudappa, 2001). Recent studies also suggest that the Brown Palm Civets are not as rare as they were thought to be (Mudappa, 2001). A detailed study about the status and distribution of Brown Palm Civet carried out by Nandini *et al.* (2002), reported illegal hunting and the conversion of rainforest into tea and coffee plantations as the major threats to the species. Mudappa and Chellam (2002) made some capture and immobilization studies of wild Brown Palm Civets in Western Ghats. Mudappa (2002b; 2006) also made extensive studies on the Brown Palm Civets of Western Ghats.

2.2.1.3 Studies on Small Indian civet

The major threats faced by the Small Indian Civets *Viverricula indica* are the illegal hunting for meat and civetone, habitat destruction, along with other antropogenic causes (Gupta, 2000). The skin of the civets is also used for the preparation of ayurvedic medicines against epilepsy (Gupta, 2004). Balakrishnan and Sreedevi (2007) studied on the Small Indian Civets under captivity. They also reported that the practice of capturing civets for keeping under captivity is the major reason for the depletion of civet's population in south India (Balakrishnan and Sreedevi, 2007). Easa and Ramachadran (2005) documented Small Indian Civet from many protected areas of Kerala.

2.2.1.4 Studies on Common Palm Civet

Krishnakumar and Balakrishnan (2003) studied the feeding ecology of Common Palm Civet *Paradoxurus hermaphroditus* in the semi urban areas of Kerala. Borah and Deka (2011) reported the mating behavior of the species. Diet

and Kumar (1999) reported the small carnivores likely to be seen in Silent Valley National Park. Anoop and Hussain (2004; 2005), studied the ecology and feeding behavior of Smooth-coated Otter in Periyar Tiger Reserve. Easa *et al.*, (2001) conducted a study on the small mammals of Kerala including small carnivores. Malik (2010) reported five species of small carnivores from Chimmomy Wildlife Sanctuary in Kerala such as Jungle Cat *Felis chaus*, Indian Grey Mongoose *Herpestes edwardsi*, Smooth-coated Otter *Lutrogale perspicillata*, Common Palm Civet *Paradoxurus hermaphrodites* and Small Indian Civet *Viverricula indica*. Sreehari (2012) studied the status of small carnivores in Parambikulam Tiger Reserve and reported 11 species.

Materials and methods

MATERIALS AND METHODS

3.1 STUDY AREA

3.1.1 Name, Location and Extent

Eravikulam National Park lies within the geographical extremes of latitudes $10^{\circ}05'$ N and $10^{\circ}20'$ N longitudes 77° E and $77^{\circ}10'$ E in Idukki district of Kerala State within the administrative jurisdiction of Munnar Wildlife division. The 97 Sq. Km. National Park is composed of mosaic montane wet temperate grasslands on hill slopes and '*sholas*' or patches of evergreen forest in the valleys. It was declared a sanctuary in 1975 and upgraded to a National Park in 1978 in recognition of its unique ecological values. The park is adjoined by three National Parks viz. Pambadum Shola, Anamudi Shola and Mathikettan Shola National Parks and two Wildlife sanctuaries viz. Kurinjimala Sanctuary and Chinnar Wildlife Sanctuary.

3.1.2 Terrain

The area is represented by undulating terrain flanked on all sides by moderate to steep slopes. The major terrain types are slopes (low to steep), flat mountain tops and valleys (water logged and well drained). The main body of the Park is comprised of a high rolling plateau, with a base elevation of about 2000m. Most of the knolls and peaks on the plateau rise 100 to 300m above it. The main plateau area is split roughly into half from northwest to southeast by the Turner's Valley. The southern fringe of the Park is mostly precipitous with broken cliffs descending from Anamudi, Umayamala and surrounding massifs. In contrast to the sustained and extremely steep escarpment along the eastern fringe of the Nilgiri plateau, the plateau fringe in the Eravikulam area is generally less steep with cliffs often grading into rock slabs with numerous brakes of grassland, shrubs or forests. Only along the west-facing crust between Kattumalai and Kumarikkalmalai, does the edge of the plateau resemble that of the Nilgiri plateau in this regard. In addition, cliffs are usually not abrupt but rounded both

horizontally and vertically. Where exposed, the rock usually has an irregular surface with numerous small dikes and discontinuities (Plate.1 and 2).

3.1.3 Climate

The climate is described as tropical montane. The bulk of the annual rainfall is from South West monsoons, from mid-May to September. The park receives an average annual rainfall of 5000 to 6500mm. The park also receives North East monsoon during October-November. April and May are the hottest months. The occurrence of frost is quite common from December to February. The mean monthly minimum temperature is 11°C, while the mean monthly maximum temperature is 22°C.

3.1.4 Water sources

Many streams criss-cross the landscape. Almost all the streams are perennial. They merge together to form tributaries of Periyar and Chalakudiyar in the west and river Pambar in the east. The lake at *Bheemanoda* is an artificial one created before the formation of the National Park.

3.1.5 Geology, rock and soil

The underlying rocks in the area are of Archaean igneous origin, consisting of granite and gneiss. The crystalline rocks consist of minerals such as silica, feldspars, muscovite and biotitic with small amounts of accessory ferro-magnesium minerals. The soil is basically a relic of a much thicker soil cover that developed formerly under pseudo-dynamic conditions prevailing from late Jurassic to early Tertiary times. It is composed of different layers, black to dark gray in colour, granular, friable, sandy loam interspersed with a little gravel. The soil is rich in organic matter. Soil is sandy-clay with sand (79.43 – 94.14 %), silt (1.43 – 11.00 %), clay (2.71 – 5.57 %) and some gravel, altogether approximately 30-100 cm in depth. Soil depth is more in valleys, bogs and shola margins when compared with that of slopes and crests. The soil moisture in the month of May ranges from 12.30 to 39.97 % in different landscape units.

3.1.6 Vegetation

Three major types of plant communities are found within the National Park, such as, grasslands, shrub lands and forests. The terrain above 2000m is covered primarily by grasslands. The valleys are extensively forested. Shrub lands predominate along the bases of the cliffs and interspersed in rocky slab areas. Around 60% of the area is covered by grasslands, about 25% by *shola* forests; about 8.45% by southern sub-tropical hill forest and 7.5% constitute the shrubs (Menon, 2001).

3.1.7 Forest types

Following forest types are recognized inside the Park.

- a. Shola forests (Southern montane wet temperate forest)
- b. Grasslands (Southern montane wet temperate grass land)
- c. Transition forests (Southern sub tropical broad leaved hill forest)
- d. Evergreen forests (Southern west coast evergreen forest)
- e. Shrub lands
- f. Deciduous forests (Southern tropical moist deciduous forests)

3.1.7.1 Flora

The Park is floristically rich due to its characteristic climatic condition. Eight hundred and three taxa (76 Peridophytes and 727 Angiosperms) were collected and described from the Park (Menon, 2001). They belong to 332 genera representing 134 families. Dicotyledons dominated with 505 species belonging to 240 genera and 90 families. Monocotyledons were represented by 222 species under 92 genera and 16 families. 10 dominant families with respect to species richness are Poaceae (105 species and 39 genera), Orchidaceae (66 species and 23 genera), Asteraceae (48 species and 24 genera), Rubiaceae (43 species and 17 genera), Balsaminaceae (39 species and 1 genus), Acanthaceae (31 species and 7 genera), Papilionaceae (26 species and 12 genera), Lauraceae (32 species and 6



Landscape of Eravikulam Block with Anamudi peak in the background. Photo Courtesy: Dileep Anthikad



Landscape of Poovar block

Plate 1. The landscape of Eravikulam National Park



a) The bloom of 'Neelakkurinji' *Strobilanthes kunthiana*



b) A juvenile Nilgiri Tahr *Nilgiritragus hylocrius*

Plate 2. The Major attractions of Eravikulam National Park

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genera), Melastomataceae (18 species and 4 genera), Lamiceae (17 species and 7 genera). Fern groups here are endemic and comprises of 76 species under 35 genera and 28 families. Nearly 190 species are Western Ghat endemics, and 89 among these are placed under various threat categories. 36 species of *Impatiens* are known from in and around the park of which 18 are locally endemic and not seen anywhere in the Western Ghats. They harbour 15 species of *Arisaema* which are confined to this area alone and two species of *Ophiorrhiza* which was recollected after 68 year. Other endemics of this region are *Anaphalis barnesii*, *Begonia aliciae*, *Didymocarpus mcrostachya*, *Habenaria flabelliformis* etc.

3.1.7.2 Shola forests: The hill forests are locally known as 'sholas', the Tamil term for forest. The shola forests in the upper plateau are dense and floristically rich with many endemic and rare species. The trees in the sholas form a continuous canopy usually not exceeding 10-15m. There is no marked differentiation into canopy layers. The tree bark is covered with lichens, orchids, mosses and climbers. The crowns are generally rounded and dense. Common tree species in the shola forests are *Pithecellobium subcoriaceum*, *Ixorantoniana*, *Syzygium arnottianum*, *Ilex denticulata*, *I. wightiana*, *Michaelia nilagirica*, *Elaeocarpus recurvatus*, *Microtropis ramiflora*, *Actinodaphne bourdellonii*, and *Symplocos pendula*.

The edges of the shola are marked by trees such as *Rhododendron arboreum* var. *nilagiricum*, *Ternstroemia japonica*, *Ligustrum perrottettii*, *Turpinia cochinchinensis*, *Mahonia leshenaultii*, *Rhodomyrtus tomentosa*, *Berberis tinctoria*, *Vaccinium neilgherrense* etc. and herbs and shrubs include *Gaultheria fragrantissima*, *Moonia heterophylla*, *Jasminum bignoneacium*, *Smithia blanda*, *Valeriana hookeriana* and a few species of *Strobilanthes*. The undergrowth in the shola is represented by *Strobilanthes* sp., *Impatiens phoenicea*, *I. coelotropis*, *Psychotria congesta*, *Viola patrinii*, *V. serpens*, *Asplenium* sp., and

Arundinaria densifolia. Epiphytic orchids in the sholas include *Aerides ringens*, *Coelogyne nervosa*, *C. mossiae*, *Eria dalzelli*, *E. pauciflora*, and *Schoenorchis filiformis*. The common climbers are *Piper schmidtii*, *Rubia cordifolia*, and *Connarus wightii*. *Rapanea capillata*, *Vaccinium leschenaultii*, *Impatiens tangachee*, *Sonerila grandiflora*, *Osmunda regalis* and *Eurya japonica* are usually found along streams. Broad-leaved forests are found on the slopes descending from the plateau. The dominant tree species found in the broad-leaved forests are *Pittosporum tetraspermum*,

Elaeocarpus munroii, *Apollonias arnotti*, *Symplocos spicata*, *Gomphandra coriacea*, *Garcinia gummi-gutta*, *Litsea coreacea*, *Prunus ceylanica* and *Photinia notoniana*. Major shrubs include *Begonia subpeltata*, *Osbeckia lineolata*, *Polygala arillata*, *Strobilanthes homotropus*, *Maesa perrottetiana* etc.

3.1.7.3 Grass lands: About 80% of the park is occupied by grasslands. They cover the plateau and descending slopes. Three hundred and eight species are recorded from the grasslands out of which 51 are endemic to the montane grasslands of the Western Ghats. The major grass species in the grasslands are *Andropogon lividus*, *Arundinella vaginata*, *Digitaria wallichiana* and *Arundinella mesophylla*. *Chrysopogon zeylanicus* and *Sehima nervosum* dominate these plateau and slopes, whereas in the cattle grazed areas, unpalatable *Cymbopogon flexuosus* is frequent. *Chrysopogon zeylanicus* the dominant grass species is found at Rajamala, down slopes of Anamudi and Poovar. *Sehima nervosum* community is more prevalent throughout the plateau. Moist valleys are characterized by *Garnotia* sps. Other dominant grasses are *Eulalia phaeothrix*, *Andropogon lividus*, *Arundinella purpurea*, *Agrostis peninsularis*, *Ischaemum indicum*, *Heteropogon contortus* and *Tripogon bromodius*. The common herbs and shrubs in the grasslands include *Anaphalis lawii*, *A. bourneii*, *A. meeboldii*, *Swertia corymbosa*, *Polygala japonica*, *Curculigo orchioides*, *Micromeria biflora*, *Bupleurum distichophyllum*, *Crotalaria fysonii*, *C. ovalifolia*, *Ranunculus reniformis*, *Hedyotis swertioides*, *Senecio lavandulaefolius*, *Parnassia mysorensis*, *Pedicularis zeylanica*, *Wahlenbergia gracilifolia*, *Impatiens pandata*, *I. modesta*,

Phlebophyllum kunthianum, *Hypericum mysorense*, *Pteridium aquilinum*, *Ageratina adenophora*, *Gaultheria fragrantissima* etc. The water logged areas are dominated by species such as *Eriocaulon robustum*, *E. collinum*, and *E. geofreyii*. The summit of the Anaimudi is vegetated with patches of stunted *Arundinaria densifolia* and *Gaultheria fragrantissima* (wintergreen), *Anaphalis* sp., *Impatiens* and some species of *Eriocaulon*.

3.1.7.4 Shrub lands: The shrub lands in the park form a stable vegetative association occurring on steep slopes below cliffs and interspersed among rock slabs. The dominant shrub present on the bouldery slopes is *Strobilanthes kunthiana*, (*Neelakurinji*). This endemic species blooms once in twelve years. Other species include *Ageratinaadenophora*, *Gaultheria fragrantissima*, *Hypericum mysorense* etc. Shrubby species predominate near tea estates and bouldery slopes.

3.1.7.5 Deciduous forests: A small portion on the eastern periphery of the Park lying close to Talliar estate has deciduous forests with trees like rosewood, *Pterocarpus* etc. The undergrowth is predominantly *Lantana*.

3.1.7.6 Tropical evergreen forests: On the western side of the Park where the hill forests merge into the Anaimudi Reserve, a small segment of the Park exhibits characteristics of tropical evergreen forests. The trees are tall and lofty with typical species like *Mesua ferrea*, *Cullenia excelsa* and *Palaquim ellipticum*.

In the present study, 77 quadrants of 10 X 10m distributed over 11 blocks were laid and recorded the parameters such as name of the plant species, girth at breast height, height of the plants, flowering status, canopy cover, ground cover and, presence of water body, liana and epiphytes.

3.1.8 VEGETATION ANALYSIS WITHIN THE STUDY LOCATIONS OF ERAVIKULAM NATIONAL PARK

The Important Value Index (IVI) of tree species were calculated from the quadrats laid out on the 11 study location. Tables 3-13 show the dominant trees in each block along with the values of Relative Basal Area, Relative Density, Relative Frequency and IVI.

Table. 3 Dominant trees of Naikkollimala block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	7.14	9.09	41.32	57.55
<i>Syzygium arnottianum</i>	11.90	7.58	9.88	29.36
<i>Albizzia sp</i>	5.95	4.55	3.40	13.90
<i>Macaranga peltata</i>	3.57	4.55	3.66	11.77
<i>Garcinia gummi-gutta</i>	3.57	4.55	3.54	11.66
<i>Schefflera sp</i>	1.19	1.52	8.43	11.14
<i>Pithecellobium subcoriaceum</i>	4.76	3.03	2.06	9.85
<i>Elaeocarpus recurvatus</i>	3.57	4.55	1.72	9.84
<i>Ixora notoniana</i>	3.57	4.55	1.26	9.38
<i>Symplocos pendula</i>	3.57	4.55	1.25	9.36

Ficus drupacea was found to be the species with highest IVI in Naikkollimala block. It was followed by *Syzygium arnottianum*, *Albizzia sp*, *Macaranga peltata* etc. Figure. 1 shows the graphical representation of the same.

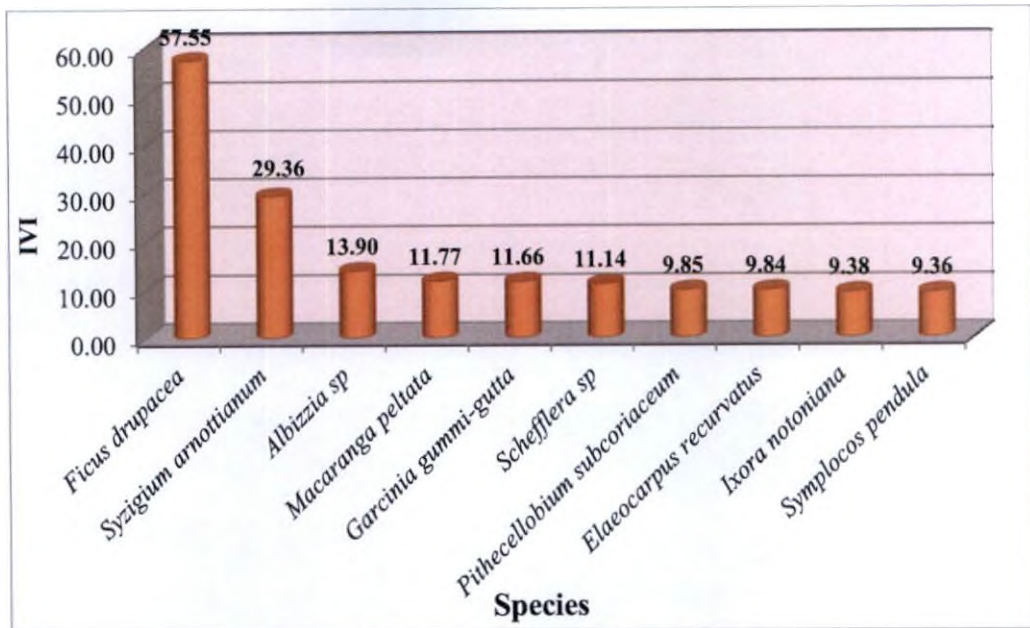


Fig. 1 Trees with most IVI in Naikkollimala block in Eravikulam National Park

Table. 4 Dominant trees of Meenthotty block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	2.74	3.17	29.59	35.51
<i>Cinnamomum wightii</i>	12.33	9.52	0.55	22.40
<i>Syzigium arnottianum</i>	2.74	3.17	8.15	14.06
<i>Gomphandra coriacea</i>	5.48	4.76	0.82	11.06
<i>Mahonia leschenaultii</i>	5.48	4.76	0.65	10.90
<i>Ixora notoniana</i>	4.11	4.76	1.69	10.56
<i>Elaeocarpus recurvatus</i>	2.74	3.17	4.29	10.20
<i>Garcinia gummi-gutta</i>	5.48	3.17	1.23	9.88
<i>Actinodaphne bourdillonii</i>	2.74	3.17	3.70	9.61
<i>Dodonea viscosa</i>	4.11	3.17	1.73	9.01

In Meenthotty block also *Ficus drupacea* was the most dominant followed by *Cinnamomum wightii* and *Syzygium arnottianum* (Table. 4). The same is graphically represented in Figure 2.

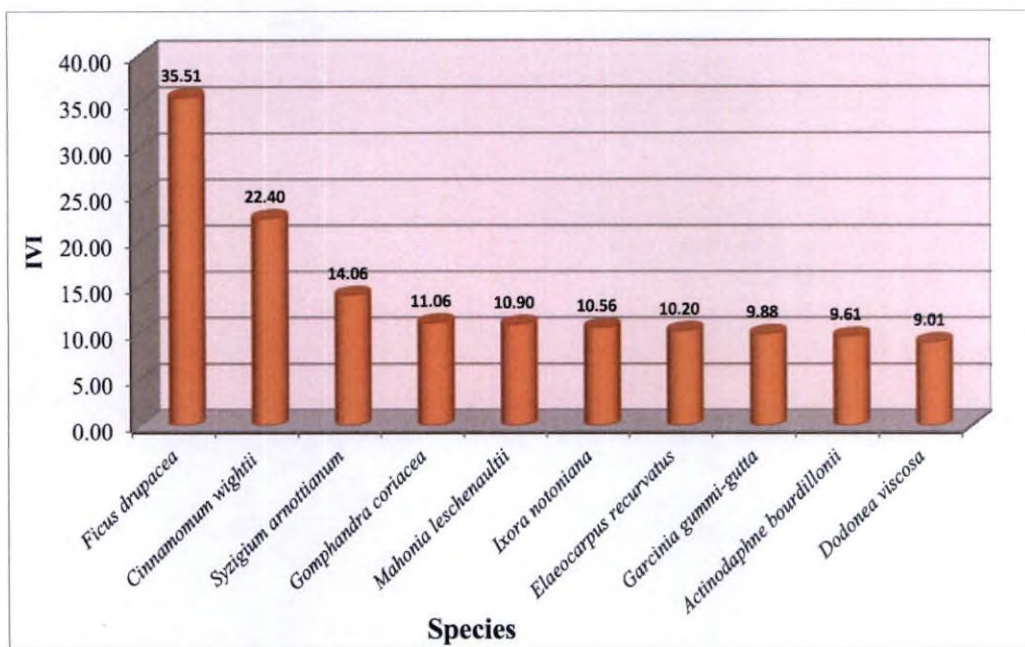


Fig. 2 Trees with most IVI in Meenthotty block in Eravikulam National Park

Table. 5 Dominant trees of Anamudi block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	12.70	7.27	31.42	51.39
<i>Syzygium arnottianum</i>	9.52	7.27	15.04	31.84
<i>Cinnamomum wightii</i>	11.11	10.91	0.34	22.36
<i>Ixora wightiana</i>	1.59	1.82	10.38	13.78
<i>Turpinia cochinchinensis</i>	4.76	5.45	1.20	11.42
<i>Elaeocarpus recurvatus</i>	1.59	1.82	8.01	11.41
<i>Myrsine wightiana</i>	4.76	5.45	0.71	10.92

<i>Syzygium densiflorum</i>	1.59	1.82	7.40	10.81
<i>Pithecellobium subcoriaceum</i>	3.17	3.64	2.22	9.03
<i>Rhododendron nilagiricum</i>	4.76	3.64	0.19	8.59

Ficus drupacea, *Syzygium arnottianum*, *Cinnamomum wightii* and *Ixora wightiana* were the dominant tree species in Anamudi block (Table. 5). Figure 3 is the graphical representation of the same.

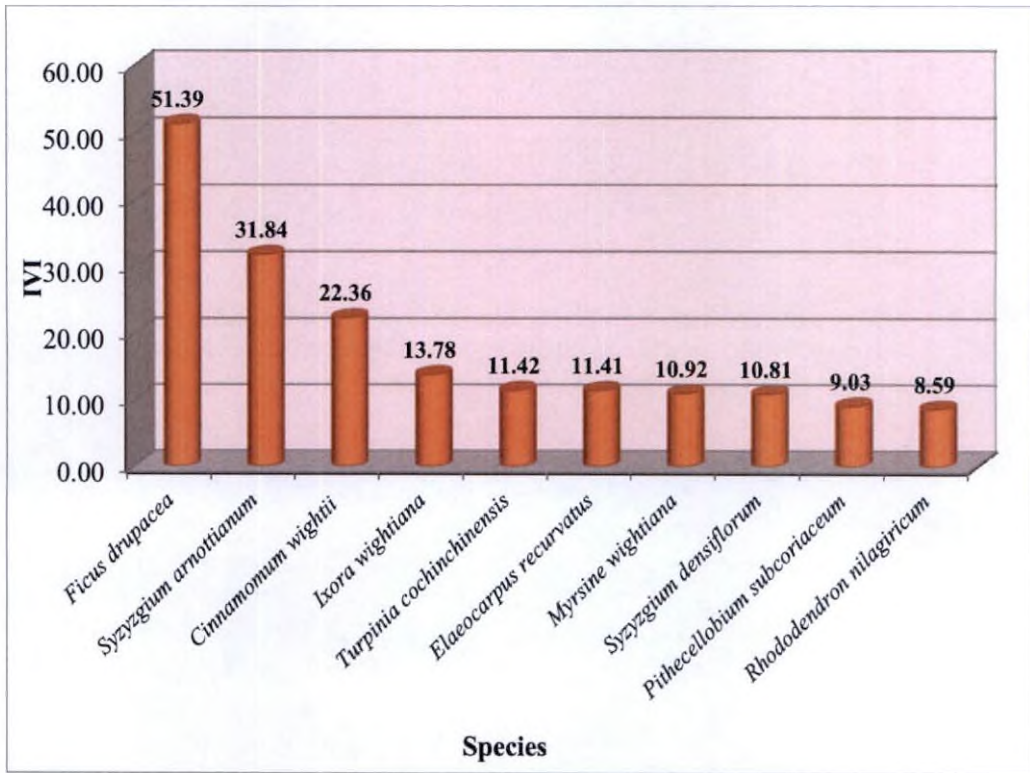


Fig. 3 Trees with most IVI in Anamudi block in Eravikulam National Park

Table. 6 shows the dominant trees of Lakkomkudy block with Relative Basal Area, Relative Density, Relative Frequency and IVI and Figure. 4 show the graphical representation of dominant trees with their corresponding IVI. Here also *Ficus spp* and *Syzygium spp* are the most dominant trees followed by *Michaelia nilagirica* and *Cinnamomum wightii*.

Table. 6 Dominant trees of Lakkomkudy block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	8.16	4.76	52.39	65.31
<i>Syzigium arnottianum</i>	18.37	14.29	10.42	43.08
<i>Michaelia nilagirica</i>	10.20	11.90	1.83	23.94
<i>Cinnamomum wightii</i>	10.20	9.52	0.38	20.11
<i>Actinodaphne bourdillonii</i>	6.12	7.14	3.19	16.46
<i>Litsea coriacea</i>	6.12	7.14	1.65	14.91
<i>Elaeocarpus recurvatus</i>	2.04	2.38	7.83	12.25
<i>Symplocos pendula</i>	6.12	4.76	0.58	11.46
<i>Ilex denticulata</i>	4.08	4.76	2.24	11.08
<i>Garcinia gummi-gutta</i>	4.08	4.76	1.75	10.60

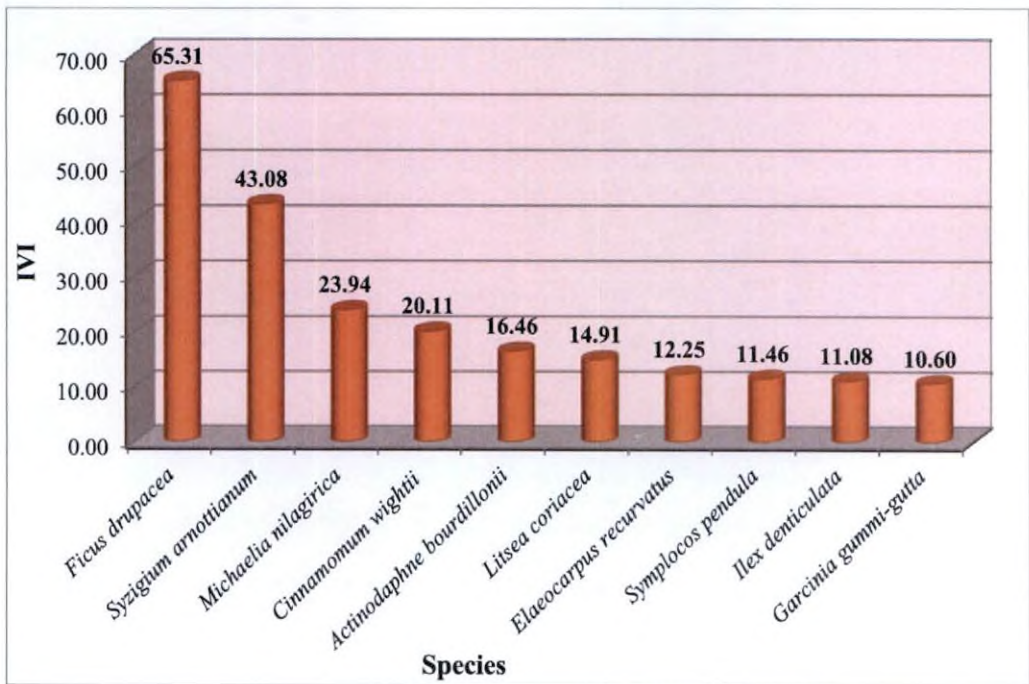


Fig. 4 Trees with most IVI in Lakkomkudy block in Eravikulam National Park

Table. 7 Dominant trees of Thirumudi block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	1.67	1.75	55.95	59.37
<i>Syzigium arnottianum</i>	8.33	7.02	8.86	24.21
<i>Pithecellobium subcoriaceum</i>	10.00	8.77	2.85	21.62
<i>Litsea coriacea</i>	6.67	7.02	3.39	17.08
<i>Microtropis ramiflora</i>	6.67	7.02	1.41	15.10
<i>Cinnamomum wightii</i>	6.67	7.02	1.27	14.95
<i>Cryptocaria neilgherrensis</i>	6.67	7.02	0.91	14.60
<i>Symplocos pendula</i>	5.00	5.26	0.92	11.19
<i>Elaeocarpus recurvatus</i>	3.33	3.51	2.48	9.32
<i>Gomphandra coriacea</i>	3.33	3.51	1.83	8.67

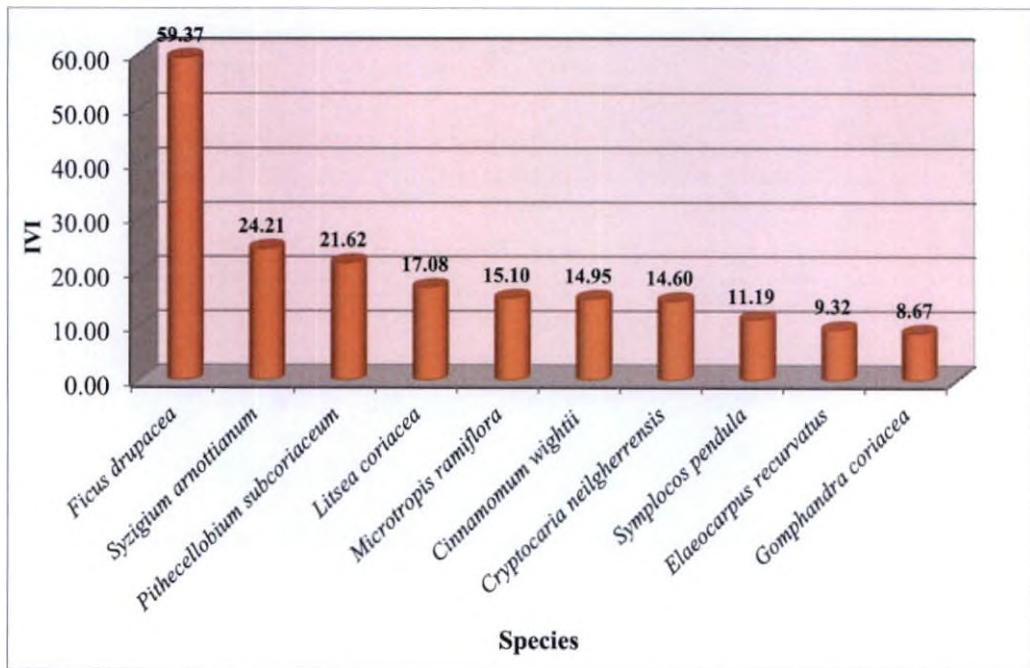


Fig. 5 Trees with most IVI in Thirumudi block in Eravikulam National Park

Ficus drupacea, *Syzigium arnottianum*, *Pithecellobium subcoriaceum* and *Litsea coriacea* are the dominant trees in Thirumudi block (Table. 7, Figure. 5)

Table. 8 Dominant trees of Perumalmala block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Ficus drupacea</i>	4.00	2.99	41.98	48.96
<i>Syzigium arnottianum</i>	2.67	2.99	13.67	19.32
<i>Pithecellobium subcoriaceum</i>	6.67	7.46	2.40	16.53
<i>Actinodaphne bourdillonii</i>	5.33	4.48	5.05	14.86
<i>Mahonia leschenaultii</i>	8.00	5.97	0.54	14.51
<i>Elaeocarpus recurvatus</i>	5.33	5.97	2.53	13.83
<i>Ixora notoniana</i>	5.33	5.97	0.77	12.08
<i>Cinnamomum wightii</i>	5.33	4.48	0.25	10.07
<i>Pittosporum tetraspermum</i>	4.00	2.99	2.55	9.53
<i>Isonandra perrottetina</i>	4.00	4.48	0.77	9.25

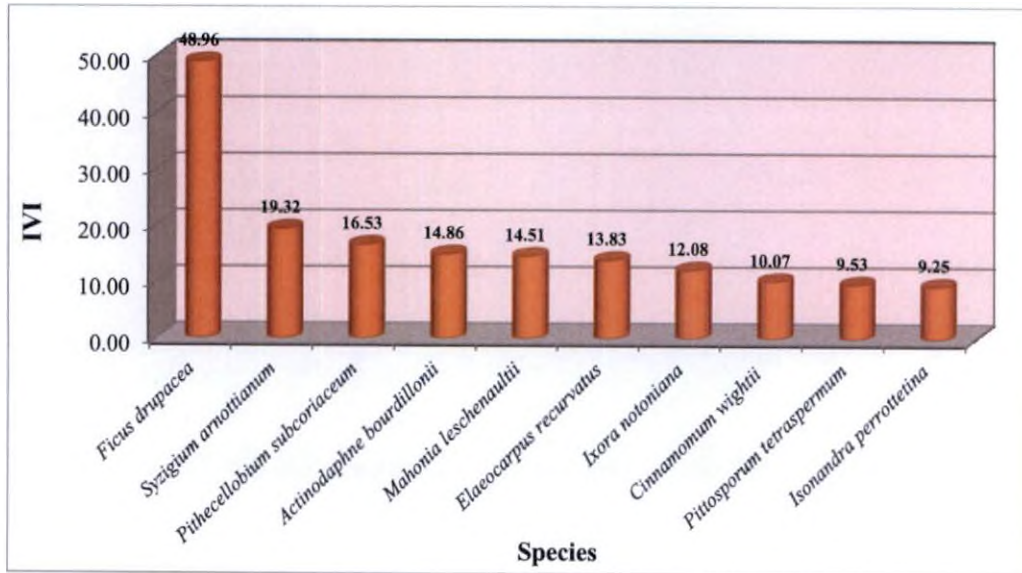


Fig. 6 Trees with most IVI in Perumalmala block in Eravikulam National Park

In Perumalmala also *Ficus drupacea* and *Syzygium arnottianum* were dominating among the tree species followed by *Pithecellobium subcoriaceum* and *Actinodaphne bourdillonii* (Table. 8, Figure. 6).

In Vembanthanny block *Pithecellobium subcoriaceum* was the most dominant tree species followed by *Cinnamomum wightii*, *Maesa indica*, *Syzygium arnottianum* and *Michaelia nilagirica* (Table. 9). Figure. 7 is the graphical representation of the same.

Table. 9 Dominant trees of Vembanthanny block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Pithecellobium subcoriaceum</i>	7.02	8.51	11.05	26.58
<i>Cinnamomum wightii</i>	8.77	10.64	6.87	26.28
<i>Maesa indica</i>	1.75	2.13	17.15	21.04
<i>Syzygium arnottianum</i>	12.28	4.26	4.23	20.77
<i>Michaelia nilagirica</i>	7.02	8.51	2.83	18.36
<i>Litsea coriacea</i>	1.75	2.13	13.03	16.91
<i>Ixora notoniana</i>	1.75	2.13	13.03	16.91
<i>Elaeocarpus recurvatus</i>	8.77	6.38	1.69	16.84
<i>Gaultheria fragrantissima</i>	7.02	6.38	2.03	15.43
<i>Ilex denticulata</i>	7.02	6.38	1.82	15.22

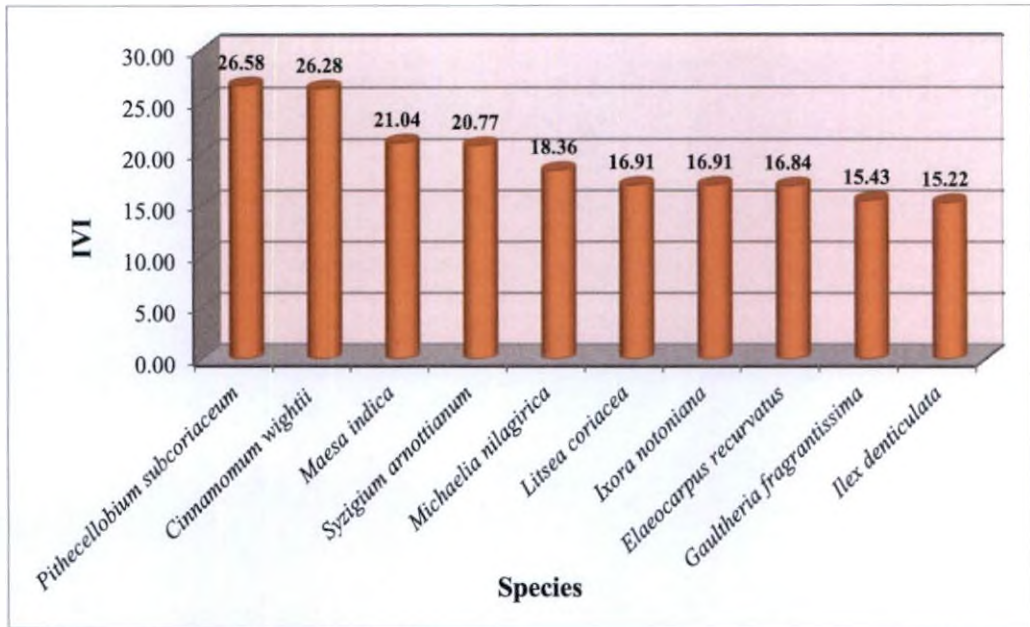


Fig. 7 Trees with most IVI in Vembanthanny block in Eravikulam National Park

Table. 10 Dominant trees of Poovar block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Syzgium arnottianum</i>	10.77	6.78	27.46	45.01
<i>Litsea coriacea</i>	4.62	5.08	11.34	21.04
<i>Pithecellobium subcoriaceum</i>	6.15	6.78	7.31	20.24
<i>Symplocos spicata</i>	7.69	6.78	2.55	17.02
<i>Elaeocarpus recurvatus</i>	6.15	6.78	3.26	16.19
<i>Vaccinium neilgherrense</i>	6.15	6.78	1.39	14.33
<i>Pittosporum tetraspermum</i>	4.62	5.08	4.31	14.02
<i>Elaeocarpus munroii</i>	1.54	1.69	9.42	12.65
<i>Gomphandra coriacea</i>	6.15	3.39	1.81	11.35
<i>Gaultheria fragrantissima</i>	4.62	5.08	0.92	10.62

Syzgium arnottianum was found to be the most dominant tree species in Poovar block followed by *Litsea coriacea* and *Pithecellobium subcoriaceum* (Table. 10).

Figure. 8 shows the graphical demonstration of the most dominant trees of Poovar block in ENP.

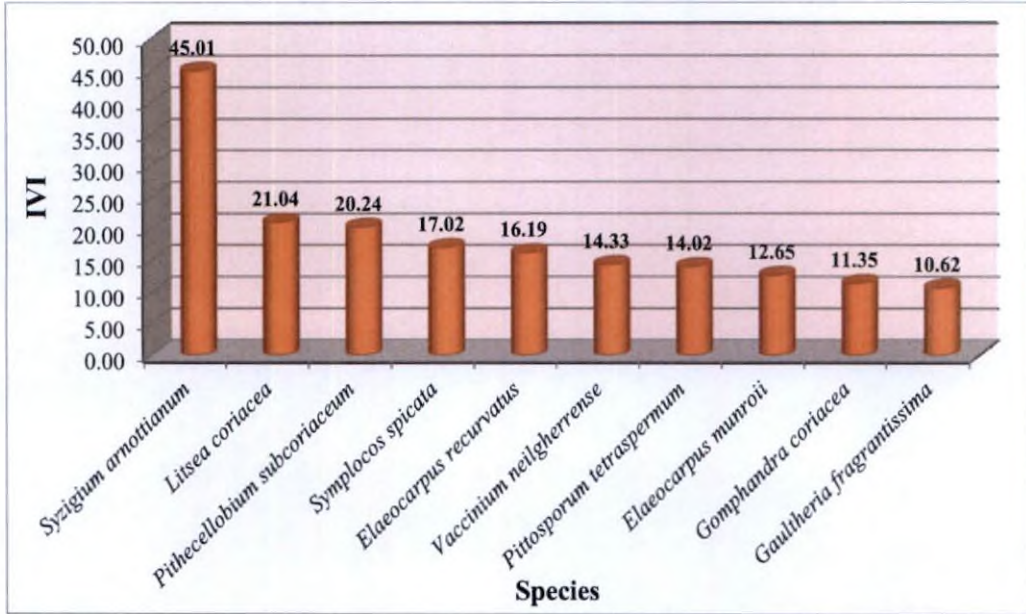


Fig. 8 Trees with most IVI in Poovar block in Eravikulam National Park

Table. 11 Dominant trees of Kumarikkal block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Syzygium arnottianum</i>	4.82	4.29	12.96	22.06
<i>Syzygium lanceolatum</i>	7.23	7.14	5.64	20.01
<i>Pittosporum tetraspermum</i>	7.23	7.14	5.61	19.99
<i>Pithecellobium subcoriaceum</i>	9.64	7.14	2.70	19.48
<i>Litsea coriacea</i>	6.02	7.14	6.06	19.22
<i>Ficus drupacea</i>	1.20	1.43	15.45	18.08
<i>Michaelia nilagirica</i>	4.82	5.71	3.93	14.47
<i>Xantolis tomentosa</i>	1.20	1.43	9.98	12.61
<i>Euonymus crenulatus</i>	4.82	5.71	1.15	11.69
<i>Symplocos pendula</i>	4.82	5.71	0.95	11.48

Syzigium arnotianum and *Syzygium lanceolatum* are the two most dominant species in Kumarikkal block followed by *Pittosporum tetraspermum* and *Pithecellobium subcoriaceum* (Table. 11, Figure. 9)

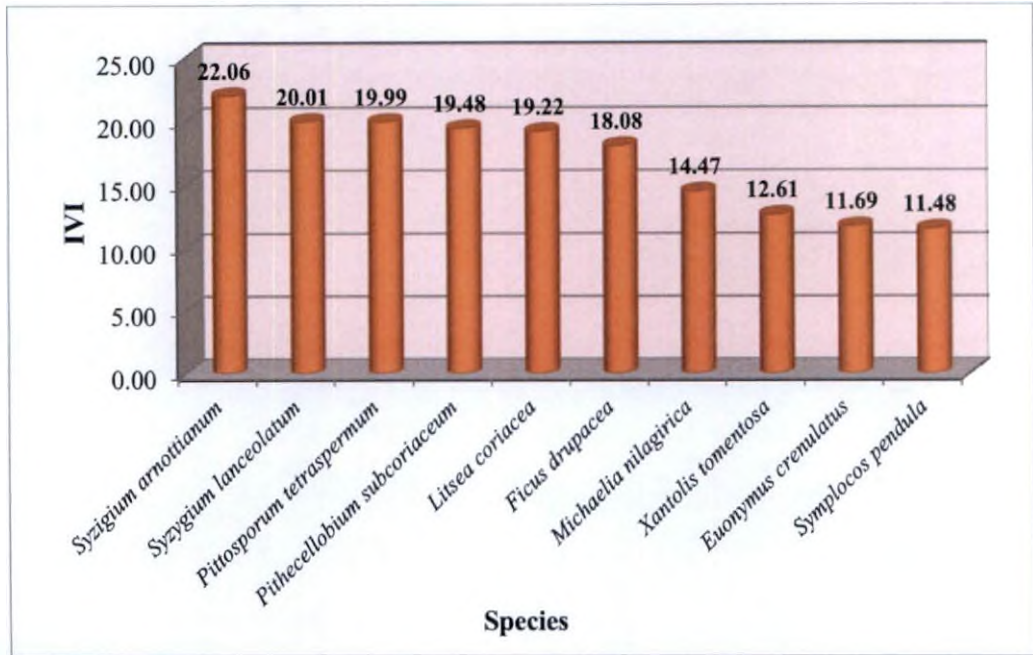


Fig. 9 Trees with most IVI in Kumarikkal block in Eravikulam National Park

Table. 12 Dominant trees of Kolukkan block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Microtropis ramiflora</i>	11.43	10.17	2.01	23.61
<i>Pithecellobium subcoriaceum</i>	11.43	8.47	3.22	23.12
<i>Elaeocarpus recurvatus</i>	5.71	6.78	8.28	20.77
<i>Actinodaphne bourdillonii</i>	8.57	8.47	3.26	20.30
<i>Ficus drupacea</i>	1.43	1.69	14.55	17.68
<i>Cinnamomum wightii</i>	8.57	6.78	1.34	16.69
<i>Syzigium arnotianum</i>	1.43	1.69	12.42	15.54
<i>Ilex denticulata</i>	5.71	6.78	2.56	15.06

<i>Ixora notoniana</i>	5.71	6.78	0.88	13.37
<i>Prunus ceylanica</i>	1.43	1.69	10.04	13.16

Microtropis ramiflora and *Pithecellobium subcoriaceum* are the two most dominant tree species found in Kolukkan block. *Elaeocarpus recurvatus*, *Actinodaphne bourdillonii* and *Ficus drupacea* are the other dominant trees (Table 12, Figure 10).

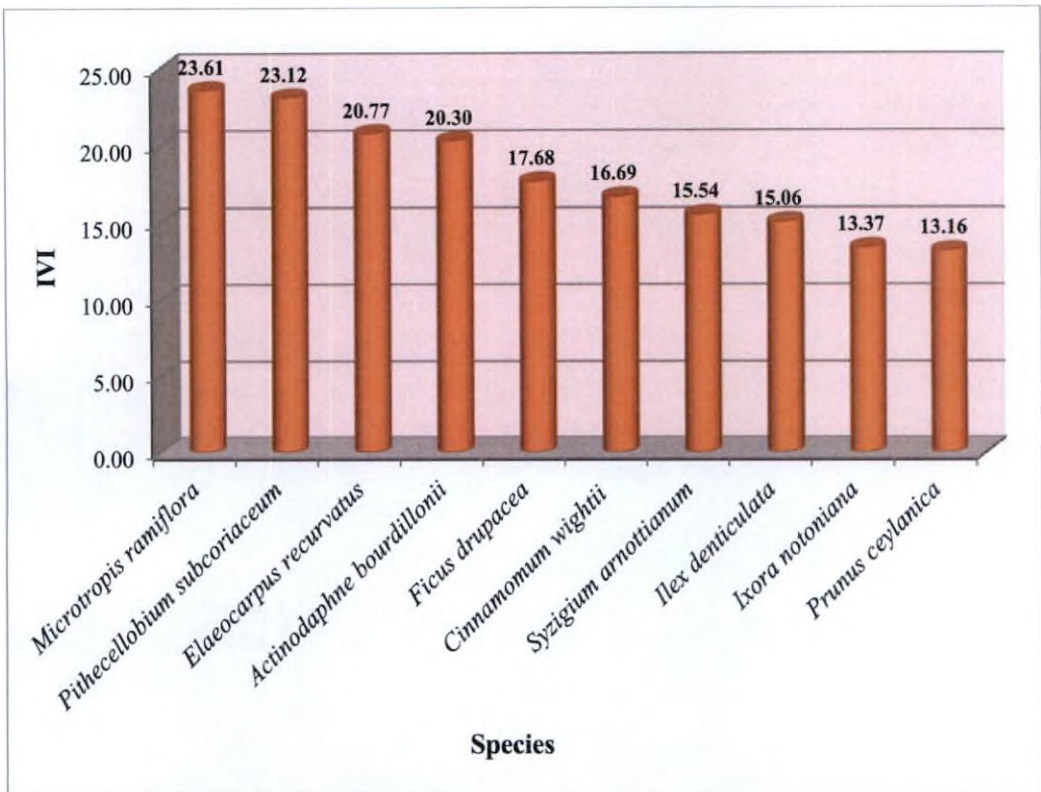


Fig. 10 Trees with most IVI in Kolukkan block in Eravikulam National Park

In Erumapetti block, *Gomphandra coriacea*, *Actinodaphne bourdillonii* and *Pithecellobium subcoriaceum* were the most dominant trees followed by *Elaeocarpus recurvatus* and *Pittosporum tetraspermum* (Table. 13, Figure. 11).

Table. 13 Dominant trees of Erumapetti block of Eravikulam National Park

Species	Relative Density	Relative Frequency	Relative Basal Area	IVI
<i>Gomphandra coriacea</i>	1.41	1.49	22.09	24.99
<i>Actinodaphne bourdillonii</i>	8.45	7.46	7.15	23.06
<i>Pithecellobium subcoriaceum</i>	9.86	8.96	2.58	21.39
<i>Elaeocarpus recurvatus</i>	7.04	7.46	2.31	16.81
<i>Pittosporum tetraspermum</i>	4.23	4.48	7.30	16.00
<i>Syzygium densiflorum</i>	4.23	4.48	7.12	15.82
<i>Microtropis ramiflora</i>	5.63	5.97	2.14	13.75
<i>Neolitsea foliosa</i>	5.63	5.97	1.32	12.93
<i>Prunus ceylanica</i>	1.41	1.49	9.19	12.09
<i>Olea paniculata</i>	4.23	4.48	3.30	12.00

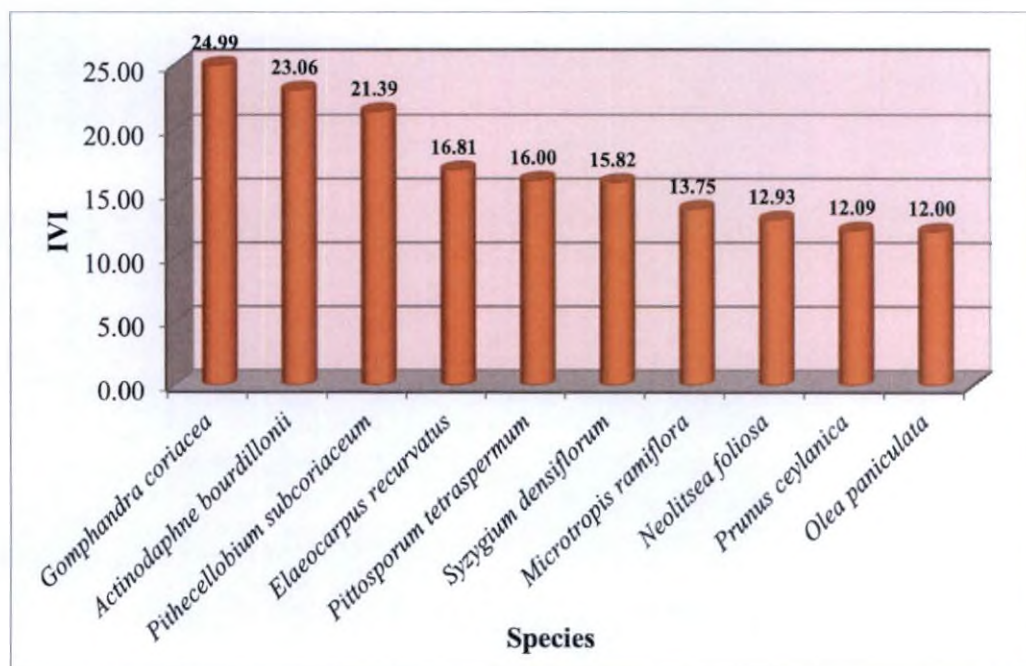


Fig. 11 Trees with most IVI in Erumapetti block in Eravikulam National Park

3.1.9 Fauna

A total of 49 species of mammals, 33 species of reptiles, 22 species of amphibians and 101 species of butterflies have been reported from ENP (Management Plan, 2012).

3.1.9.1 **Mammals:** There are 49 species of mammals recorded from the Park, including the Nilgiri Tahr, Nilgiri Marten, Clawless Otter, etc. (Management Plan, 2012).

3.1.9.2 **Reptiles:** 33 species of reptiles which include five species of lizards and eight species of snakes are reported (Management Plan, 2012).

3.1.9.3 **Amphibians:** A total number of 22 species of amphibians are reported from the Park of which 17 are endemic to Western Ghats (Management Plan, 2012).

3.1.9.4 **Butterflies:** A total number 101 species of butterflies have been identified in the Eravikulam National Park of which 11 are endemic to Western Ghats (Management Plan, 2012).

3.1.10 Administrative Blocks

The whole area of the National Park is divided into thirteen administrative blocks for the purpose of effective management and conservation of Nilgiri Tahr *Nilgiritragus hylocrius*. These administrative blocks were also used in the present study for data collection. The list of the thirteen administrative blocks is given in Table 14.

Table. 14. Administrative blocks in Eravikulam National Park

Block No.	Name of the block
1	Naikkollimala
2	Meenthotty
3	Anamudi
4	Karikkombumala
5	Kolukkan
6	Erumamala
7	Eravikulam
8	Perumalmala
9	Thirumala/ Thirumudi
10	Lakkomkudy
11	Vembanthanny
12	Kumarikkal
13	Poovar

Figure. 12 show the location map of Munnar Wildlife Division along with the boundaries of Eravikulam National Park and Figure. 13 show the outline map of Eravikulam National Park with its thirteen blocks.



Fig. 12 Location Map of Munnar Wildlife Division



Fig. 13 Outline map of Eravikulam National Park

3.2. METHODS

3.2.1. Period of observation

Reconnaissance of the study area was done during September 2014. And the intensive field study was done from September 2014 to March 2015. The whole study period was divided into two broad seasons such as rainy season (September to December) and non-rainy season (January to March). We spent at least five days each in each of the 13 blocks of the National Park.

3.2.2. Site Selection

A random walk was carried out in each of the survey blocks to identify potential activity sites of small carnivores. The evidences taken in to consideration were scats, spraints, pugmarks etc. Two methods were used to study the small carnivores in ENP such as camera trapping and line transect survey for direct and indirect evidence, which are detailed below.

3.2.3. Camera Trap Survey

Camera trapping is one of the best methods to study the small carnivores. Digital scout cameras having passive infra-red sensors for heat and motion detection (Bushnell Trophy Cam model no. 119436 and Cuddeback Attack model 1149) were used for this survey (Plate. 3). Overall 171 trapping stations were identified based on the presence of the indirect evidences of the small carnivores (Mudappa *et al.*, 2007). The camera traps were set at a height of 30-40cm above the ground and 150m apart from each other (Plate. 4). The cameras were set up in default mode with the time-delay of 10 seconds between pictures. The camera trap locations were recorded with a Garmin GPS etrex 30. The cameras were kept open for 24 hours a day. The date and time of exposure were automatically recorded by the camera on the images, as and when the images were taken. At each trapping stations, cameras were opened for 5 days each. Thus a total of 855 camera-trap days with 20,520 trapping hours were carried out in the Eravikulam National Park.



CUDDEBACK ATTACK



BUSHNELL TROPHY CAM

Plate 3. Camera traps used for the study



Fixing camera trap in *shola* forests



Camera trap in the field

Plate 4. Setting up of camera traps

3.2.4. Line transect survey for both direct and indirect evidences

Transects of 1 kilometer length were laid in different habitat. The length of each transect were measured using GPS. A total of 65 transects were laid covering a length of 65km. A single transect run through more than one vegetation type. All the transects were walked at least once and most of them repeated. During the transect walk, the indirect evidences primarily the scats of the small carnivores were recorded. Direct sightings if any were also noted. The data collected through this method were used for estimating encounter rate of the different species of small carnivores. The scats were identified to the small carnivore group such as civet, mongoose, cat etc. or to the species level using Su (2005).

3.3 DATA ANALYSIS

The diversity of a species can be expressed by various indices. In the present study, the species richness, species diversity and relative abundance were estimated. The details on the indices used for expressing the species richness, diversity, abundance, similarity and habitat use are detailed below.

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

$$\lambda = \sum p_i^2$$

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

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

Where, $i = 1, 2, 3, 4, \dots, S$, 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. Simpson's 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 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

$$H' = \sum (p_i \cdot \ln p_i)$$

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

3.3.3 Estimation of Abundance

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

3.3.3.1 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. 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.

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

3.3.4 Habitat Use Assessment

3.3.4.1 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 ENP. In this study, this index was used to analyze the habitat preference of small carnivores and porcupines since they gave only indirect evidences. The HUI is calculated by the formula given below.

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

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).

3.3.5 Statistical Analysis

Various statistical packages including the Microsoft Office Excel (Version 2007), SPSS (Version 20) and PAST (Hammer *et.al.* 2001) were used for statistical analysis of the data collected.

Results

RESULTS

4.1 SPECIES COMPOSITION OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

The present study at Eravikulam National Park recorded eight species of small carnivores represented in four families such as Viverridae, Herpestidae, Mustelidae and Felidae (small cats) (Table. 15). This comprises of two species each of herpestids, viverrids, felids and mustelids. Of these seven species, all have been captured in the camera traps except the Indian Grey Mongoose, which was only sighted from Naikkollimala (Table. 16).

Table. 15 Small carnivores recorded from Eravikulam National Park

Common Name	Scientific name	Family
1. Small Indian Civet	<i>Viverricula indica</i>	Viverridae
2. Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	
3. Indian Grey Mongoose	<i>Herpestes edwardsii</i>	Herpestidae
4. Stripe-necked Mongoose	<i>Herpestes vitticollis</i>	
5. Asian Small-clawed Otter	<i>Aonyx cinerea</i>	Mustelidae
6. Nilgiri Marten	<i>Martes gwatkinsii</i>	
7. Jungle Cat	<i>Felis chaus</i>	Felidae
8. Leopard Cat	<i>Prionailurus bengalensis</i>	



Plate 5. Jungle Cat *Felis chaus*



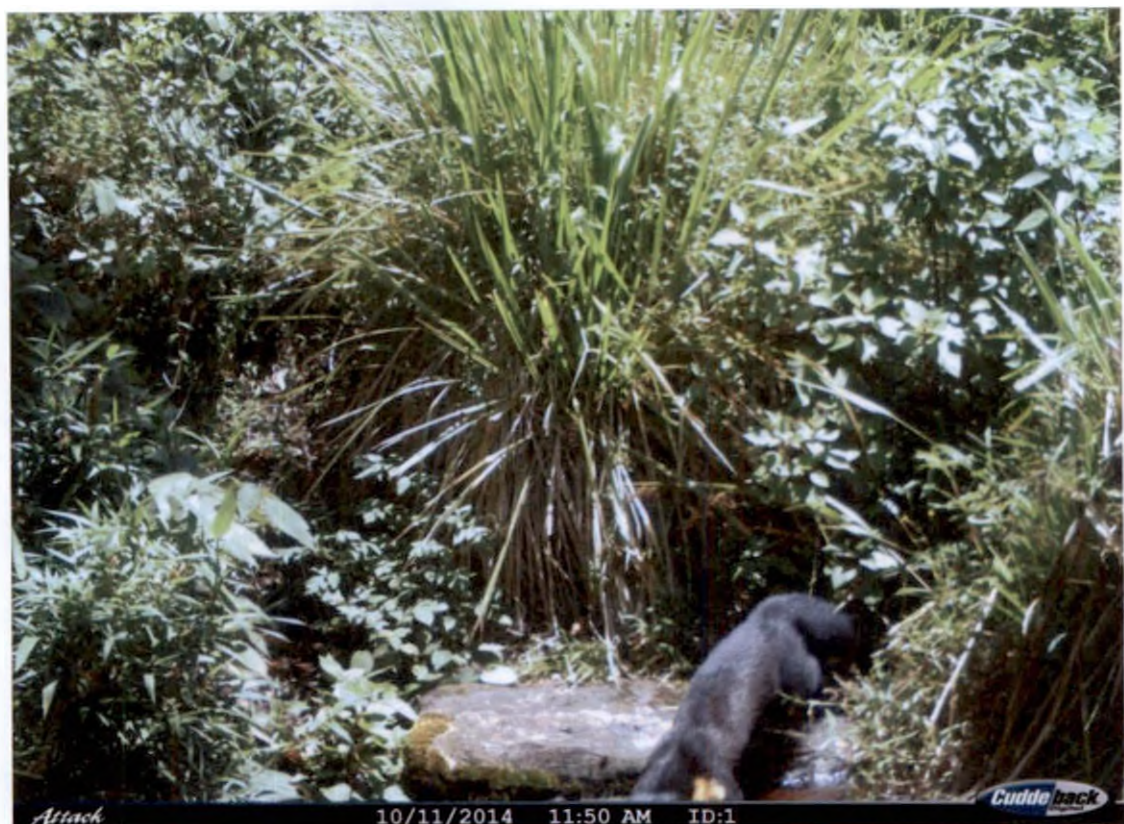
Plate 6. Leopard Cat *Prionailurus bengalensis*



Plate 7. Stripe-necked Mongoose *Herpestes vitticollis*



Plate 8. Asian small-clawed Otter *Aonyx cinerea*



Camera trapped picture of Nilgiri Marten *Martes gwatkinsii*



Plate 9. Nilgiri Marten *Martes gwatkinsii*

Table. 16 Evidences showing the presence of small carnivores in Eravikulam National Park

Evidences	CPC	SIC	GM	SM	JC	LC	ASO	NM
Camera trap	1	1	0	4	5	4	2	1
Day transect	0	0	1	2	0	0	0	1

CPC: Common Palm Civet; **SIC:** Small Indian Civet; **GM:** Grey Mongoose; **SM:** Stripe-necked Mongoose; **JC:** Jungle Cat; **LC:** Leopard Cat; **ASO:** Asian Small-clawed Otter; **NM:** Nilgiri Marten.

4.2 CAMERA-TRAPPING OF SMALL CARNIVORES AT ERAVIKULAM NATIONAL PARK

One hundred and seventy one trap stations were established in the Eravikulam National Park. The camera trap sampling was done for an effective total of 855 days, monitoring 20,520 hours. The details of the trapping effort in Eravikulam National Park are shown in Table 17.

Table.17 Camera trapping effort in various habitats of Eravikulam National Park

Sl. No.	Administrative Blocks of ENP	Trap effort (days)	
		Shola forest	Grasslands
1	Naikkollimala	65	10
2	Meenthotty	70	5
3	Anamudi	60	15
4	Lakkomkudy	70	5
5	Thirumudi	60	15
6	Perumalmala	55	20
7	Vembanthanny	55	20

8	Poovar	60	15
9	Kumarikkal	65	10
10	Kolukkan	55	20
11	Erumapetti	25	30
12	Eravikulam	20	30
13	Karikkombumala	0	0
	Total trap days	660	195
		855	

A total of 84 photographs of 17 mammal species and two bird species were obtained. Out of these, the carnivores accounted for 30 (35.7%) photographs, of which 60% were small carnivores in seven species. The most common species recorded was Jungle Cat *Felis chaus* (27.8%) followed by Leopard Cat *Prionailurus bengalensis* (22.2%), Stripe-necked Mongoose *Herpestes vitticollis* (22.2%) and Asian small-clawed Otter *Aonyx cinerea* (11.1%). The Nilgiri Marten *Martes gwatkinsii*, Common Palm Civet *Paradoxurus hermaphrodites* and Small Indian Civet *Viverricula indica* were captured only once (5.5%) in the camera traps during the study period. The camera trap data of small carnivores is given in Appendix II.

4.2.1 Success rate of camera traps in various locations in Eravikulam National Park

The camera trap success rates of small carnivores of ENP in various locations are presented in Table. 18. The overall small carnivore success rate is 2.1% (18 of 855 trap-days), capturing seven species of small carnivores. The camera capture success rate was highest at Thirumudi (0.46%) followed by Erumapetti (0.35%), Naikollimala, Anamudi, Lakkomkudy, Perumalmala and Kolukkan with 0.23% each. The graphical representation of camera trap success rate in terms of location and species are given in Figure. 14 and 15 respectively.

Table. 18 Success rate of small carnivore detections in camera traps at Eravikulam National Park

Block	Camera trap %							SR (%)
	SIC	CPC	SM	JC	LC	ASO	NM	
Naikkollimala	0.11	0.0	0.11	0.0	0.0	0.0	0.0	0.23
Meenthotty	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anamudi	0.0	0.0	0.11	0.0	0.0	0.11	0.0	0.23
Lakkomkudy	0.0	0.0	0.0	0.0	0.23	0.0	0.0	0.23
Thirumudi	0.0	0.11	0.11	0.11	0.11	0.0	0.0	0.46
Perumalmala	0.0	0.0	0.0	0.11	0.0	0.0	0.11	0.23
Vembanthanny	0.0	0.0	0.0	0.0	0.0	0.11	0.0	0.11
Poovar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kumarikkal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kolukkan	0.0	0.0	0.0	0.11	0.11	0.0	0.0	0.23
Erumapetti	0.0	0.0	0.11	0.23	0.0	0.0	0.0	0.35
Eravikulam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.11	0.11	0.46	0.58	0.46	0.23	0.11	

SR: Success Rate; SIC: Small Indian Civet; CPC: Common Palm Civet; SM: Stripe-necked Mongoose; JC: Jungle Cat; LC: Leopard Cat; ASO: Asian Small-clawed Otter; NM: Nilgiri Marten

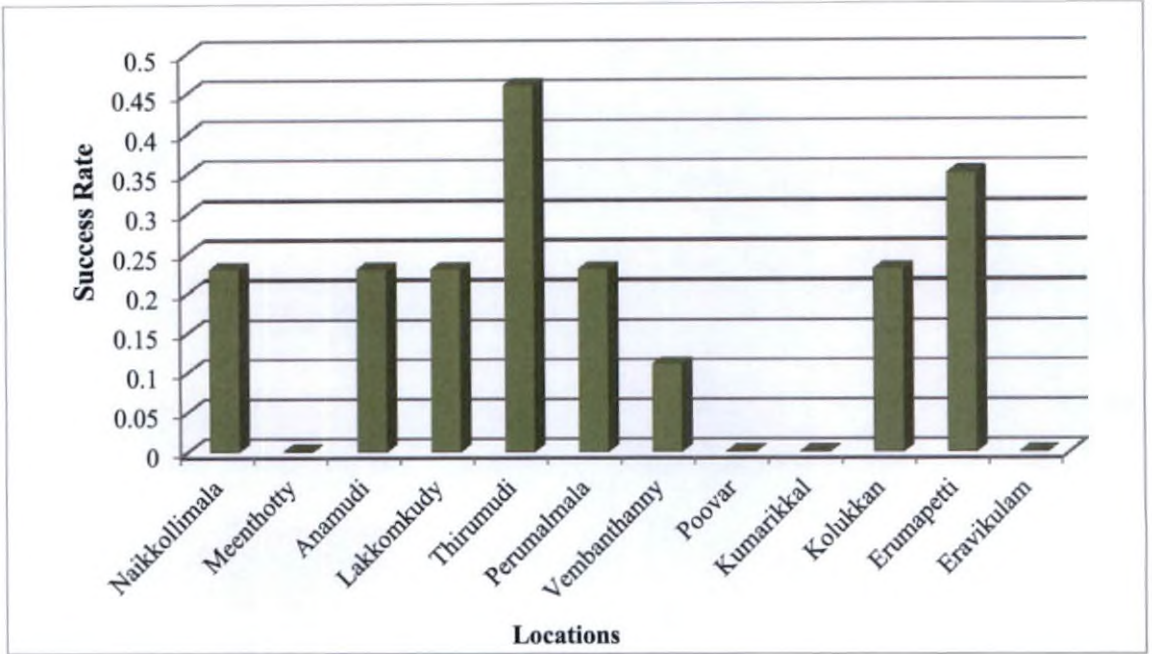


Fig. 14 Camera trap success rate in various study locations in Eravikulam National Park

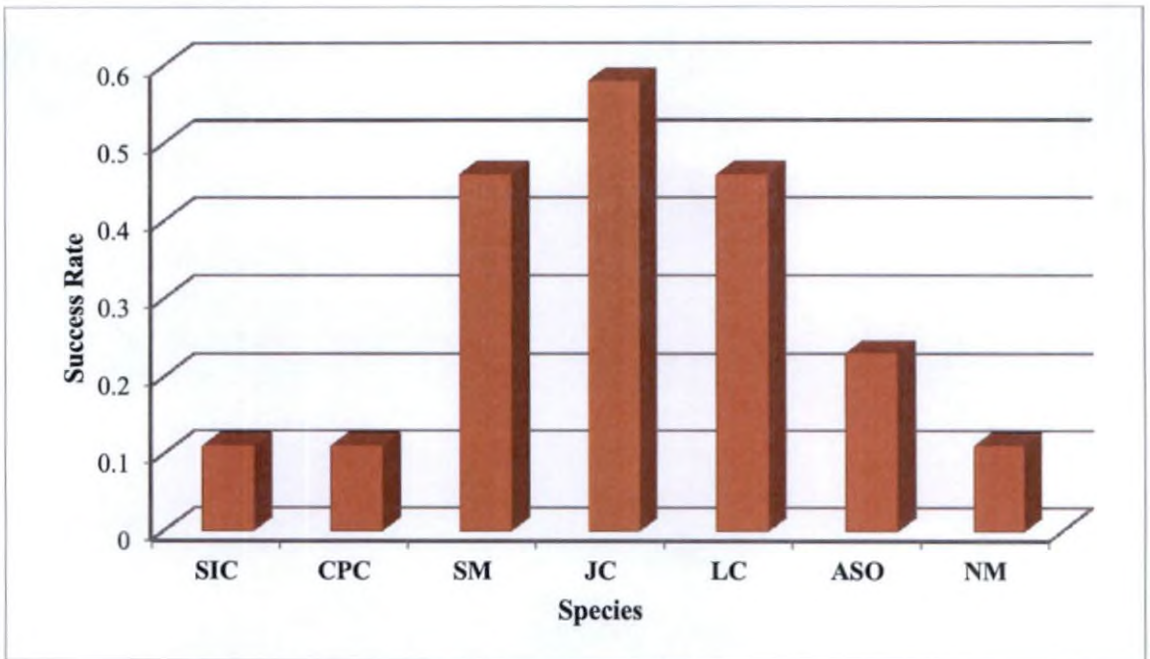


Fig. 15 Camera trap success rate of different small carnivore species in Eravikulam National Park

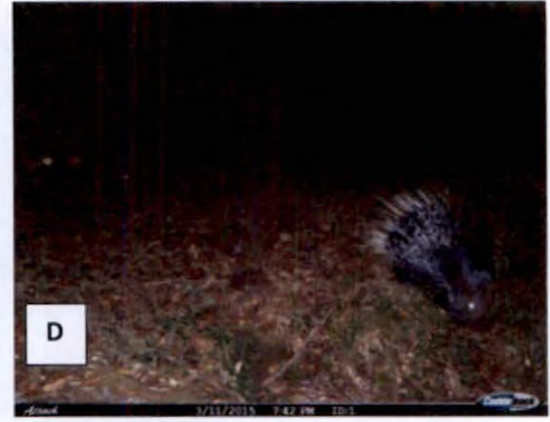
The camera traps also documented the presence of 10 other mammals such as Wild Dog *Cuon alpinus*, Asian Elephant *Elephas maximus*, Sambar Deer *Rusa unicolor*, Barking Deer *Muntiacus muntjak*, Mouse Deer *Moschiola indica*, Gaur *Bos gaurus*, Indian Crested Porcupine *Hystrix indica*, Bonnet Macaque *Macaca radiata*, Nilgiri Langur *Semnopithecus johnii* and an unidentified rodent species from the ENP. These species have accounted for the 67.8% of the camera trap pictures at the National Park. Table. 19 shows the camera trap success rate for other mammals form ENP.

Table. 19 Camera trap success rate of other mammals captured from Eravikulam National Park

SI No	Species	Camera Trap Success rate (%)
1	Barking Deer	2.1
2	Mouse Deer	2.1
3	Indian crested Porcupine	0.70
4	Sambar Deer	0.46
5	Asian Elephant	0.11
6	Gaur	0.11
7	Nilgiri Langur	0.11
8	Wild Dog	0.11
9	Bonnet Macaque	0.11
10	Unidentified rodent	0.11

4.2.2 Species richness and diversity of the Small Carnivores at Eravikulam National Park

The various diversity indices and species richness parameters such as number of taxa (S), number of individuals (n), Shannon-Weiner index (H), Simpson's index (1-D) and Margalef index (M) were estimated for the two seasons such as rainy season (September to December) and non-rainy season (January to March) (Table. 20). Rainy season showed greater species diversity and species richness when compared to non-rainy season, though it was statistically not significant.



A: Sambar Deer, B: Barking Deer, C: Nilgiri Langur , D: Indian crested Porcupine, E: Gaur, F: Mouse Deer

Plate 10. Camera trap images of other mammals from Eravikulam National Park

Table. 20 Species richness and diversity of the small carnivores of Eravikulam National Park

Indices	Rainy Season (Sept.-Dec.)	Non- rainySeason (Jan. - Mar.)
Taxa (S)	8	3
Individuals (n)	15	6
Shannon (H)	1.99	1.01
Simpson's (1-D)	0.85	0.61
Margalef (M)	2.59	1.12

Diversity indices for the two different habitats of ENP are given in Table. 21. During rainy season there is no significant difference in diversity and species richness between *shola* forests and grasslands whereas during non-rainy season grasslands showed greater diversity and species richness when compared to *shola* forests.

Table. 21 Species richness and diversity of the small carnivores in the different habitats in the rainy and non-rainy seasons at Eravikulam National Park.

Indices	Rainy		Non-rainy	
	SF	GR	SF	GR
Taxa (S)	5	5	1	2
Individuals (n)	7	8	1	5
Shannon (H)	1.55	1.56	0	0.67

Simpson (1-D)	0.76	0.78	0	0.48
Margalef's (M)	2.06	1.92	0	0.62

SF: *Shola* Forest, GR: Grassland

Student t-test was carried out to compare the diversity among the various habitats of ENP in rainy and non-rainy seasons (Table. 22). The t-value for comparing the diversities of rainy and non-rainy seasons was found to be non-significant at 0.05 levels.

Table. 22 T- values for the comparison of diversity in the different habitats in Eravikulam National Park in the rainy and non-rainy seasons

Habitats	Rainy Season		Non-rainy Season	
	<i>Shola</i> Forest	Grassland	<i>Shola</i> Forest	Grassland
<i>Shola</i> Forest	NA	0.284 ^{ns}	NA	0.487 ^{ns}
Grassland	0.284 ^{ns}	NA	0.487 ^{ns}	NA

ns: non-significant

4.3 INDIRECT EVIDENCES ON SMALL CARNIVORES OF ERAVIKULAM NATIONAL PARK

The day transects were done on the existing trails, forest roads and streams, searching for indirect evidences of small carnivores at ENP. A total of 65km was walked through the various habitats in search of the indirect evidences. One hundred and fifty three indirect evidences including 138 scats and 15 tracks pertaining to small carnivores were identified from the National Park. Appendix III provides the summary of indirect evidences recorded from transects in different vegetation types in ENP. Apart from the scats and sparints, the tracks of civets, mongoose, small cats and otters were also confirmed. The otter trailswere

collected from the stream beds. Pugmarks of other carnivores were also located from the ENP which included Leopard *Panthera pardus* and Wild Dog *Cuon alpinus*.

Among the 153 indirect evidences, 68 were of small cats (44.4%), 52 of civets (33.9%), 19 of mongoose (0.12%), 11 of otters (0.07%) and three of marten (0.01%).

Scat abundance (scats/kilometer) was calculated as a measure to represent the abundance of small carnivores in ENP. Scat abundance was greater for the small cats (1.04) followed by civets (0.80), mongoose (0.26), otters (0.17) and Nilgiri Marten (0.04) (Table. 23). The small cats were abundant in all the grasslands than in the *shola* forests. The least abundant group was the Nilgiri Marten. Abundance of civet is almost four times greater in the *shola* forests than the grasslands. Similarly, the abundance of mongoose is greater in the grassland when compared to the *shola* forests. The difference in abundance of otter between the two habitats are negligible. Figures. 16 and 17 show the relative abundance and abundance of small carnivores from indirect evidences in ENP.

Table. 23 Abundance (scat/kilometer) of small carnivores in Eravikulam National Park

Habitat	Civets	Mongoose	Otters	Small Cats	Nilgiri Marten
<i>Shola</i> Forest	0.64	0.10	0.09	0.14	0.04
Grassland	0.15	0.18	0.07	0.90	0.00
Total in theNP	0.80	0.26	0.17	1.04	0.04

NP: National Park

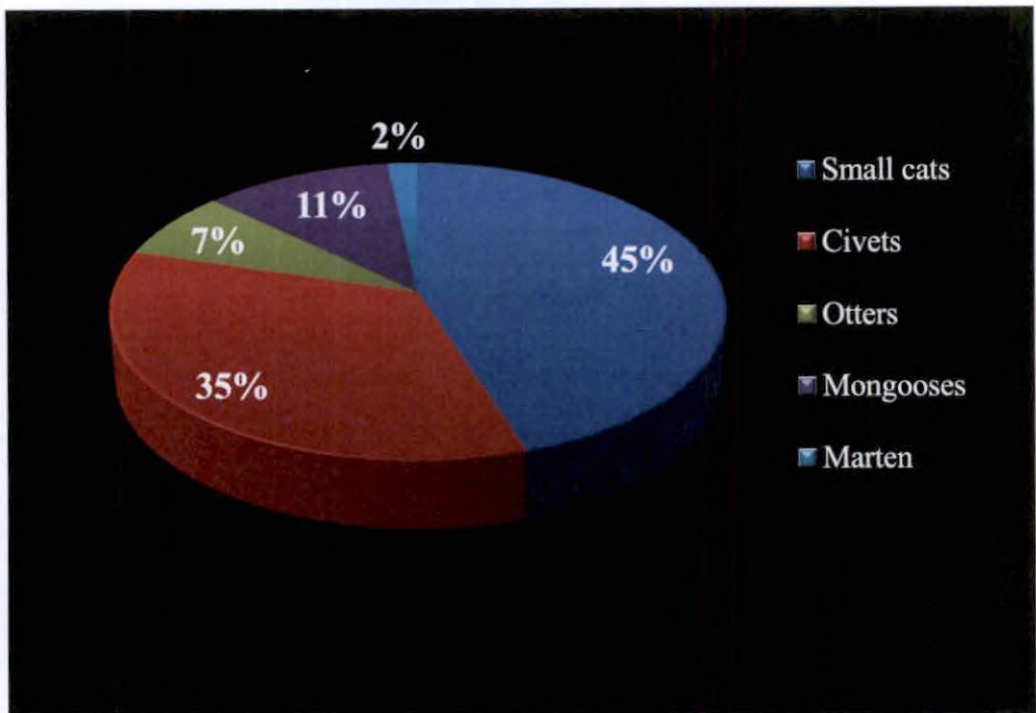


Fig. 16 Relative abundance of small carnivores from indirect evidences in Eravikulam National Park

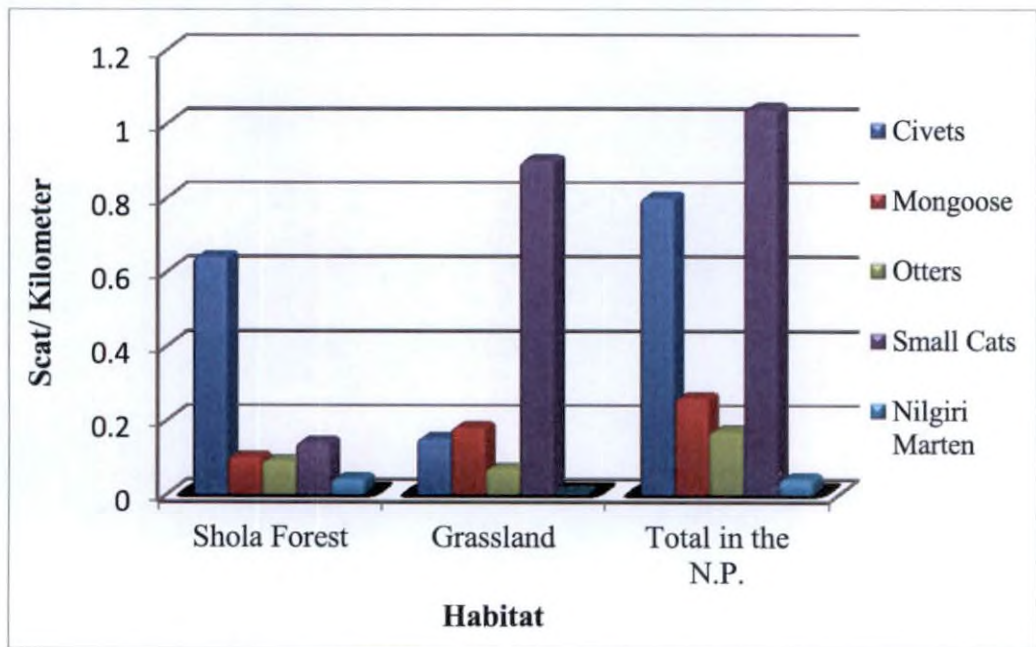


Fig. 17 Abundance (scat/kilometer) of small carnivores in different habitats of Eravikulam National Park



A and B: Scat of Small Cat C: Scat of Civet D: Scat of Mongoose, E. Spraints of Otter F. Scat of Nilgiri Marten

Plate 11. Indirect evidences of small carnivores in Eravikulam National Park

4.4 SMALL CARNIVORES OF ERAVIKULAM NATIONAL PARK BASED ON DIRECT SIGHTINGS

There were only three direct sightings of three different species of small carnivores during the day transects, though 65km of day transect was walked. These three species were Indian Grey Mongoose, *Herpestes edwardsii*, Stripe-necked Mongoose *Herpestes vitticollis*, and Nilgiri Marten *Martes gwatkinsii*. The two species of the mongooses sighted were from the grasslands of Naikkollimala and Erumapetti blocks respectively and the Nilgiri Marten was sighted from the *shola* forest in Naikkollimala block. The Stripe-necked Mongoose *Herpestes vitticollis* was sighted as a pair.

4.5 HABITAT PREFERENCE OF THE SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

The habitat utilisation of the small carnivores in Eravikulam NP is presented in Table. 24. The data were compiled from the day transects and the camera traps. Stripe-necked Mongoose *Herpestes vitticollis*, Asian small-cawed Otter *Aonyx cinerea*, Nilgiri Marten *Martes gwatkinsii*, Jungle Cat *Felis chaus* and Leopard Cat *Prionailurus bengalensis* were recorded from both the habitats. Small Indian Civet *Viverricula indica* and Common Palm Civet *Paradoxurus hermaphroditus* were recorded only from *shola* forests whereas Indian Grey Mongoose was recorded only from the grassland ecosystem. The indirect evidences of small cats, civets and mongooses are not considered, as the species level identification was not possible.

Table. 24. Presence of small carnivores in different habitats of Eravikulam National Park

Species	<i>Shola</i> Forest	Grasslands
1. <i>Viverricula indica</i>	CT	NO
2. <i>Paradoxurus hermaphroditus</i>	CT	NO
3. <i>Herpestes edwardsii</i>	NO	D
4. <i>Herpestes vitticollis</i>	CT	D and CT
5. <i>Aonyx cinerea</i>	CT	I
6. <i>Martes gwatkinsii</i>	D and I	CT
7. <i>Felis chaus</i>	CT	CT
8. <i>Prionailurus bengalensis</i>	CT	CT

D= Direct sightings, CT= Camera Trapped I = Indirect evidences, NO = Not observed

4.6 HABITAT USE INDEX (HUI) OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

Habitat Use Index (HUI) of small carnivore species in various habitats of Eravikulam NP was developed from the indirect evidences collected during the study period. The HUI of small carnivores is given in Table 25, Figure. 18. All the small carnivore groups except small cats and mongooses showed a greater preference to the *shola* forests, followed by grasslands. Otters were found to prefer both *shola* forests and grasslands nearer to water bodies.

Table. 25 Habitat Use Index of small carnivores in Eravikulam National Park

Small carnivore group	<i>Shola</i> Forest	Grassland
Civets	82.7	17.3
Mongoose	36.8	63.1
Otters	54.5	45.4
Nilgiri Marten	100	0
Small Cats	13.2	86.7

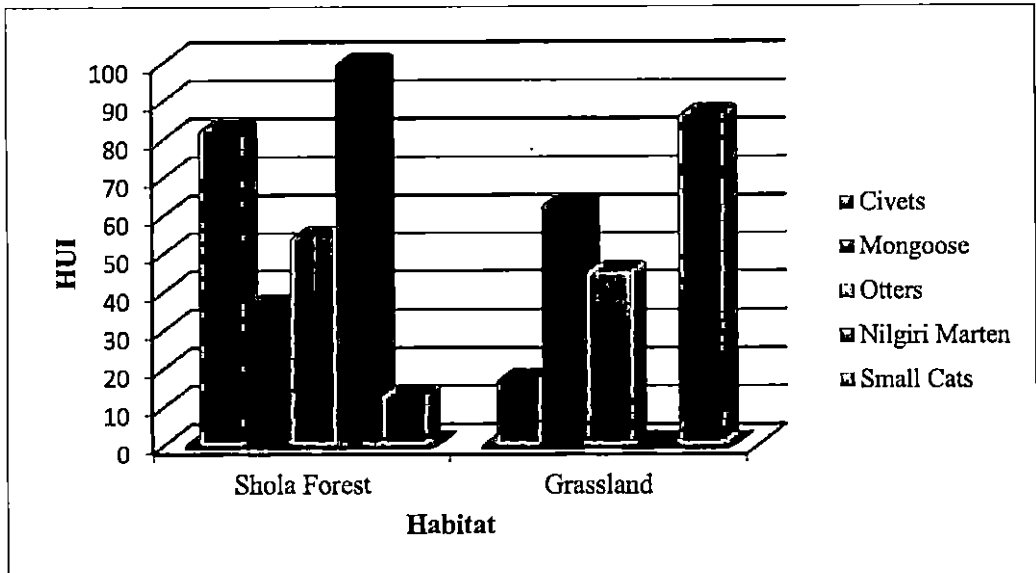


Fig. 18 Habitat Use Index of the small carnivores in Eravikulam National Park

Seasonal variation in habitat use of small carnivores is given in Table. 26, Figure. 19. During rainy season all the small carnivores except small cats preferred *shola* forests whereas during non-rainy season all of them except civets preferred grasslands.

Table. 26. Habitat Use Index of small carnivores in different seasons in Eravikulam National Park

Small carnivores	Rainy Season		Non-rainy Season	
	SF	GR	SF	GR
Civets	82.6	15.3	100	0.0
Mongoose	60.0	40.0	0.0	100.0
Otters	60.0	40.0	0.0	100.0
Nilgiri Marten	100.0	0.0	0.0	0.0
Small cats	32.2	67.7	0.0	100.0

SF: Shola Forest, GR: Grassland

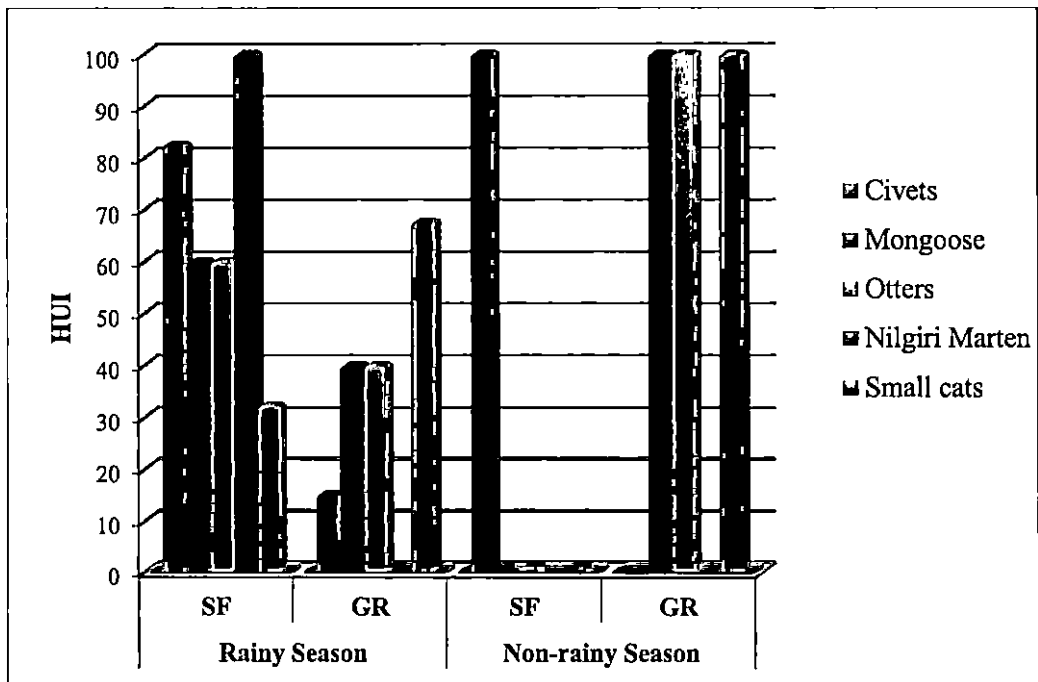


Fig. 19. Habitat Use Index during rainy and non-rainy seasons in Eravikulam National Park

4.7 THE DISTRIBUTION OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

The distribution of small carnivores in ENP is given in Figures 20-24. Figure 20 shows the distribution of Jungle Cat *Felis chaus* in ENP. Jungle Cat was recorded from four study locations such as Thirumudi, Perumalmala, Kolukkan and Erumapetti.

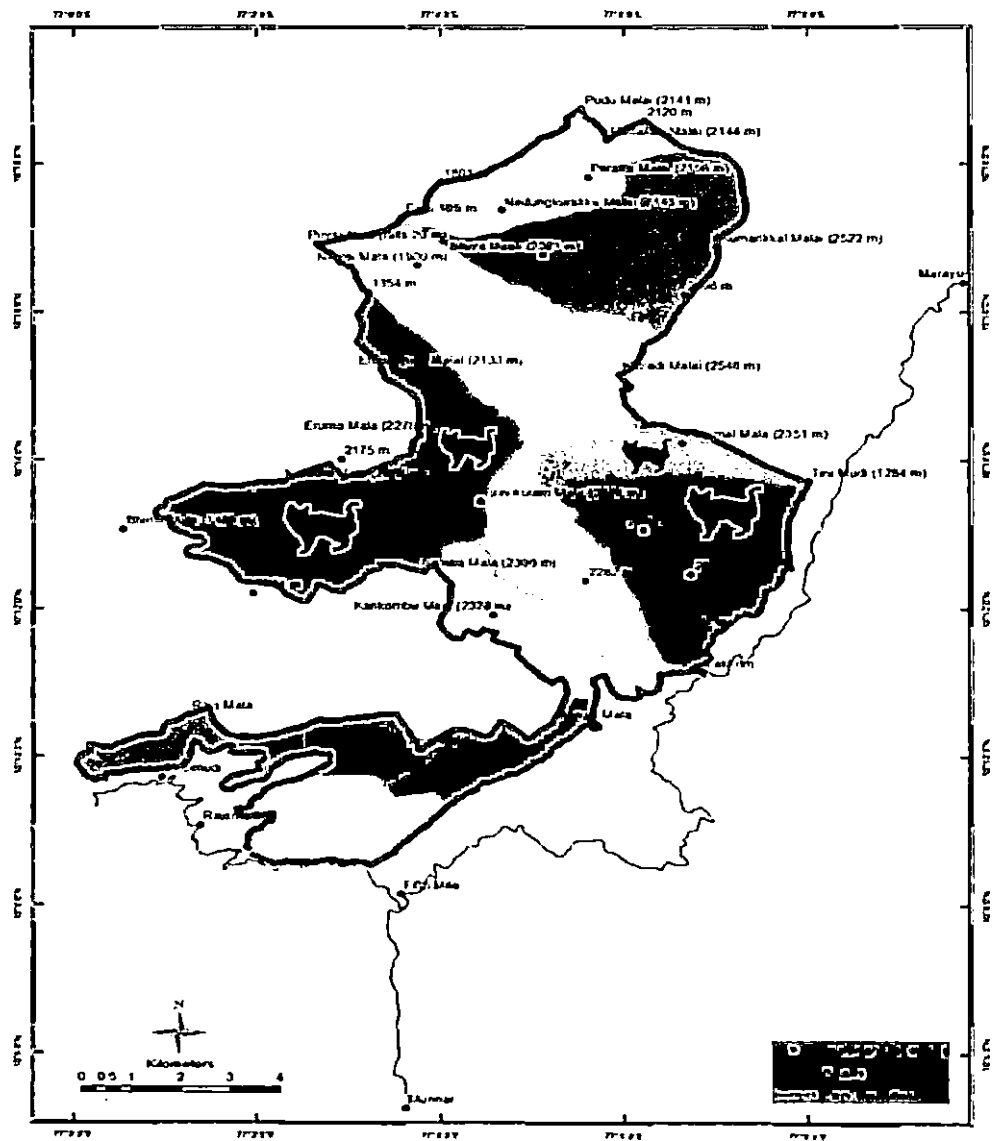


Fig. 20 Distribution map of Jungle Cat *Felis chaus* in Eravikulam National Park

Figure. 21 shows the distribution of Leopard Cat *Prionailurus bengalensis* in ENP and was camera trapped from three locations such as Lakkomkudy, Thirumudi and Kolukkan.

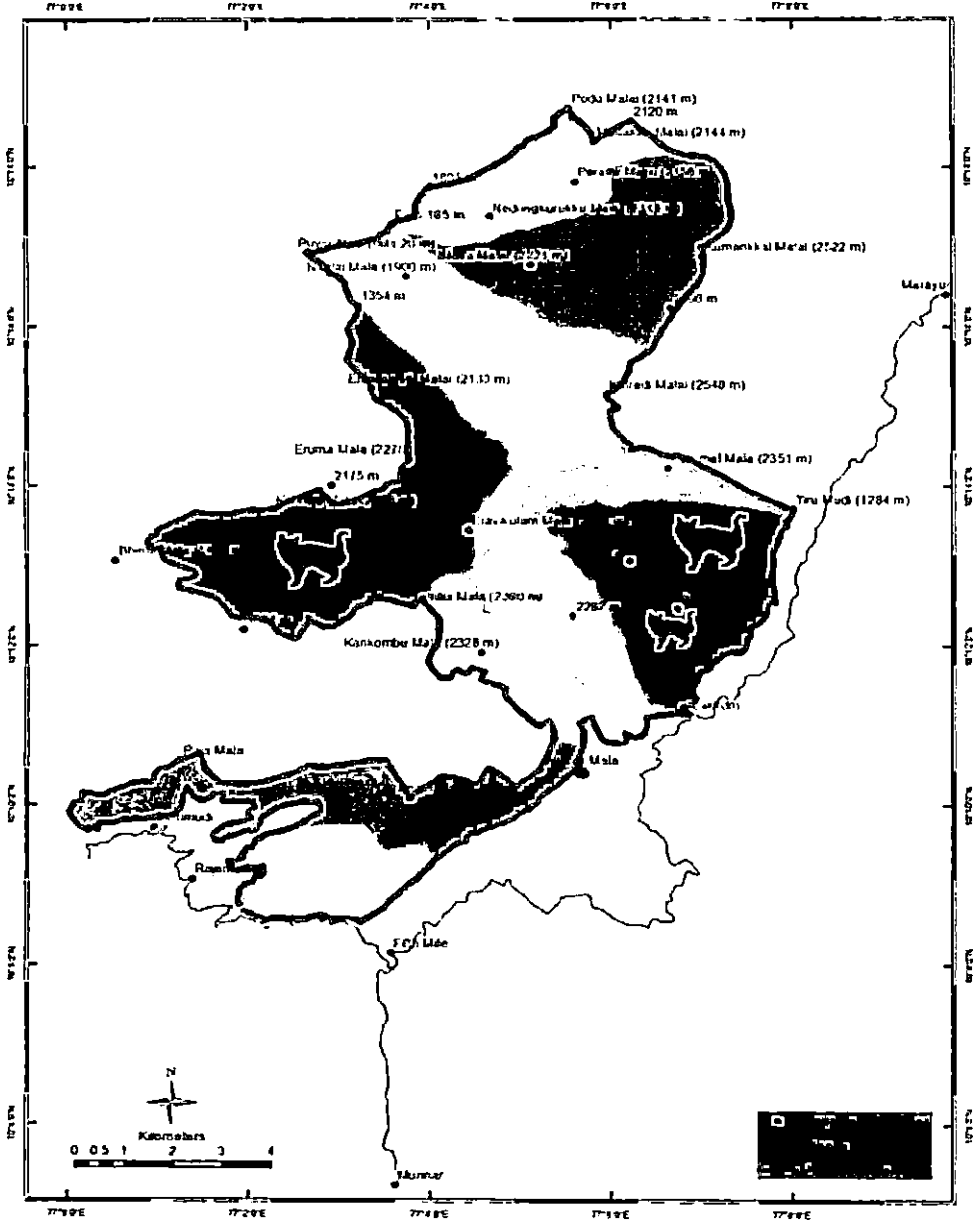


Fig. 21 Distribution map of Leopard Cat *Prionailurus bengalensis* in Eravikulam National Park

Stripe-necked Mongoose *Herpestes vitticollis* was recorded from Naikkollimala, Anamudi, Thirumudi and Erumapetti blocks in ENP (Figure. 22).

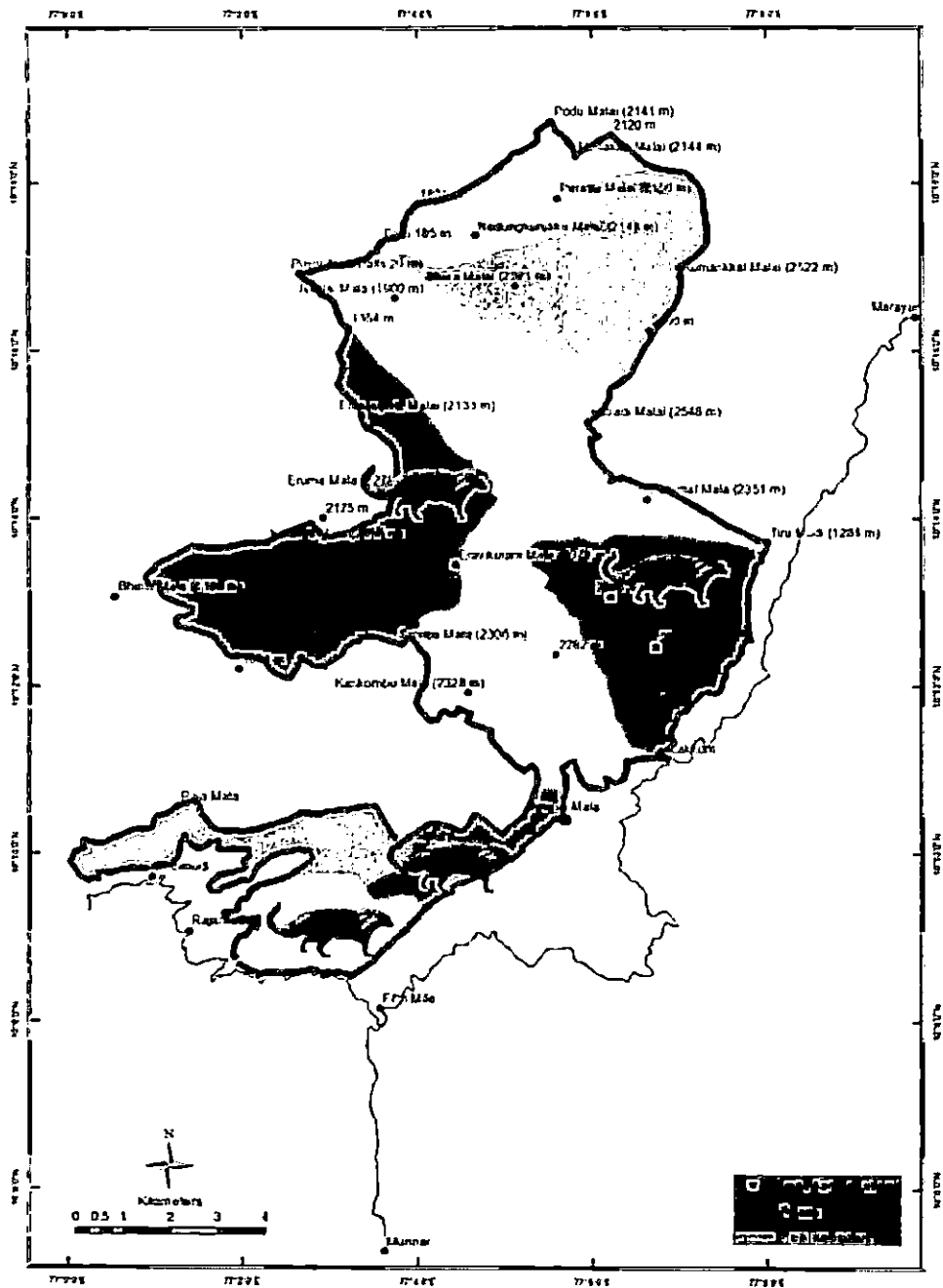


Fig. 22 Distribution map of Stripe-necked Mongoose *Herpestes vitticollis* in Eravikulam National Park

The members of family Mustellidae were distributed in four locations, with Asian small- clawed Otter *Aonyx cinerea* in Anamudi and Vembanthanny and Nilgiri Marten *Martes gwatkinsii* in Naikollimala and Perumalmala.

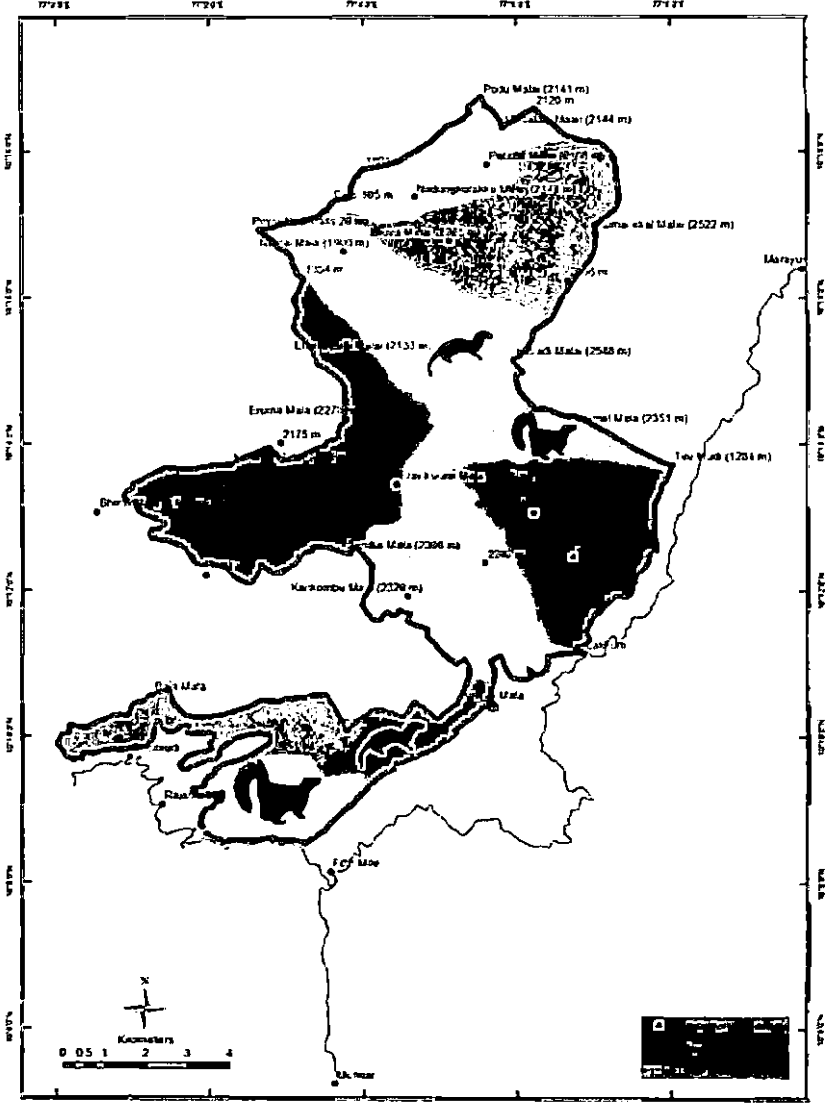


Fig. 23 Distribution map of Mustelids in Eravikulam National Park

Discussion

DISCUSSION

5.1 DIVERSITY OF SMALL CARNIVORES OF ERAVIKULAM NATIONAL PARK

The present study identified the presence of eight species of small carnivores in Eravikulam National Park (ENP). These include two species of civets viz. *Viverricula indica* and *Paradoxurus hermaphrodites*, two species of mongoose viz. *Herpestes edwardsii* and *Herpestes vitticollis*, two species of small cats *Felis chaus* and *Prionailurus bengalensis* and two species mustelids such as one otter *Aonyx cinerea* and the Nilgiri Marten *Martes gwatkinsii*. This account for 50% of the small carnivores of Western Ghats.

5.1.1 Family Viverridae

5.1.1.1 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, 2014). Weight ranges from 2.4 to 4.0kg, head and body length varies between 480 and 590 mm and tail length between 440 to 535mm.

The palm civets use prominent sites such as rocks and fallen logs along the trails in forest to defecate. Like other civets it is mostly solitary and nocturnal. The Common Palm Civet is mostly a terrestrial frugivore and it is highly tolerant to disturbances. It is mostly found in a wide range of habitats including evergreen, moist and dry deciduous forest and plantations from sea level up to an altitude of 2,400 m and in plantations (Yoganand and Kumar, 1999). It also lives close to human habitation on roofs and in homesteads. 16 subspecies have been reported from Asia (Pocock, 1939).

During the present study, only a single camera trapped image of the Common Palm Civet was obtained from Thirumudi, at an altitude of 1804m.

5.1.1.2 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 (Prater, 1971). 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, 2014). The tail is almost two third the length of head and body and is conspicuously marked with 9-10 concentric black rings. The weight varies from 2.2 - 3.4 kg (Shortridge, 1914; Roberts, 1977). The head and body measure 450 to 630 mm while tail length varies from 369 and 413 mm. Secretions from their perineal glands are used to mark territories. Small Indian civets are commercially exploited for the "civetone" or scent, extracted at regular intervals from the perineal gland that is used in perfume industries and in Indian medicine for its purported aphrodisiac properties. The species is also hunted for its meat which got a great demand in the market. Five subspecies of Small Indian Civet have been identified from India; *V. indica indica* from Western Ghats, *V. indica bengalensis* from the plains of northern India, *V. indica deserti* from Rajasthan, *V. indica wellsi* from Kangra, Kumaun and Uttar Pradesh, and *V. indica baptistae* from upper Bengal and Assam (Pocock, 1939).

During the present study, one camera trapped image of *Viverricula indicawas* obtained. The species was seen foraging on the ground, within a *shola*

patch. Small Indian Civets have been reported to be the most common small carnivore in the drier forests of the southern Western Ghats and rare in the tropical wet evergreen forests of the region (Mudappa, 2002a). Thus the present record of the Small Indian Civet from Naikkollimalain ENP at an altitude of 1789m is of interest.

5.1.2 Family Herpestidae

5.1.2.1 Indian Grey Mongoose *Herpestes edwardsii*

Its tawny-grey fur is much more grizzled and coarse than that of other mongooses. The legs are darker than body and tail is as long as head to body length. The desert subspecies is more reddish, the southern Indian one is more brownish and the northern Indian one is more greyish. The legs are always darker than the body. Total length is up to 900mm with tail length of around 450mm (Medway, 1978; Corbet & Hill, 1992). Males are always heavier and larger than females with weights ranging from 1.34-1.7kg and 0.89-1.12kg respectively (Medway 1978). 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 (Prater, 1971; Menon, 2003, 2014). They are found singly or in pairs. They prey on rodents, snakes, bird's eggs and hatchlings, lizards and variety of invertebrates. They breed throughout the year, gestation period is around 60-65 days, litter size 2-5. Maturity is achieved at the age of 6 to 9 months.

Pocock (1939) has identified three Indian subspecies of Indian Grey Mongoose, a north and central Indian race *H. edwardsii nyula* with a fuller somewhat darker coat, a desert race *H. edwardsii ferrugineus*, with reddish fur, and a typical south Indian race *H. edwardsii edwardsii*. In field conditions, however, the subspecies are difficult to identify as there is marked variation in the colour of the coat due to age, season and locality factors.

Though we did not get any photographic evidence of *Herpestes edwardsii* in the camera traps, an individual was sighted on 13 September 2014 from the grasslands of Naikkollimala at an altitude of 1789m, during the day-transects. A black morph of the species was recorded from Mannavanshola National Park in Munnar (Easa et al., 2001).

5.1.2.2 Stripe-necked Mongoose *Herpestes vitticollis*

It is the largest of the Asiatic mongooses. It is restricted to the Western Ghats in India and Sri Lanka (Prater, 1971). The species has a distinct black stripe with a white border on the sides of the neck. 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). General colour varies from grizzled dark brown and yellowish-grey to tawny-red. Three to four inches of the tip of the tail is jet black. Head and body length is between 430 to 530mm (Pocock, 1939; Phillips 1984; Corbet & Hill, 1992) tail 304.5 to 325mm and weight ranges from 1.36 to 2.73kg. The species is typically a forest dwelling species. It is rarely found far away from water sources. This indicates that probably it preys upon frogs and crabs. Though it is diurnal in habit it is more active during crepuscular period. The litter size is probably two to three. Two subspecies of Stripe-necked Mongoose are known from India. The typical form *H. vitticollis vitticollis* from Western Ghats, Coorg and Kerala is characterised by the dominance of chestnut red on its coat and the second *H. vitticollis inornatus* from north Kanara has no red tinge on the upper side of the body (Pocock, 1939).

During the present study, four camera trapped images of *Herpestes vitticollis* were obtained and there was direct sighting of a pair during the day transect. These four images were obtained from Naikkollimala, Anamudi, Thirumudi and Erumapetti at an altitude of 1731m, 2159m, 1792m and 2238m respectively. Apart from the camera trapped images, on 6 December 2014,

one pair of Stripe-necked Mongooses was sighted on the way to Erumapettimala in Erumapetti block of ENP.

The Stripe-necked Mongoose is distributed from Bombay to Dharwar to Cape Comorin (Jerdon, 1874; Blanford, 1888-1891). In Kerala the known distribution include Periyar Tiger Reserve (Ramachandran, 1985), Eravikulam national Park (Madhusudan, 1995), Anaikatty reserve forest (Rompaey and Jayakumar, 2003) and Parambikulam Wildlife Sanctuary (Pillay, 2009). Easa *et al.* (2001) and Easa and Ramachandran (2005) also reported the animal from various parts of Kerala.

5.1.3 Family Mustelidae

5.1.3.1 Nilgiri Marten *Martes gwatkinsii*

The Nilgiri Marten is endemic to Western Ghats. The Nilgiri Marten is almost similar to Yellow-throated Marten *Martes flavigula* of Himalayas in size. Blackish body with yellowish orange neck, typical weasel like leg, stout tail, pointed head and a flat skull with a concave depression on the forehead are the unique identifying characters of Nilgiri Marten (Pocock, 1941; Prater, 1971). The head to body length varies from 550 to 650 mm, tail length 400-450 mm and weight is around 2.1kg (Riely, 1913; Pocock, 1941). Very little information about the distribution, occurrence, abundance and ecology makes the Nilgiri Marten as one of the least known species of martens in the world (Wirth and Van Rompaey, 1991) and is currently listed in the IUCN Red List as Vulnerable (Choudhury *et al.*, 2012). It is believed to be diurnal and arboreal, like other marten species it possibly descends to the ground for hunting. Nilgiri Martens have been observed to hunt small vertebrates like Mouse Deer and varanus. There is a report of them feeding on the nectar of *Ceiba pentandra* (Hutton, 1944). There is a report of it preying on crows in the high ranges of Kerala (Gouldsbury, 1949) and Malabar Giant Squirrel in the high wavy mountains of Kerala (Hutton, 1944) and on insects (Pocock, 1941). Moist and

tropical rainforests are its preferred habitats within an altitudinal range of 300-1200m.

During the present study, a single Nilgiri Marten was camera trapped from the Perumalmala block (N 10°12.840' E 77 ° 06.379') at an elevation of 2085m on 11 October 2014. The species was also sighted from the *shola* forest of Naikollimala on 12 September 2014. The Nilgiri Marten has been reported from the following areas in the Western Ghats such as Sholayar (Vijayan, 1979), Brahmagiris (Schreiber et al., 1989), Eravikulam National Park (Madhusudan, 1995), Mukkurthi National Park (Yoganand & Kumar 1995, 1999), Peppara Wildlife Sanctuary and Silent Valley National Park (Christopher & Jayson 1996), Upper Bhavani (Gokula & Ramachandran 1996), KMTR (Mudappa, 2002a), Periyar Tiger Reserve (Kurup and Joseph, 2001) and Parambikulam Tiger Reserve (Sreehari and Nameer, 2013). It was also sighted in Silent Valley National Park, Attappadi Reserve Forest, Muthikkulam South Reserve Forest, and Nilambur South Reserve Forest by Balakrishnan (2005) and Easa *et al.*, (2001). The Nilgiri Marten sightings from the Western Ghats have been compiled by Krishna and Karnad (2010). The additional Nilgiri Marten sighting locations reported by them include, Anamalai Tiger Reserve, Nelliampathy Reserve Forest, Grass Hills National Park, Pambadum shola National Park, Talakaveri Wildlife Sanctuary and Sandynallah in Nilgiris.

5.1.3.2 Asian small-clawed Otter *Aonyx cinerea*

The Asian Small-clawed Otter is smaller than all other otter species, head and body measuring 40.6-63.5 cm, tail length, 24.6-30.4 cm, total length, 65.2-93.9 cm, and weight ranging between 2.7 and 5.4 kg (Walker 1975). They have distinct webbed feet, with the third and fourth digits markedly longer than the second and fifth of each foot, and claws reduced to small rudiments, which do not protect beyond the tips of the digits (Harris 1968). The dorsal body colour is typically dark brown, sometimes with tawny or rufous tinge, and the tip of the contour hair often paler, but rarely white, giving a grey tint. The ventral side is

generally paler brown than the upper, often showing the grey cast (Pocock 1941). They are generally nocturnal and crepuscular (Foster-Turley 1992) and are adapted to feed on invertebrates.

Two sub species were reported by Pocock (1941). One is the *A. cinerea concolor* which is seen in northeast India, Nepal, Bhutan, Bangladesh and Myanmar, extending to Sumatra and the second is the *A. cinerea nirnai* that is seen in the hill ranges of southern India.

There were two camera trap captures of Asian Small-clawed Otter from the ENP. These reports were from the base of Anamudi peak and from Vembanthanny block. In addition, otter spraints and tracks were found on the banks of the streams and grasslands from six blocks including Thirumudi, Perumalmala, Vembanthanny, Poovar, Kolukkan and Eravikulam. There were only three published study on the otters in Western Ghats, viz. Meena (2002), Anoop & Hussain (2004 & 2005) and Perinchery *et.al* (2011) and only one on the Asian Small-clawed Otter (Perinchery *et.al*, 2011).

5.1.4 Family Felidae

5.1.4.1 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 (Prater, 1971; Menon, 2003,

2014). The main conservation threat for the animal includes poaching and habitat destruction. The jungle cat is frequently by day, more usually in the morning and in the evening. It preys on small mammals principally rodents, are the prey most frequently found in feces and stomach contents. Other prey species are taken more opportunistically, including hares, nutria, lizards, snakes, frogs, insects, and fish. It is probably absent from all closed canopy forests, including rainforest.

Five individuals were camera trapped during the present study in ENP. Various indirect evidences like the pugmarks and scats were also encountered from *shola* forests and grasslands of the National Park during the day transects. Jungle Cat was the species with most number of camera trapped images throughout the study period.

5.1.4.2 Leopard Cat *Prionailurus bengalensis*

The species is one of the most adaptable wild cats, similar to leopard. Its colour and marking give it the aspect of a miniature leopard. The prevailing colour of the body is yellowish above white below ornamented throughout with black or brownish spot. Both colour and pattern are very variable in this species. Among other markings are four more or less distinct bands running from the crown over the neck which breaks up into short bars and elongate spots on the shoulders. There is a pair of horizontal cheek stripes, the lower joining a black bar across the throat and the usual two black bars on the inside of the forearm. The spots on the tail form cross bars towards its end. It is an extremely versatile cat, which is arboreal and preys up on small birds and animals. It is nocturnal in habit and seldom seen. It takes rest in hollows in trees. Total body length comes up to 60 cm and weights from 3 to 7 kg (Prater, 1971; Menon, 2003, 2014).

Four Leopard Cats were captured in the camera traps, two from Lakkomkudi on 25 September 2014 at an altitude of 1621m and one each from Thirumudi on 9 October 2014 at an altitude of 1776m and Kolukkan on 29

November 2014 at 2071m. Out of the four individuals, two were captured from *shola* forest and the other two from the grassland.

5.2 SPECIES RICHNESS AND ABUNDANCE OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

At Eravikulam NP, seven species of small carnivores have been captured in the camera trapped from 855 trap days. Mudappa et al. (2007), who studied the small carnivores in KMTR, with a camera trap effort of 295 recorded three species, while her studies at Anamalai hills with 95 camera trap nights also recorded three species. Rao et al. (2007), during their survey on Malabar Civet using camera traps in Kerala and Karnataka, after 1084 camera trap efforts recorded only four species of small carnivores. Aparajita et al. (2008), who studied the small carnivores of two protected areas in Arunachal Pradesh, after a camera trap effort of 1537 reported six species from Namdapha NP. While at Pakke WLS, after a camera trap effort of 231, they recorded four species (Aparajita et al. (2008). In Parambikulam TR, Sreehari (2012) recorded eight species from 1349 trap nights.

In Thailand 1,224 trap-nights, five species were captured (Grassman, 1998). In Laos, with 3,588 trap-nights, 11 small carnivore species were camera-trapped (Johnson et al. 2006), and eight were recorded in Vietnam in 6,337 trap-nights (Long & Hoang, 2006). In the Hukaung Valley, Myanmar, even after 8,836 trap-nights, only ten species were captured (Than Zaw et al. 2008). In Malaysia only nine small carnivore species were recorded in 14,054 trap-nights (Belden *et.al.* 2007).

Variation in species recorded and capture rates may reflect real differences in abundance among sites but it is difficult to make conclusions, given that most of these studies were designed primarily for tigers and other large carnivores. Even though seven species of small carnivores were camera trapped from

Eravikulam NP, the number of occurrence were very low when compared to other similar studies in South Asia and from Western Ghats. The overall small carnivore capture success rate is 2.1% (18 of 855 trap-days), while the small carnivore capture success at Parambikulam TR (Sreehari, 2012) was 4.5% and in KMTR (Mudappa, 2007) was 41.1%. This could be due to the high altitude of the study area and also due to lack of enough food.

5.3 SPECIES RICHNESS AND ABUNDANCE OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

The abundance of scats was used as a measure of the abundance of the small carnivores in the NP. Scat abundance was estimated as the number of scat encounter per kilometer surveyed in different habitats of the NP. However, based on scat morphology it was possible to identify the scats only to the family level. Indirect evidences like pugmarks or tracks were also recorded for identifying the presence of small carnivores. Using the scat abundance study, it was observed that the small cats were the most abundant small carnivore at ENP. This was followed by civets and mongooses. Nilgiri Marten was the least abundant. There was a notable variation in the scat abundance among the two habitats of the NP. The overall scat abundance of the small carnivores was seen almost similar for the *shola* forests and the grasslands. The abundance of civets and otters were higher in the *shola* forests whereas the mongoose and small cats were abundant in the grassland habitats. Interestingly the direct sighting of mongoose was from the grasslands whereas the sole sighting of Nilgiri Marten was from a *shola* habitat, probably indicating the habitat preference of these species.

This estimation, however, has couple of limitations such as; the scat abundance need not be proportional to animal abundance. Yoganand and Kumar (1999), has opined that the fruit eaters such as civets would have a higher defecation rate than meat eaters such as cats and mustelids. Thus one cannot estimate the abundance of small carnivore using the indirect evidence method; it

can at the best be used for recording the presence absence of the small carnivores and to supplement the camera trap data.

5.4 STATUS OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

Out of the eight species of small carnivores recorded from ENP, Stripe-necked Mongoose *Herpestes vitticollis* and Jungle Cat *Felis chaus* were the commonest small carnivores and were distributed in four blocks in the National Park. They are followed by Leopard Cat *Prionailurus bengalensis* which was found to be widely distributed in both the *shola* forests and grasslands of ENP and Stripe-necked Mongoose *Herpestes vitticollis* which was recorded four times from ENP.

Among the herpestids, Stripe-necked Mongoose *Herpestes vitticollis* was the commonest one at ENP and is distributed in four blocks of the park. Indian Grey Mongoose *Herpestes edwardsii*, which is a species of the plains, was sighted only once from Naikkollimala. Brown Mongoose *Herpestes fuscus* was recorded during a previous study from ENP (Sreehari *et.al.* 2013), but the present study failed to record the presence of this animal.

Asian Small-clawed Otter *Aonyx cinerea* is the only otter recorded from the ENP. This species is found primarily near most of the streams of ENP and was found feeding primarily on the aquatic invertebrates, dominated by crabs.

The endemic Nilgiri Marten *Martes gwatkinsii* was found to be a rare animal in ENP and was recorded only from Perumalmala and Naikkollimala.

The small carnivore observations were more during the rainy season when compared to the non-rainy season. However, Chetana and Ganesh (2007) recorded a greater camera trap capture success during the winter than monsoon season in a fragmented dry deciduous forest of Karnataka.

5.5 HABITAT PREFERENCE OF SMALL CARNIVORES IN ERAVIKULAM NATIONAL PARK

The Habitat Use Index (HUI), which shows the habitat preference, was worked out for each group of small carnivores at ENP. The HUI showed remarkable variations between the various habitats of the NP. The small cats were found to be using mostly the grasslands during rainy season. But during the non-rainy seasons small cat evidences were obtained only from grasslands, which indicates they generally prefer grassland habitat and use *shola* forests as a shelter from adversities. Duckworth *et.al.* (2005) observed that in the Laos the Jungle Cat was probably absent from all closed canopy forests, including rainforest.

In the case of mongoose the HUI was not showing much difference between the *shola* forests and the grasslands. The direct sightings of both the *Herpestes vitticollis* and *Herpestes edwardsii* were from the grasslands. *Herpestes edwardsii* was recorded from Naikkollimala which is close to human habitations. Shekhar, (2003), recorded *Herpestes edwardsii* mostly from near human settlements.

HUI of otters in the park was seen to be higher in the grasslands during non-rainy seasons and in the *shola* forests during rainy season. The only otter species identified from the area *Aonyx cinerea*, was observed more in the rocky and open areas in grasslands than the areas having canopy cover. No individuals were directly sighted during the study period. Other studies on otter also showed that they prefer to use habitats where food is plentiful and anthropogenic disturbances low (Hussain and Choudhury, 1997; Anoop and Hussain, 2004; Shenoy, 2006, Perinchery *et.al.*, 2011).

One capture each of Small Indian Civet *Viverricula indica* and Common Palm Civet *Paradoxurus hermaphrodites* was obtained in the camera trap during the whole study period. Civets showed more preference to *shola* forests than open grasslands during both rainy and non-rainy seasons. The more frugivorous nature

of the civets may be a reason for avoiding vegetation less grasslands. Studies elsewhere on the Common Palm Civet, have also recorded wide range of habitat use by the Common Palm Civet (Duckworth, 1997; Azlan, 2003; Su, 2005).

Very little evidences were obtained of Nilgiri Marten from the whole study area. All the indirect evidences were collected from *shola* forests whereas the only camera trap capture was from the grasslands adjacent to a water body.

5.6 VEGETATION ASSESSMENT OF SHOLA FORESTS IN ENP

The prominent vegetation at the ENP was *Ficus drupacea*, *Syzygium arnottianum*, *Pithecellobium subcoriaceum*, *Microtropis ramiflora*, *Gomphandra coriacea*. Though no correlation could be found between the vegetation type and the small carnivore distribution, most of the study locations were dominated by *Ficus drupacea* and *Syzygium arnottianum*. The most widely distributed small carnivore at ENP were the civets and the greater presence of the fruit trees across the ENP could be the reason for the wider distribution of the viverrids, which has a diet preference towards fruits.

5.7 CONSTRAINS FOR THE PRESENT SMALL CARNIVORES STUDY IN ERAVIKULAM NATIONAL PARK

The process of camera trapping in grassland is less effective when compared to that in a closed canopy forest. The camera traps we used, Bushnell Trophy Cam model no. 119436 and Cuddeback Attack model 1149 were designed to detect motion as well as body temperature. The camera captured many blank images during present study whenever there was a movement of the leaves due to wind, particularly in the grasslands. So for camera trapping studies in grasslands, camera traps without motion sensors but heat sensors alone are recommended.

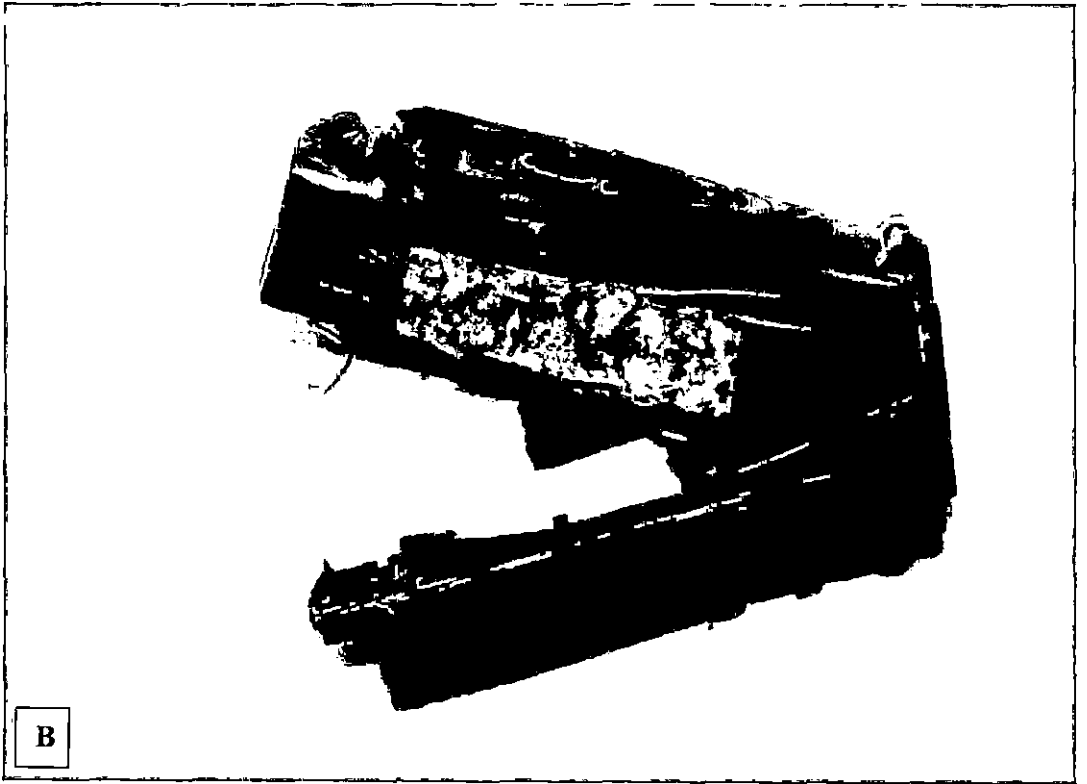
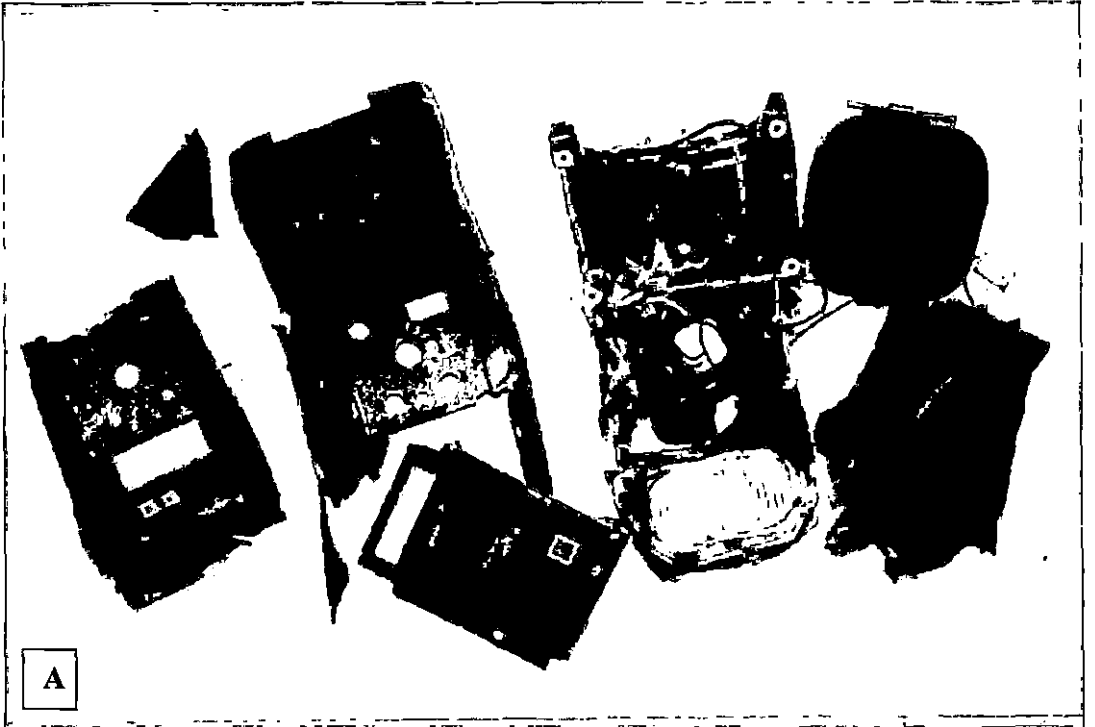


Plate 12. Camera trap damaged by Asian Elephants (A& B)

Summary

SUMMARY

Small carnivores are small, nocturnal and solitary mammals and are one of the least studied mammals in India in general and Western Ghats in particular. Accordingly very little information is available on their ecology, behaviour, habits, taxonomy, conservation threats etc. As far as Kerala is concerned there are only two detailed studies on the small carnivores in Kerala, which is from Chimmony Wildlife Sanctuary and Parambikulam Tiger Reserve. Easa *et al.*, (2001) however did a detailed study of mammals throughout Kerala. The present study is the first-ever study on the small carnivores of Eravikulam National Park (ENP). The objectives of the study were to understand the diversity, abundance, status, distribution and habitat preference of the small carnivores of the National Park. The study was carried out from September 2014 to March 2015. The methods employed to study the small carnivores were, camera-trap survey and day transect survey for the direct and indirect evidences. The vegetation at ENP was studied using quadrats. A total of 855 camera-trap days consisting of 20,520 hrs of trapping, 65 kilometers transect walk and 77 quadrants of size 10x10m for the vegetation studies were done. The salient findings are summarised below.

- A total of eight species of small carnivores in four families were recorded from the ENP during the present study. This includes two species mongooses, two civets, two small cats and two mustelids.
- The mongooses reported from ENP are Indian Grey Mongoose *Herpestes edwardsii* and Stripe-necked Mongoose *Herpestes vitticollis*. Thus 50% of mongoose species known from the Kerala have been recorded from ENP.
- The civets reported from ENP are Common Palm Civet *Paradoxurus hermaphroditus*, and Small Indian civet *Viverricula indica*. Thus out of the three species of viverrids of the Western Ghats two have been recorded from ENP.

- The mustelids reported from ENP are Asian small-clawed Otter *Aonyx cinerea* and Nilgiri Marten *Martes gwatkinsii*. Thus out of the four species of mustelids known from the Western Ghats two have been recorded from ENP.
- The lesser cats reported from ENP are Jungle Cat *Felis chaus* and Leopard Cat *Prionailurus bengalensis*. Thus out of the four species of lesser cats of the Western Ghats two have been recorded from ENP.
- The camera trap studies show that the 50% of the small carnivores captured in the camera traps belonged to two species of small cats such as the Jungle Cat *Felis chaus* and Leopard Cat *Prionailurus bengalensis*. The other small carnivores accounted for the rest which includes, Stripe-necked Mongoose (22.2%), Asian small-clawed Otter (11.1%), Nilgiri Marten (5.5%), Common Palm Civet (5.5%) and Small Indian Civet (5.5%).
- The camera traps also documented the presence of 10 other mammals such as Wild Dog *Cuon alpinus*, Asian Elephant *Elephas maximus*, Sambar Deer *Rusa unicolor*, Barking Deer *Muntiacus muntjak*, Mouse Deer *Moschiola indica*, Gaur *Bos gaurus*, Indian Crested Porcupine *Hystrix indica*, Bonnet Macaque *Macaca radiata*, Nilgiri Langur *Semnopithecus johnii* and an unidentified rodent species from the ENP.
- The camera trap success rate has been generally lower at ENP (2.1%) when compared to the other locations in the Western Ghats, North-East Indian and the South-East Asia.
- Out of the 12 locations used for the camera trapping the camera trapping success rates were higher in Thirumudi (0.46%) and Erumapetti (0.35%) of ENP.

- A total of 153 incidence of indirect evidences of small carnivores were recorded from 65km transect walk. Abundance of small carnivores (scats/kilometer), with the small cats (1.04) having the maximum abundance followed by civets (0.80), mongoose (0.26), otters (0.17) and Nilgiri Marten (0.04) at the ENP.
- The 65km of day transects also resulted in 3 sightings of three different species of small carnivores. They are Indian Grey Mongoose *Herpestes edwardsii*, Stripe-necked Mongoose *Herpestes vitticollis* and Nilgiri Marten *Martes gwatkinsii*.
- The Nilgiri Marten *Martes gwatkinsii* sighted from the ENP is the second record of this species from ENP.
- The Asian small-clawed Otter *Aonyx cinerea* from ENP is the third report of the species from ENP.
- During rainy season, civets and Nilgiri Marten were found to be preferring *shola* forests than grasslands whereas mongooses and small cats were choosing grassland habitat. There was no specific distinction between habitats in the case of otter. But during non-rainy season, civets were not found from the grasslands and small cats, mongoose and otter were not found from the *shola* forests.
- The vegetation assessment showed that, majority of the study locations were dominated by *Ficus drupacea* and *Syzygium arnottianum*. *Pithecellobium subcoriaceum*, *Microtropis ramiflora*, *Gomphandra coriacea*, *Cinnamomum wightii* etc. were some other dominant trees at ENP.

- Out of the eight species of small carnivores of ENP two are Vulnerable, according to IUCN Red List. They are, Nilgiri Marten *Martes gwatkinsii* and Asian small- clawed Otter *Aonyx cinerea*
- No conservation threats could be observed on the small carnivores of ENP, and ENP would be acting as an important adobe for the survival of the small carnivores of Western Ghats.

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**STATUS, DISTRIBUTION AND HABITAT
PREFERENCES OF SMALL CARNIVORES IN
ERAVIKULAM NATIONAL PARK, KERALA**

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A study was conducted to understand the diversity, status, distribution and habitat preferences of small carnivores in Eravikulam National Park (ENP). The study was conducted from September 2014 to March 2015. This was the first ever study on the small carnivores in ENP. The small carnivores were studied using the camera traps. This was supplemented through the study of the indirect evidences of the small carnivores, using line transect methods. A total of 855 camera trap days, having 20,520 hrs and 65km of transect walk was done at ENP. The vegetation of the study site was studied by taking 77, 10x10m quadrants, covering an area of 7700m².

A total eight species of small carnivores were recorded from ENP. This accounted for 50% of small carnivores of W. Ghats and 19% of India. Small cats of the family dominated the small carnivores at ENP, accounting for 50% of the total small carnivores. The small cats at ENP were the Jungle Cat *Felis chaus* (27.7%) and Leopard Cat *Prionailurus bengalensis* (22.2%). The other small carnivores found at the ENP were Stripe-necked Mongoose *Herpestes vitticollis* (22.2%), Asian small-clawed Otter *Aonyx cinerea* (11.1%), Nilgiri Marten *Martes gwatkinsii* (0.05%), Common Palm Civet *Paradoxurus hermaphrodites* (0.05%) and Small Indian Civet *Viverricula indica* (0.05%).

A total of 153 incidence of indirect evidences of small carnivores were recorded from 65 km transect walk. Abundance of small carnivores (scats/kilometer), with the small cats (1.04) having the maximum abundance followed by civets (0.80), mongoose (0.26), otters (0.17) and Nilgiri Marten (0.04) at the ENP.

There was no significant difference in the habitat preference by the small carnivores. They were using both the *shola* forests as well as grasslands. There

was no significant difference in the habitat preferences across the seasons under study too.

The prominent vegetation at the ENP was *Ficus drupacea*, *Syzygium arnottianum*, *Pithecellobium subcoriaceum*, *Microtropis ramiflora*, *Gomphandra coriacea*. Though no relationship could be made between the vegetation type and the small carnivore distribution, most of the study locations were dominated by *Ficus drupacea* and *Syzygium arnottianum*. The most widely distributed small carnivore at ENP was the civets and the greater presence of the fruit trees across the ENP could be the reason for the wider distribution of the viverrids, which has a diet preference towards fruits.

Out of the eight species of small carnivores of ENP two are Vulnerable, according to IUCN RedList. However, no conservation threats could be observed on the small carnivores of ENP, and ENP would be acting as an important adobe for the survival of the small carnivores of Western Ghats.

Appendices

Appendix I: Checklist of small carnivores of India

Sl. No.	Scientific name	Common Name	Family
1.	<i>Ailurus fulgens</i>	Red Panda	Aliuridae
2.	<i>Caracal caracal</i>	Caracal	Felidae
3.	<i>Felis chaus*</i>	Jungle Cat	Felidae
4.	<i>Felis silvestris</i>	Wild Cat	Felidae
5.	<i>Lynx lynx</i>	Eurasian Lynx	Felidae
6.	<i>Otocolobus manul</i>	Pallas's Cat	Felidae
7.	<i>Pardofelis marmorata</i>	Marbled Cat	Felidae
8.	<i>Pardofelis temminckii</i>	Asiatic Golden Cat	Felidae
9.	<i>Prionailurus bengalensis*</i>	Leopard Cat	Felidae
10.	<i>Prionailurus rubiginosus*</i>	Rusty-spotted Cat	Felidae
11.	<i>Prionailurus viverrinus*</i>	Fishing Cat	Felidae
12.	<i>Herpestes edwardsii*</i>	Grey Mongoose	Herpestidae
13.	<i>Herpestes fuscus*</i>	Brown Mongoose	Herpestidae
14.	<i>Herpestes javanicus</i>	Small Indian Mongoose	Herpestidae
15.	<i>Herpestes palustris</i>	Indian Marsh Mongoose	Herpestidae
16.	<i>Herpestes smithii*</i>	Ruddy Mongoose	Herpestidae
17.	<i>Herpestes urva</i>	Crab-eating Mongoose	Herpestidae
18.	<i>Herpestes vitticollis*</i>	Striped-necked Mongoose	Herpestidae
19.	<i>Aonyx cinerea*</i>	Small-clawed Otter	Mustelidae
20.	<i>Arctonyx collaris</i>	Hog-badger	Mustelidae
21.	<i>Lutra lutra*</i>	Eurasian Otter	Mustelidae

22.	<i>Lutra perspicillata*</i>	Smooth-coated Otter	Mustelidae
23.	<i>Martes flavigula</i>	Yellow-throated Marten	Mustelidae
24.	<i>Martes foina</i>	Beech Marten	Mustelidae
25.	<i>Martes gwatkinsii*</i>	Nilgiri Marten	Mustelidae
26.	<i>Mellivora capensis*</i>	Ratel or Honey Badger	Mustelidae
27.	<i>Melogale personata</i>	Large-toothed Ferret Badger	Mustelidae
28.	<i>Melogale moschata</i>	Small-toothed Ferret Badger	Mustelidae
29.	<i>Mustela kathiah</i>	Yellow-bellied Weasel	Mustelidae
30.	<i>Mustela altaica</i>	Pale Weasel	Mustelidae
31.	<i>Mustela ermine</i>	Ermine or Stoat	Mustelidae
32.	<i>Mustela putorius</i>	Tibetan Polecat	Mustelidae
33.	<i>Mustela sibirica</i>	Siberian Weasel	Mustelidae
34.	<i>Mustela strigidorsa</i>	Back-striped Weasel	Mustelidae
35.	<i>Prionodon pardicolor</i>	Spotted Linsang	Prionodontidae
36.	<i>Arctictis binturong</i>	Binturong	Viverridae
37.	<i>Arctogalidia trivirgata</i>	Small-toothed Palm Civet	Viverridae
38.	<i>Paguma larvata</i>	Masked Palm Civet	Viverridae
39.	<i>Paradoxurus jerdoni*</i>	Brown Palm Civet	Viverridae
40.	<i>Paradoxurus hermaphrodites*</i>	Common Palm Civet	Viverridae
41.	<i>Viverra zibetha</i>	Large Indian Civet	Viverridae
42.	<i>Viverra civettina*</i>	Malabar Civet	Viverridae
43.	<i>Viverricula Indica*</i>	Small Indian Civet	Viverridae

*Seen in Western Ghats

Source: (Nayerul and Vijayan.1993; Nameer 2014; Schipper et al., 2008)

Appendix II: Camera trap data on small carnivores at ENP from September 2014 to March 2015

Sl. No.	Place	Latitude (N)	Longitude (E)	Altitude (m)	Date	Habitat
Jungle Cat						
1.	Thirumudi	10°12.641'	77°07.142'	1632	06-10-2014	Grassland
2.	Perumalmala	10°12.552'	77°06.618'	2078	11-10-2014	Grassland
3.	Kolukkan	10°13.699'	77°03.098'	2127	28-11-2014	Grassland
4.	Erumpatti	10°14.365'	77°03.755'	2238	06-12-2014	Shola
5.	Erumpatti	10°14.365'	77°03.755'	2238	06-12-2014	Shola
Leopard Cat						
6.	Lakkomkudi	10°12.100'	77°06.819'	1621	25-09-2014	Grassland
7.	Lakkomkudi	10°12.100'	77°06.819'	1621	25-09-2014	Grassland
8.	Thirumudi	10°13.120'	77°07.149'	1776	06-10-2014	Shola
9.	Kolukkan	10°13.730'	77°02.694'	2071	28-11-2014	Shola
Stripe-necked Mongoose						
10.	Naikollimala	10°08.749'	77°03.111'	1730	15/9/2014	Shola
11.	Anamudi	10°10.003'	77°04.270'	2159	23/9/2014	Grassland
12.	Thirumudi	10°13.203'	77°07.116'	1792	10-07-2014	Shola
13.	Erumpatti	10°14.365'	77°03.755'	2238	07-12-2014	Grassland
Asian small-clawed Otter						
14.	Anamudi	10°09.572'	77°04.350'	2032	24/9/2014	Shola
15.	Vembanthanny	10°16.318'	77°04.485'	1970	01/11/2014	Shola
Nilgiri Marten						

16.	Perumalmala	10°12.840'	77°06.379'	2085	10-11-2014	Grassland
Small Indian Civet						
17.	Naikollimala	10°08.870'	77°03.492'	1724	09/11/2014	Shola
Common Palm Civet						
18.	Thirumudi	10°13.198'	77°07.130'	1804	10-09-2014	Shola

Appendix III: Small carnivore indirect evidence data collected from ENP from September 2014 to March 2015

Sl. No.	Species	Latitude N	Longitude E	Alt (m)	Habitat	Terrain
1.	Civet	10°08.765'	77°03.148'	1787	Shola	Slope
2.	Civet	10°08.763'	77°03.207'	1763	Shola	Slope
3.	Civet	10°08.763'	77°03.207'	1765	Shola	Slope
4.	Civet	10°08.757'	77°03.089'	1778	Shola	Moderate Slope
5.	Civet	10°08.773'	77°03.087'	1763	Shola	Moderate Slope
6.	Civet	10°08.778'	77°03.100'	1759	Shola	Moderate Slope
7.	Civet	10°08.788'	77°03.127'	1777	Shola	Slope
8.	Civet	10°08.795'	77°03.136'	1760	Shola	Plain
9.	Civet	10°08.795'	77°03.136'	1762	Shola	Plain
10.	Civet	10°08.804'	77°03.141'	1769	Shola	Slope
11.	Civet	10°08.786'	77°03.151'	1782	Shola	Slope
12.	Civet	10°08.587'	77°02.815'	1758	Shola	Moderate Slope
13.	Civet	10°08.510'	77°02.835'	1731	Shola	Slope
14.	Civet	10°08.510'	77°02.834'	1730	Shola	Slope
15.	Civet	10°08.481'	77°02.782'	1725	Shola	Plain
16.	Civet	10°08.488'	77°02.696'	1733	Grassland	Moderate Slope
17.	Civet	10°08.668'	77°02.968'	1779	Shola	Slope
18.	Civet	10°08.652'	77°02.996'	1775	Shola	Plain
19.	Civet	10°08.652'	77°02.996'	1775	Shola	Plain
20.	Civet	10°08.652'	77°02.996'	1775	Shola	Plain
21.	Civet	10°08.652'	77°02.996'	1775	Shola	Plain

22.	Civet	10°08.652'	77°02.996'	1775	Shola	Plain
23.	Civet	10°08.629'	77°03.066'	1758	Shola	Moderate Slope
24.	Civet	10°08.636'	77°03.070'	1758	Shola	Slope
25.	Civet	10°00.315'	77°01.315'	1910	Shola	Plain
26.	Civet	10°10.482'	77°01.490'	1980	Shola	Plain
27.	Civet	10°10.331'	77°01.684'	2039	Grassland	Plain
28.	Civet	10°10.335'	77°01.781'	2034	Grassland	Plain
29.	Civet	10°10.337'	77°01.788'	2034	Grassland	Plain
30.	Civet	10°10.594'	77°01.577'	1957	Shola	Plain
31.	Civet	10°10.587'	77°01.456'	1999	Grassland	Slope
32.	Civet	10°09.598'	77°04.315'	2014	Shola	Moderate Slope
33.	Civet	10°09.575'	77°04.286'	2000	Shola	Moderate Slope
34.	Civet	10°09.495'	77°04.161'	1974	Shola	Moderate Slope
35.	Civet	10°09.402'	77°04.092'	1921	Shola	Moderate Slope
36.	Civet	10°09.348'	77°04.086'	1930	Shola	Moderate Slope
37.	Civet	10°09.748'	77°04.495'	2033	Shola	Plain
38.	Civet	10°09.517'	77°04.427'	2061	Shola	Slope
39.	Civet	10°09.528'	77°04.413'	2053	Shola	Slope
40.	Civet	10°11.807'	77°06.666'	1557	Shola	Moderate Slope
41.	Civet	10°11.815'	77°06.638'	1570	Shola	Moderate Slope
42.	Civet	10°11.767'	77°06.716'	1540	Shola	Slope
43.	Civet	10°11.778'	77°06.777'	1548	Shola	Slope
44.	Civet	10°12.087'	77°06.716'	1615	Shola	Moderate Slope
45.	Civet	10°12.103'	77°06.824'	1622	Shola	Moderate Slope
46.	Civet	10°12.550'	77°07.301'	1542	Grassland	Moderate Slope

47.	Civet	10°13.115'	77°07.126'	1554	Shola	Slope
48.	Civet	10°12.840'	77°06.379'	2085	Shola	Plain
49.	Civet	10°16.758'	77°06.119'	2174	Grassland	Plain
50.	Civet	10°16.675'	77°06.353'	2179	Grassland	Plain
51.	Civet	10°16.669'	77°06.367'	2180	Grassland	Plain
52.	Civet	10°13.355'	77°05.275'	1942	Shola	Plain
53.	Mongoose	10°08.666'	77°02.979'	1776	Shola	Slope
54.	Mongoose	10°08.756'	77°03.137'		Shola	Plain
55.	Mongoose	10°08.766'	77°03.154'		Shola	Plain
56.	Mongoose	10°10.445'	77°01.314'	1973	Shola	Plain
57.	Mongoose	10°11.764'	77°06.727'	1541	Shola	Slope
58.	Mongoose	10°12.623'	77°07.127'	1635	Grassland	Plain
59.	Mongoose	10°12.566'	77°07.311'	1529	Shola	Moderate Slope
60.	Mongoose	10°12.711'	77°07.336'	1571	Grassland	Moderate Slope
61.	Mongoose	10°13.233'	77°06.691'	1982	Grassland	Plain
62.	Mongoose	10°12.710'	77°06.547'	2081	Shola	Plain
63.	Mongoose	10°16.547'	77°05.254'	2083	Shola	Slope
64.	Mongoose	10°16.407'	77°05.309'	2063	Shola	Slope
65.	Mongoose	10°16.675'	77°06.340'	2179	Grassland	Plain
66.	Mongoose	10°13.560'	77°03.610'	2237	Grassland	Plain
67.	Mongoose	10°13.887'	77°03.298'	2172	Grassland	Plain
68.	Mongoose	10°14.148'	77°03.522'	2227	Grassland	Plain
69.	Mongoose	10°12.263'	77°05.109'	2204	Grassland	Moderate Slope
70.	Mongoose	10°13.457'	77°05.051'	2080	Grassland	Plain
71.	Mongoose	10°13.401'	77°04.983'	2144	Grassland	Moderate Slope
72.	Otter	10°12.365'	77°07.121'	1555	Grassland	Plain

151	Nilgiri Marten	10°08.592'	77°02.810'	1759	Shola	Plain
152	Nilgiri Marten	10°08.471'	77°02.758'	1724	Shola	Plain

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