STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY, KERALA

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY, KERALA"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Vellanikkara

Date: 20-07-2017

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CERTIFICATE

Certified that this thesis **entitled "STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY, KERALA"** is a record of research work done independently by Mr. Sreekumar. E. R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Sreekumar, E. R.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

INTRODUCTION

INTRODUCTION

The Western Ghats, one of the global biodiversity hotspot running parallel to the west coast of Indian Peninsula, is an isolated 1600km long mountain chain with discontinuity at Palghat Gap and rich in endemic flora and fauna. Western Ghats covers six Indian states *viz.*, Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu and extend from river Tapti (21°N) in Gujarat to southernmost tip of India (8°N). High floral and faunal diversity makes the Western Ghats one of the biodiversity hotspot in the World (Myers *et al.*, 2000).

Mammals have evolved from reptilian ancestors in the Traissic Period (Wilson and Mittermeier, 2009) and considered as the most successful taxa. It is estimated that the first mammal species originated about 225 million years back and they are occupied in all the continents and oceans (Wilson and Mittermeier, 2009). As per the most recent records there are a total of 5,411 species of mammals all over the world grouped in 1231 genera, under 154 families and 29 orders (Wilson and Mittermeier, 2009; Wilson and Reeder, 2005). The Indian mainland harbours 424 species of mammals in 197 genera (Nameer, 2015a) while 32% (137 species) of these species are found in the Western Ghats (Nameer *et al.*, 2001) and Kerala State accounts for 118 species of mammals (Nameer, 2015b).

Mammals less than about 5kg in body weight belonging to the order Carnivora are generally called the small carnivores (Yoganand and Kumar, 1999). There are 194 species of small carnivores in the world and 41 species have been reported from India (Wilson and Mittermeier, 2009; Mudappa, 2013; Menon, 2014). Out of the 14 species of small carnivores distributed in the Western Ghats and the Kerala region has 13 species, which include Felidae (3 species), Herpestidae (4 species), Mustelidae (3 species) and Viverridae (3 species) (Nandini and Mudappa, 2010; Nameer, 2015b). Honey Badger *Mellivora capensis,* a member of

the Mustelidae family, which though occur in the other parts of Western Ghats, is not reported from the political boundaries of Kerala (Nameer, 2015b) (Figure 1).

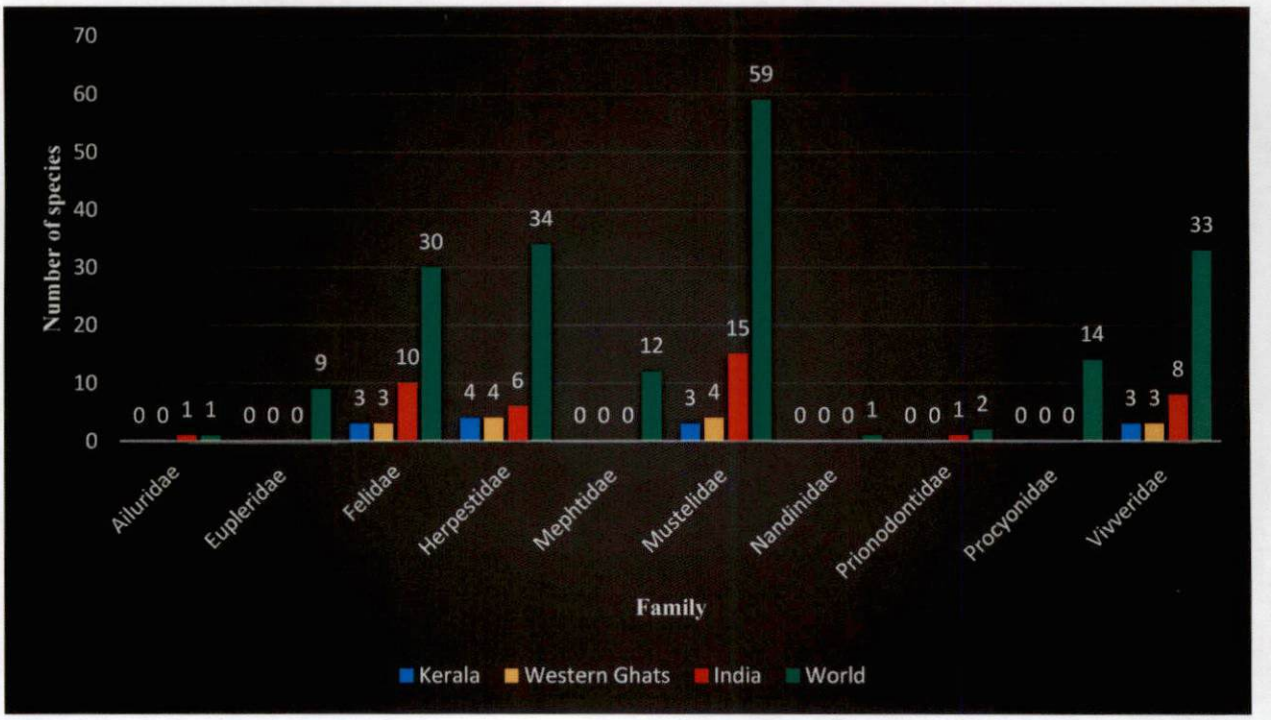


Figure 1. A comparison of small carnivores of India, Western Ghats and Kerala (Schipper *et al.,* 2008; Nandini and Mudappa, 2010; Janardhanan *et al.,* 2014; Nameer, 2015b)

Out of 14 species of small carnivores in Western Ghats, Brown Palm Civet *Paradoxurus jerdoni* and Nilgiri Marten *Martes gwatkinsii* are endemic to the region. The IUCN categorise four species, includes Rusty-spotted Cat *Prionailurus rubiginosus*, Smooth-coated Otter *Lutrogale perspicillata*, Asian Small-clawed Otter *Aonyx cinereus* and Nilgiri Marten *Martes gwatkinsii,* as *Vulnerable* (VU), while the remaining 10 species of small carnivores in Western Ghats have been listed as *Least Concern* (LC) (Table 1).

Table 1. Checklist of small carnivores in Western Ghats along with IUCN Redlist category, WPA (1972) schedules and CITES appendices

Sl. No.	English Name	Scientific Name	Family	IUCN Redlist category	WPA Schedule	CITES Appendix
1.	Brown Palm civet	*Paradoxurus jerdoni*	Viverridae	LC	Sch. II	App. III
2.	Common Palm Civet	*Paradoxurus hermaphroditus*	Viverridae	LC	Sch. II	App. III
3.	Small Indian civet	*Viverricula indica*	Viverridae	LC	Sch. II	App. III
4.	Indian Grey Mongoose	*Herpestes edwardsi*	Herpestidae	LC	Sch. II	App. III
5.	Brown Mongoose	*Herpestes fuscus*	Herpestidae	LC	Sch. II	App. III
6.	Ruddy Mongoose	*Herpestes smithii*	Herpestidae	LC	Sch. II	App. III
7.	Stripe-necked Mongoose	*Herpestes vitticollis*	Herpestidae	LC	Sch. II	App. III
8.	Jungle Cat	*Felis chaus*	Felidae	LC	Sch. II	App. II
9.	Leopard Cat	*Prionailurus bengalensis*	Felidae	LC	Sch. I	App. I
10.	Rusty-spotted Cat	*Prionailurus rubiginosus*	Felidae	VU	Sch. I	App. I
11.	Smooth-coated Otter	*Lutrogale perspicillata*	Mustelidae	VU	Sch. II	App. II
12.	Asian Small-clawed Otter	*Aonyx cinereus*	Mustelidae	VU	Sch. I	App. II
13.	Nilgiri Marten	*Martes gwatkinsii*	Mustelidae	VU	Sch. II	App. III
14.	Honey Badger	*Mellivora capensis*	Mustelidae	LC	Sch. I	App. III

IUCN-International Union for Conservation of Nature; WPA-Wildlife (Protection) Act; CITES- Convention on International Trade in Endangered Species of Wild Fauna and Flora

Source: Schipper *et al.* (2008); Nandini and Mudappa (2010); Janardhanan *et al.* (2014); Nameer (2015b); IUCN (2017); CITES (2017)

Small carnivores occurred in wide variety of habitats *viz.*, tropical rain forest to arid desert, high altitude shola ecosystem and wetland associated ecosystems. Habitat fragmentation and degradation due to increasing human population is the major threat to these lesser known mammals. Here comes the importance of

protection of natural habitats at landscape level. Scientific management and protection of these landscapes may help to the survival of these species.

Small carnivores play key role in ecosystem services and they are an integral component of forest animal communities. They have major roles in the level of predators, seed dispersers and pollinators in tropical forests (Engel, 1998; Nandini and Karthik, 2007; Mudappa *et al.,* 2010; Jothish, 2011). These lesser known animals also act as important prey base for medium sized carnivores and raptors (Mudappa *et al.*, 2010). Small carnivores depend upon large variety of food *viz.*, small mammals, birds, amphibians, reptiles, fishes, invertebrates and often fruits and seeds. Because of this aspect both species diversity and habitat diversity indices help to know the status of small carnivores in that region.

Direct observation of small carnivores may not be easy because of some constrains. Small population, solitary social unit, nocturnal activity and small size are the some of the constrains in the field. Due to these reasons camera traps are preferable to studying the small carnivores (Mudappa, 1998). Along with camera trap study line transect for direct sighting and scat collection and nigh transect using vehicle will help to strengthen the data.

Most of the protected areas in the country do not have a comprehensive inventory on small carnivores. Basic information like distributional range of the species and species diversity data is also lacking (Nameer, 2000). No previous studies have been done on the small carnivores of Wayanad Wildlife Sanctuary, Kerala. It is hoped that the information such gathered, as part of the present study would help to strengthen the scientific management of the small carnivores of Wayanad WLS.

Thus, the objectives of the present study were:

1. To study the diversity of small carnivores of Wayanad WLS
2. To study the status and distribution of small carnivores of Wayanad WLS
3. To study the habitat preference of small carnivores of Wayanad WLS
4. To assess the spatial and temporal variation in distribution of small carnivores using Geographic Information System (GIS) tools.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In the first publication on the Indian mammals by Jerdon (1867), itself there were reference on the mammals of Kerala. Sterndale (1884) discussed about the Natural History of the mammals of Indian region. The first edition of the fauna of British Indian series on Indian mammals were authored by Blanford (1888-1891) and he mentioned about 410 species of mammals. Pocock (1939 and 1941) and Ellerman (1961) published the taxonomic account of mammals of India. Prater (1971) gives the account of Indian mammals and discussed the endemic mammals of Malabar region. Prater (1971) described all common mammals of India in his book, named The Book of Indian Animals. Menon (2003 and 2014) published a book on Indian mammals. Menon (2014) gave an account of about 400 mammals from India.

Sathasivam (1996) listed 158 species of mammals from Tamil Nadu and Kerala. After that Nameer *et al.* (2001) reported 135 species of mammals from Western Ghats. Cheruvat *et al.* (2004) reported 106 species of mammals while Easa and Ramachandran (2005) reported 145 species from Kerala. However, according to Nameer (2015b) reported 118 species of mammals from the political boundaries of Kerala, which include 13 small carnivores from Kerala.

2.1. STUDIES BASED ON DISTRIBUTION AND DIVERSITY OF THE SMALL CARNIVORES

According to Mudappa (1998) camera traps are the best tool for studying small carnivores. They used camera trapping method for studying about nocturnal mammals. Small carnivores of Nilgiri Biosphere Reserve were studied by Yoganand and Kumar (1995) by direct as well as indirect evidences and they surveyed in 12 selected sites in the Nilgiri Biosphere Reserve. Twenty-three species including Red Panda *Ailurus fulgens* and Spotted Linsang *Prionodon pardicolor*

were reported from Arunachal Pradesh and Assam (Choudhury, 1997a, 1997b and 2002; Borah, 2010; Mahar and Kaul, 2012). Distribution of small carnivores, including Red Panda were studied in Darjeeling by Bahuguna *et al.* (1998). They also assessed the population of Red Panda and estimated that not more than 26 individuals were present in the Singalila National Park. Choudhury (1999 and 2000) reported 22 species of small carnivores from West Bengal and 19 species from Nagaland. Mudappa (2002), reported ten species of small carnivores from Kalakad-Mundanthurai Tiger Reserve and she also observed four species of additional carnivores. Choudhury (2004) assessed the status of small carnivores in three different Protected Areas in Assam and reported eight species of small carnivores from Amchang WLS, 11 species from Barail WLS and 12 species from Dihing-Patkai WLS. Kumara and Singh (2006a and 2006b) done a three year study on wild mammals in Karnataka and they reported 11 species of small carnivores from the state. Occurrence and conservation status of small carnivores in Protected Areas in Arunachal Pradesh were studied by Datta *et al.* (2008) and they reported seven species of small carnivores. They used camera trap method for studying the small carnivores and they get high capture rate for Large Indian Civet *Viverra zibetha* among four camera trapped species. Remaining three species of small carnivores were recorded by indirect evidences. Pillay (2009) recorded five species of small carnivores from southern Western Ghats. Five species of small carnivores reported from Chimmony Wildlife Sanctuary by Fasil (2010). Small carnivores of Barsey Rhododendron Sanctuary, Sikkim was studied by Ghose *et al.* (2014) and reported four species. Kumara *et al* (2014) reported nine species of small carnivores from Biligiri Rangaswamy temple Tiger Reserve in Karnataka. Elven species of small carnivores recorded from Parambikulam Tiger Reserve (Sreehari and Nameer, 2016). Nikhil (2015) reported eight species of small carnivores from Eravikulam National Park by assessing 855 camera trap days. Sanghamithra (2016) did an effort of 1450 camera trap days in Silent Valley National Park and recorded seven species of small carnivores.

2.2. SPECIES DISTRIBUTION STUDIES AND OPPORTUNISTIC RECORDS OF THE SMALL CARNIVORES

2.2.1. Family Mustelidae

Ramakantha (1995) studied the natural distribution and ecology of mustelids in Manipur. Four members of mustelids were reported from Ladakh (Shawl *et al.*, 2008). Ved and Lalramnuna (2008) reported Yellow-bellied Weasel *Mustela kathiah* from Mizoram.

Hog Badgers found to be most common among all badgers or ferret badgers in Nagaland (Choudhury, 2000) and Hog badgers shares the same habitat type of Ferret Badgers in Manipur (Ramakantha, 1995). Datta *et al.* (2008) reported the Ferret Badger from Arunachal Pradesh. The presence of the Large-toothed Ferret Badger was recorded from the Garo Hills in Meghalaya and species level confirmation was done from the carcass of animal (Kakati *et al.*, 2014). Small-toothed Ferret Badger and Large-toothed Ferret Badger have extensively overlapping range on the Asian mainland from Bangladesh (and possibly Nepal) in the west, across Bhutan and east China to north-east India and south-east Asia (Pocock, 1941). Both species were occurred in hill forests and grasslands of abandoned *jhums* of Nagaland (Choudhury, 2000).

Yellow-throated Marten *Martes flavigula* was photographed from Arunachal Pradesh and Kyongnosla Alpine Sanctuary, Sikkim (Datta *et al.*, 2008; Khatiwara and Srivastava, 2014). According to Ramakantha (1995) Yellow-throated Marten distributed in the dense forests of Manipur and Teak-Gurjan type forests in the Indo-Myanmar border. The species also reported from Nagaland and restricted in the forest areas (Choudhury, 2000). Honey Badger *Mellivora capensis* is reported from Western Asia and the Indian peninsula, Africa, and the Arabian Peninsula. In India, the species recorded from Karnataka and Gujarat (Do Linh San *et al.* 2016; Joshi and Andavan, 2008; Gubbi *et al.*, 2014).

In India, Asian Small-clawed Otter *Aonyx cinereus* already known from southern Western Ghats and recently the species reported from Maharashtra and Goa and that confirms the distribution of the species in northern Western Ghats (Punjabi *et al.*, 2014).

There have been a series of records of the Niligiri Marten *Martes gwatkinsii* from Western Ghats. These include, Nilgiri Biosphere Reserve (Yoganand and Kumar, 1995), Eravikulam National Park (Madhusudan, 1995; Nikhil, 2015), Peppara Wildlife Sanctuary (Christopher and Jayson, 1996; Raj, 2013), Periyar Tiger Reserve (Kurup and Joseph, 2001), Silent Valley National Park (Christopher and Jayson, 1996; Balakrishnan, 2005; Sanghamithra, 2016), Muthikkulam South Reserve Forest, Attappadi Reserve Forest, Nilambur South Reserve Forests (Balakrishnan, 2005), Anamalai Tiger Reserve, Nelliampathy Reserve Forest, Pambadum Shola National Park (Krishna and Karnad, 2010) and Parambikulam Tiger Reserve (Sreehari and Nameer, 2013; Sreehari and Nameer, 2016).

2.2.2. Family Viverridae

Malabar Civet *Viverra civettina,* though known from historical reports, (Jerdon, 1874; Blyth, 1862; Pocock, 1933), no confirmed evidences for its presence were obtained during the recent searches done specifically for the species in Western Ghats (Kurup, 1989; Rao *et al.*, 2007; Ashraf *et al.*, 2009; Jayson, 2007). After reviewing all available records, Nandini and Mundappa (2010) ruled out the distribution of Malabar Civet from Western Ghats.

Small Indian Civet distributed all over India (Menon, 2014). It has been recorded from Kashmir by Charoo *et al.* (2010). Small Indian Civet was reported from various parts of Western Ghats *viz.*, Parambikulam TR (Sreehari and Nameer, 2016), Eravikulam NP (Nikhil, 2015), Silent Valley NP (Sanghamithra, 2016),

Kalakad-Mundanthurai TR (Mudappa, 2002), Biligiri Rangaswamy TR (Kumara *et al.*, 2014) etc. Common Palm Civet occurred in all the parts of India except Himalayas and arid western parts (Menon, 2014). According to Ramakantha (1995), Common Palm Civet found in north-east India have variation in body markings when compared to south Indian forms. The animal was photo captured from north-east India (Datta *et al.,* 2008) and Western Ghats (Mudappa, 2002; Kumara *et al.*, 2014; Nikhil, 20105; Sreehari and Nameer, 2016). Brown Palm Civet or Jerdon's Palm Civet *Paradoxurus jerdoni* is endemic to Western Ghats and reported from rain forests of above 500m altitude (Ashraf *et al.*, 1993; Mudappa, 1998). Rajamani *et al.* (2002) studied the status and distribution of the species in Western Ghats. They assessed all museum records and previous records in literature, and they also conducted a survey exclusively for Brown Palm Civet. They recorded the Brown Palm Civet from 12 different study locations and all the study locations comes under either west coast tropical evergreen forest or southern gill top tropical evergreen forest. Mudappa and Chellam (2002) attempted to do a capture immobilization survey on Brown Palm Civet. The species was recorded from Nilgiris, Anamalais, Coorg (Schreiber, 1989), Silent Valley (Ramachandran, 1990; Sanghamithra, 2016), Kakachi-Upper Kodayar (Ganesh, 1997) Kalakkad-Mundanthurai Tiger reserve (Ganesh, 1997; Mudappa, 1998; Mudappa, 2002) and Parambikulam TR (Sreehari and Nameer, 2016). Brown Palm Civet with lighter in colour, pale abdomen and face markings reported from Maharashtra (Bhosale *et al.*, 2013). Also, a white-coated individual reported from the Amboli hills of Maharashtra by Chunekar (2014). These two records help to understand about the northern Western Ghats distribution of Brown Palm Civet. Detailed status and distribution study helps to understand that the species were not as unusual as they were thought to be (Mudappa, 2001; Nandini *et al.*, 2002).

First camera trap record of Small-toothed Palm Civet *Arctogalidia trivirgata* was recorded from Meghalaya (Kakati and Srikant, 2014). Murali *et al.* (2014) studied about the Small-toothed Palm Civet in Arunachal Pradesh.

2.2.3. Family Herpestidae

Indian Grey Mongoose *Herpestes edwardsii* is commonly found near to the human settlements and distributed throughout India except in the parts of Himalayas (Menon, 2014; Mudappa, 2013). The species specifically reported from the forests of Western Ghats *viz.*, Parambikulam TR (Sreehari and Nameer, 2016), Eravikulam NP (Nikhil, 2015) and Biligiri Rangaswamy TR (Kumara *et al.*, 2014). Stripe-necked Mongoose *Herpestes vitticollis* distributed in Western Ghats and Sri Lanka. According to Allen (1911) the species distributed in Eastern Ghats. Recent studies help us to understand the distribution of the species in north-central Western Ghats (Punjabi *et al.*, 2014). The Stripe-necked Mongoose also distributed in Similipal Tiger Reserve, Odisha, and Eastern India (Nayak *et al.*, 2014). Stripe-necked Mongoose was reported from Parambikulam TR (Sreehari and Nameer, 2016), Eravikulam NP (Nikhil, 2015), Silent Valley NP (Sanghamithra, 2016) and Biligiri Rangaswamy TR (Kumara *et al.,* 2014). Ruddy Mongoose *Herpestes smithii* is reported from Parambikulam Tiger Reserve and Chinnar Wildlife Sanctuary (Sreehari *et al.,* 2013). Dookia (2013) recorded Ruddy Mongoose from Eserna hill range, in the western part of the Aravalli Hills. Brown Mongoose *Herpestes fuscus* was reported from Kalakkad-Mundunthurai TR (Mudappa, 1998; Mudappa, 2002), Anamalai Tiger Reserve (Mudappa *et al.*, 2007), Valparai (Mudappa *et al.*, 2007; Navya *et al.*, 2014) Peeramedu (Mudappa, 2006), Parambikulam TR, Eravikulam National Park (Sreehari *et al.*, 2013), Pampadum Shola National Park, Shendurney WLS, Peppara WLS and Periyar TR (Sreehari *et al.*, 2016). Crab-eating Mongoose *Herpestes urva* was reported from Assam (Sinha and Das, 2012).

2.2.4. Family Felidae

Three species of lesser cats (Jungle Cat *Felis chaus,* Rusty-spotted Cat *Prionailurus rubiginosus* and Asiatic wild Cat *Felis silvestris*) reported from eastern Gujarat (Patel, 2011). Gogate (1997) reported five species of lesser cats from Maharashtra, which includes Jungle Cat. The species was recorded from

Sikkim by Jha (2000). From Western Ghats, the species was reported from Parambikulam TR (Sreehari and Nameer, 2016), Eravikulam NP (Nikhil, 2015), Kalakad-Mundanthurai TR (Mudappa, 2002) and Biligiri Rangaswamy TR (Kumara *et al.*, 2014). Mukherjee and Groves (2007) studied the geographic variations in Jungle Cat. The Rusty-spotted Cat has been reported from Jammu and Kashmir (Chakraborty, 1978), Gujarat (Chavan *et al.*, 1991), Rajasthan (Tehsin, 1994; Nayak *et al.*, 2017), Madhya Pradesh (Digveerendrasinh, 1995), Orissa (Acharjyo *et al.*, 1997), Maharashtra (Dubey, 1999), Tadoba (Karnat, 1999) and Andhra Pradesh (Rao *et al.*, 1999; Manikadan and Sivakumar, 2005). Rusty-spotted Cat was also reported from Kalakad-Mundanthurai TR (Mudappa, 2002), Biligiri Rangaswamy TR (Kumara *et al.*, 2014) and east coast of Tamil Nadu (Guptha and Ramanujam, 2017). Leopard Cat *Prionailurus bengalensis* was reported from Peppara Wildlife Sanctuary (Jayson and Christopher, 1996), Parambikulam TR (Sreehari and Nameer, 2016), Eravikulam NP (Nikhil, 2015), Silent Valley NP (Sanghamithra, 2016), Kalakad-Mundanthurai TR (Mudappa, 2002), Biligiri Rangaswamy TR (Kumara *et al.*, 2014), Kyongnosla Alpine Sanctuary, Sikkim (Jha, 2000; Khatiwara and Srivastava, 2014), and Namdapha National Park, Arunachal Pradesh (Datta *et al.*, 2008). According to Sathyakumar *et al.* (2011) Leopard Cat is the most abundant lesser cat in Khangchendzonga Biosphere Reserve. The species is not recorded from the Deccan Plateau, arid areas of Rajasthan and Gujarat and very south of India (Menon, 2014).

Fishing Cat *Prionailurus viverrinus* found to be very common species in Sundarbans and rare in the other parts of the West Bengal (Bhattacharya, 1989). The species is also reported from Terai region, Himalaya (Choudhury, 2003) and Sikkim (Jha, 2000). Janardhanan *et al.* (2014) hypothesize that the species perhaps never occurred along the western coast of India due to higher salinity levels as compared to the eastern coast.

2.2.5. Family Prionodontidae

Spotted Linsang *Prionodon pardicolor* was reported from Assam (Borah, 2010), Arunachal Pradesh (Lyngdoh *et al.*, 2011; Mahar and Kaul, 2012) and Sikkim (Ghose *et al.*, 2012).

2.3. STUDIES RELATED TO THE ECOLOGY AND BEHAVIOR OF SMALL CARNIVORES

Feeding behaviour of Nilgiri Marten was observed by Hutton (1944). Nandini and Karthik (2007) observed that Yellow-throated Marten feeding on flowers in Balpakram National Park in Meghalaya. Major diet of Honey Badger includes flesh and supplemented by other vegetarian diets (Menon, 2014). Mating behaviour of *Millivora capensis* was studied by Pillai (2000). Fishes are the preferred food of otters (Hussain and Choudhury, 1998) and Haque and Vijayan (1995) studied the feeding ecology of Smooth-coated Otter under captivity. Anoop and Hussain (2004 and 2005) studied ecology and feeding behaviour of Smooth-coated Otter *Lutrogale perspicillata* using spraint analysis in Periyar Tiger Reserve. They identified the fish was the major prey of Smooth-coated Otter, followed by frogs, crabs, birds and insects. Perinchery *et al.* (2011) studied the habitat parameters that effects the distribution and movement of Asian Small-clawed Otter *Aonyx cinereus* in high altitude streams. Asian Small-clawed Otter prefers third order streams than first order streams and movement of the species according to the water level in the streams (Perinchery *et al.*, 2011). Aneesh (2012) observed the feeding behaviour of Asian Small- clawed Otter in Eravikulam National Park and crab (90%) includes the major diet of the species followed by insects (5%), fish (3%) and other vertebrate remains (2%). He followed spraint analysis as the method of the study. Habitat preference of Asian Small- clawed Otter studied by Prakash *et al.* (2012) and observed that the otters have a fairly high habitation in protected areas and neighbouring human landscapes. Group size, group structure and breeding behaviour of otters in the lower Himalayas was observed by Hussain (1996 and 1998). According to Anoop and Hussain (2005) otter prefers selected areas with

low water depth and width with a gentle slope and more number of streams joining the lake and a less rockiness. Shenoy (2006) observed that the higher percentage of loose sand on the river banks was a potential factor for the site selection by Smooth-coated Otter and areas having high human disturbances were avoided by them.

Feeding ecology of Common Palm Civet in semi urban areas was observed by Krishnakumar and Balakrishnan (2003). Eighteen fruit species preferred by Common Palm Civet and seeds collected from the scat of Common Palm Civet have high germination percentage (Borah and Deka, 2011). The species act as effective seed disperser of forests plants (Jothish, 2011). Borah and Deka (2011) studied the mating behaviour of the Common Palm Civet. Choudhury (1981) observed that Indian Grey Mongoose predate on Gharial *Gavialis gangeticus* eggs. Ruddy Mongoose is an excellent tree climber and hunts on trees and carries prey on to the trees for feeding (Shekhar, 2003). Rompaey and Jayakumar (2003) studied the food and feeding habits and reproductive aspects of Stripe-necked Mongoose. Ramachandran (1985) observed the scavenging behaviour of Stripe-necked Mongoose at Periyar TR.

Mukherjee (2013) studied the significance of rodents in the diet of Caracal *Caracal caracal* and Jungle Cat *Felis chaus*. They found that the rodents constituted up to 70% of the daily metabolizable energy in lesser cats. Chakraborty *et al.* (1988) reported melanism in Jungle Cat. Rodents are the most preferable food of Leopard Cat followed by insects, birds, plant materials, agamids and crabs (Khan, 2004). Nayerul and Vijayan (1993) studied the feeding habits of the Fishing Cat in Keoladeo National Park. Scavenging behaviour of Fishing Cats was studied by Haque (1988). Importance of rodents in diet of Fishing Cat was studied by Mukherjee *et al.* (2004). Bhattacharya (1992) studed the breeding behaviour of Fishing Cat.

2.4. STUDIES ON THE THREATS TO THE SMALL CARNIVORES

Small carnivores play major roles in ecosystem functioning such as predator, seed dispersers and scavengers. In highly human populated areas status of these animals are under great concern in understanding ecosystem integrity. Small carnivores are hunted and traded for various purposes (Lau *et al.*, 2010). Datta *et al.* (2008) studied the threats, reasons of threats and conservation aspects of small carnivores of Arunachal Pradesh.

Hog Badgers and Ferret Badgers were poached for the purpose of food and medicine (Ramakantha, 1995). Heavy habitat loss and fragmentation is the main threat of Nilgiri Marten (Mudappa *et al.*, 2015). Construction of hydro-electric project, water pollution and loss of wetland habitats were reported as the threats to otters (Dehadrai and Ponniah, 1997). Small Indian Civets were harvested for their skin in China (Lau *et al.*, 2010). The animal is also used for getting their perineal secretion civetone, a raw ingredient in the perfume, medicine and other industries (Balakrishnan and Sreedevi, 2007; Chutipong *et al.*, 2014). Habitat loss and degradation is also a major threat to Small Indian Civets. Habitat loss and fragmentation due to raising of plantations and illegal hunting is the major threat to the Brown Palm Civet (Ashraf *et al.*, 1993; Gupta, 2004; Mudappa *et al.*, 2007).

Habitat degradation is the potential threat to the Stripe-necked Mongoose (Van Rompaey and Jayakumar 2003). Conflict with poultry farmers, hunting by domestic dogs and local hunting are the other threat factors to the species (Adams, 1931; Webb-Peploe, 1947). Habitat destruction due to the expansion of agriculture, urbanisation and industrialisation are the main threat to lesser cats (Duckworth *et al.*, 2005). Poaching of Leopard Cat for their skin, as food and as pets (McCarthy, 2013), is another threat.

MATERIALS AND METHODS

MATERIALS AND METHODS

3.1. STUDY AREA

Wayanad, major part of Nilgiri Biosphere Reserve, under the administration of North Wayanad Forest Division, South Wayanad Forest Division and Wayanad Wildlife Division. Wayanad is contiguous with Bandipur Tiger Reserve and Mudumalai National Park in the South and Southeast and Rajiv Gandhi National Park in the North and Northeast (between 11° 20′ and 12° 7′ N latitude and between 75°28′ and 76° 36′ E longitude). The total extent of area is about 520.78 km^2, of which 344.44 km^2 forms the Wayanad Wildlife Sanctuary (Figure 2).

'Wayanad' derives its name from the numerous swamps (locally called as *vayals*). Coffee was probably the first plantation crop to be introduced into Wayanad in 1828 and by 1839. Paddy was the commonest crop and was cultivated in the swamps. The dry higher grounds were cultivated with crops such as *ragi* and *chama*. These were often grown on the shifting system. Wildlife was so numerous that crop raiding was frequent. One of the characteristics of Wayanad fields is the large number of watchers or raised platforms (machans) which are dotted about them.

The annual rainfall varies from 1200-1700 mm and maximum precipitation is from June to September. The South West monsoon brings the greater part of the total rainfall bursts normally by first week of June proceeded by a few showers in April and May. Mean atmospheric temperature in Southern Ranges varied from a monthly maximum of 31°C in March to 24°C in July and monthly minimum of 19°C in May to 14°C in December. The average relative humidity ranged between 60.4% in January and 87.6% in June.

Northern portion of Kurichiat Range is drained by Kannarampuzha and Kurichiat Thodu flowing northward and joining Kabini river. Cheru Puzha, Bavali

Puzha and Chedalathu Puzha are the other drainage systems in Wayanad WLS (Nair, 1991; Easa and Sankar, 2001).

A long belt of Dry Deciduous Forest exists in the areas bordering Tamil Nadu and Karnataka. About one third of the sanctuary is covered by plantations of teak, eucalypts and mixed species interspersed with bamboo. The forest types could be broadly classified into the following categories (Champion and Seth, 1968).

3.1.1. Southern Moist Mixed Deciduous Forest (3B/C_2)

The Southern Moist Mixed Deciduous Forest covers most of the area of sanctuary. Moist deciduous forests are interspersed with seasonally waterlogged areas in the depressions known as *vayals* (marshy/wet lands). Vayals are dominated by grass and are devoid of tree cover. The moist deciduous forest has a moderate canopy cover (50-70%) during the wet seasons. During the dry season, most of the trees shed leaves and canopy cover is comparatively less (10-20%). Bamboo brakes (*Bambusa arundinacea*) are distributed sporadically all over the habitat. It is also found all along the perennial streams and in the wet areas. The upper canopy consists of *Terminalia tomentosa, Terminalia bellirica, Terminalia paniculata, Pterocarpus marsupium, Tectona grandis, Grewia tiliaefolia, Adina cordifolia* etc. A few climbers like *Butea parviflora, Caesalpinia sp., Calycopteris floribunda* are also seen. Grasses such as *Cyrtococcum patens, Apluda mutica and Oplismenus compositus* are thinly distributed with low productivity. Fire occurrence is comparatively less in this type of forests.

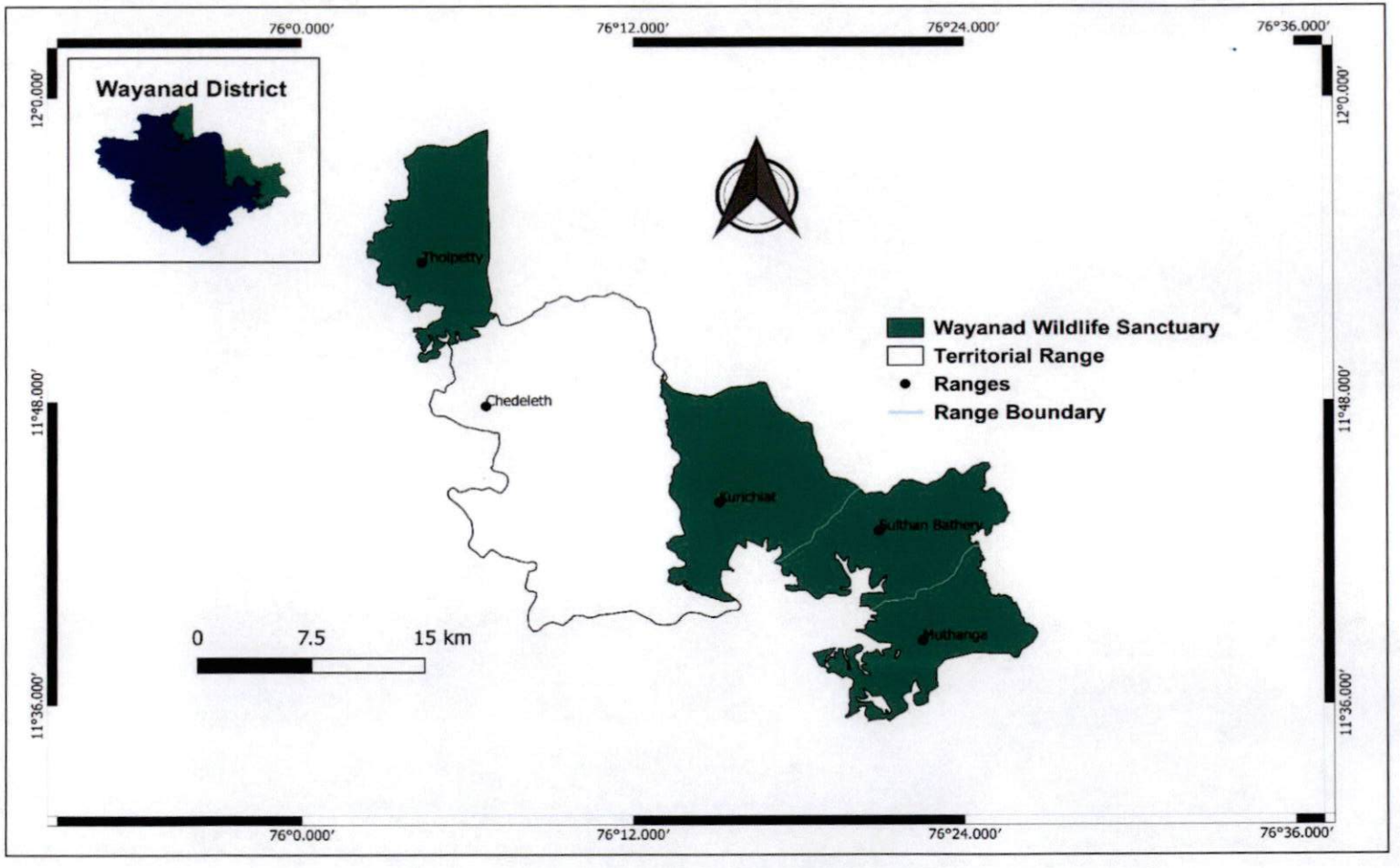
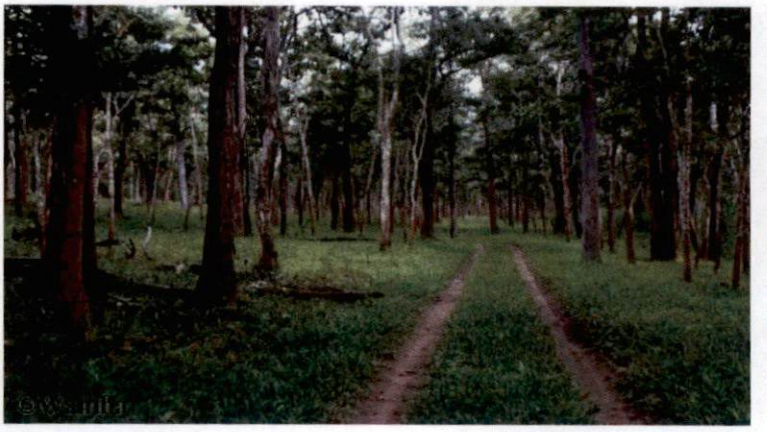


Figure 2. Location map of Wayanad Wildlife Sanctuary



Natural Forest

Swamp (*Vayal*)

Eucalyptus Plantation

Plate 1. Habitats available in Wayanad Wildlife Sanctuary

3.1.2. Southern Dry Mixed Deciduous Forest (5A/C3)

The dominant tree species are *Shorea roxburghii, Anogeissus latifolia, Terminalia alata, Terminalia chebula, Pterocarpus marsupium, Gmelina arborea, Schrebera sweitenioides, Diospyros montana, Schleichera oleosa, Grewia tiliaefolia, Dalbergia latifolia, Mitragyna parvifolia, Bauhinia racemosa, Xeromphis uliginosa* and *Tectona grandis*. Grass species such as *Themeda cymbaria, Themeda triandra, Cymbopogon flexuosus* and *Imperata cylindrica grow* more than 200 cm in height and form a dominant ground cover. The canopy layer of the trees is broken due to the spatial distribution as well as comparatively low tree density. Canopy cover is less (10-20%) during dry season. The bamboo (*Bambusa arundinacea*) is less frequented compared to moist deciduous forest. In the dry deciduous forests, the *vayals* are comparatively less and are dominated by tall grass (*Themeda sp.* and *Pennisetum hohenackeri*).

3.1.3. Plantations

Total area of the plantation in the study area is about 163 km^2, which includes pepper, eucalypts, teak and mixed softwood species. Eucalypts plantations do not have any other tree species except a few saplings of *Cassia fistula* and *Terminalia sp*. The whole plantation is occupied by *Lantana camara* Tall grasses *viz*., *Themeda cymbaria, Themeda triandra* and *Cymbopogan flexuosus* are found in open areas in the plantations. In Teak plantations, apart from a few deciduous tree species, *Helicteres isora* occupy a large proportion of the area (Plate 1).

3.2. METHODS

3.2.1. Period of Observation

Reconnaissance of the study area was done during November 2016. Five study locations were selected after the reconnaissance. Intensive field work carried

out from November 2016 to February 2017. Ten days each of field work were spent in each of the five study locations *viz.*, Kurichiat, Muthanga (natural forest), Muthanga (*Senna spectabilis* area), Sulthan Batheri and Tholpetty.

3.2.2. Site Selection

Reconnaissance survey in each of the study location help to identify the potential activity sites of the small carnivores based on the indirect evidences of small carnivores viz., scats, scratches and pug marks. Line transect and camera trapping methods were the main techniques for studying small carnivores in the Wayanad Wildlife Sanctuary. Scats, spraints, pugmarks, scratches etc. were taken as the indirect evidences of small carnivores.

3.2.3. Camera Trap Survey

Camera trapping technique is the one of the best method to study the small carnivores (Mudappa, 1998). Digital camera with infra-red sensors for heat and motion detection sensor (Model: Cuddeback Attack C1) was used for the study. Based on the detection of indirect evidences *viz.,* presence of scats, pug marks and scratches, of the small carnivores a total of 111 camera trap stations were identified. The camera traps were set at a height of 30cm – 40cm above the ground and kept at least 150m apart from each other (Plate 2). The cameras were set up in default mode with the time-delay as fast as possible between pictures in day time and of five seconds between pictures during night. The camera trap locations were marked using a Garmin GPS etrex 30. The cameras were kept open for 24 hours a day and remained open for 10-20 days in each station. The date and time of exposure were automatically recorded on the images, as and when the images were taken. Thus, a total of 1932 camera-trap days with 46,368 trapping hours were carried out in the Wayanad WLS. The camera trap data is given in Appendix I.

Plate 2. A-Camera trap; B-Fixing camera trap; C-Camera trap in the field

3.2.3.1. Relative abundance

The relative abundance of the small carnivores is calculated by the following formula.

$$Relative\ Abundance, RA = \frac{Number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ individuals\ of\ small\ carnivores} \times 100$$

3.2.3.2. Camera trap success rate

The camera trap success rate of the small carnivores calculated by using the following formula.

$$Camera\ trap\ success\ rate = \frac{Number\ of\ images\ captured\ of\ a\ species}{Total\ number\ of\ images\ taken\ by\ camera\ trap} \times 100$$

3.2.3.3. Time activity pattern

Time activity of the small carnivores are calculated for each 1hr interval using the formula:

$$Time\ activity\ percent\ in\ given\ time\ interval = \frac{No.individuals\ of\ a\ speceis\ recorded\ in\ a\ given\ time\ interval}{Total\ no.individuals\ recorded\ for\ the\ same\ speceis} \times 100$$

Using the data of each interval of time plot a graph with percent of activity against active time.

3.2.4. Line Transect Survey for Both Direct and Indirect Evidence

In each study locations five random transects of 2km long were taken at 07:00hrs in the morning. Transects were marked using Global Positioning System. A total of 25 transects were laid which covers a distance of 50km. Direct sighting and indirect evidences of small carnivores were recorded on these transects. The scats were identified to the family level or to the species level using the keys developed by Silveira *et al.* (2003); Su (2005); Sridhar *et al.* (2008).

3.2.5. Micro-habitat Parameters

Micro-habitat parameters were documented at each of the study locations. All these observations were made within five-meter radius circular plot taking camera trap station as the center of the circle. Twenty-two micro-habitat parameters were studied. The parameters were Canopy Height, Canopy Closure, Litter Depth, Shrub Density, Tree Density, Climber Density, Buttress Density, Density of Canes, Presence of Reeds or Bamboo, Distance to Largest Tree, Presence of Hole, Presence of Waterbody, Width of the Waterbody, Depth of the Waterbody, Presence of Rock, Presence of Fruiting Tree, Presence of Swamp, Presence of Roots, Presence of Roads, Presence of Log, Girth at Breast Height (GBH) of the Largest Tree, and Slope of the terrain.

Canopy height is defined as the height of the highest vegetation components above ground level (Balzter *et al.,* 2007). Which is estimated using clinometer or visual estimation. Canopy cover is the area of ground covered by a vertical projection of the canopy (Jennings *et al.,* 1999). It is estimated by visual estimation. Litter depth is the thickness of the litter layer is measured around the trap using calibrated probe. An average of four measurements taken in a camera trap station. Girth at breast height is measured for trees within the 5m radius with a girth more than 30 cm. Densities of shrubs, trees, climbers, buttresses and canes are estimated within 5 m radius around the camera trap point. Distance to the nearest large tree

is measured with a tape to a tree > 60 cm girth with in the vicinity. Presence or absence of rocks, fruiting tree, swamp, forest paths, natural hollow in the trees, logs and roots were recorded. Presence or absence of water body is recorded and if it is present width of water body is measured. Slope of the terrain is calculated in degrees using clinometer.

Apart from these the gross habitat features such as vegetation type and the GPS location of the study site were also documented and the relationships was worked out between these and the animal abundance (Mudappa *et al.* 2001).

3.3. DATA ANALYSIS

In the present study the species richness, species diversity and relative abundance were calculated using PAST package (Hammer *et al.*, 2001). The details of indices used in present study are given below.

3.3.1. Margalef's Diversity Index

Margalef's index gives the species richness of an area. The formula for calculation of the Margalef's diversity index is given below (Magurran, 1988).

$$D_{Mg} = \frac{S-1}{\ln N}$$

Where S = *number of species in given area;*

N = *total number of individuals of* 'S' *species*

3.3.2. Diversity Indices

3.3.2.1. Shannon-Wiener Index, H

The Shannon-Wiener index (Shannon and Wiener, 1963) is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of 'S' species and 'N' individuals will belong. This average uncertainty increases and as the distribution of individuals among the species becomes even. Thus H' has two properties that have made it a popular measure of species diversity: (1) H'=0 if and only if there is only one species in the sample, (2) H' is maximum only when all 'S' species are represented by the same number of individuals, that is, a perfectly even distribution of abundance (Ludwig and Reynolds, 1988; Magurran, 1988).

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

$$H' = \sum (P_i * \ln P_i)$$

Where H'

= average uncertainty per species in the infinite community made up of 'S' species with known proportional abundance $P_1, P_2, P_3, P_4, \ldots\ldots\ldots\ldots P_s$

3.3.3. Estimation of Dominance

The group of heterogeneity indices are known as dominance measures since they are weighted towards the abundance of the commonest species rather than providing a measure of species richness.

3.3.3.1. Berger-Parker index (d)

Berger-Parker index is very simple dominance index. It expresses the proportional importance of the most abundant species (Magurran. 1988).

The equation to calculate Berger-Parker index is given below:

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

$$Where\ N_{max} = the\ number\ of\ individuals\ in\ the\ most\ abundant\ species$$

$$N = total\ number\ of\ individuals$$

3.3.4. Statistical Analysis

The statistical analysis done in the data includes binary logistic regression and test of association was done using SPSS.

3.3.4.1. Binary logistic regression

Logistic regression is a probabilistic statistical classification model. This is done to determine the relationship between an outcome variable and a predictor variable. Logistic regression can handle not only continuous data but also discrete data as independent variables. When the outcome variable is binary, binary logistic regression analysis is used. In logistic regression, the conditional mean is bounded between 0 and 1 and the conditional distribution of the outcome variable is binomial distribution. They are generally continuous which use probability scores as the predicted values of the dependable variable. The model of binary regression is given below.

$$Logit\ [p(y = 1(x_1,\ x_2,\ x_3,\ \ldots\ldots x_p)) \div (1 - p(y = 1(x_1,\ x_2,\ x_3,\ \ldots\ldots x_p))]$$

The classification table is a method to evaluate the predictive accuracy of the logistic regression model (Peng and So, 2002). In this table, the observed values for the dependent outcome and the predicted values (at a user defined cut-off value) are cross-classified. For example, if a cut-off value is 0.5, all predicted values above 0.5 can be classified as predicting an event and all below 0.5 as not predicting the event.

If the logistic regression model has a good fit, then 'a' and 'd' cells have higher counts and 'b' and 'c' cells have fewer counts.

3.3.4.1.1. Test of association

The Karl Pearson's chi square test is used to test the significance of association between variables. Here the null hypothesis is that;

H_o = The two variables are independent or there is no significant association between two variables (Ludwig and Reynolds, 1988).

If the p-value is greater than 0.05, we will accept the null hypothesis. That means, statistically there is no significant association between two variables. The strength of the association was also calculated by using the tests of *Phi* and *Cramer's V*. The value ranges from -1 to 1. If the value is negative it is an indication of negative relation.

3.3.4.1.2. Odds of an event ratio

Odds of an event are the ratio of the probability that an event will occur to the probability that it will not occur. If the probability of an event occurring is p and the probability of the event not occurring is $1 - p$ then the corresponding odds is a value given by

$$odds\ of\ an\ event = \frac{p}{1-p}$$

For every one unit increase in the predictor variable the odds will be increased by a factor.

Significance of the impact of predictor variables can be arrived from the range of lower and upper limit of 95% confidence interval for odds. When the value one where the regression coefficient will be zero lies in between the lower and upper limits the conclusion is that there is no significant impact by predictor variable on the presence of the species. If the value one lies outside the range of 95% confidence interval, then it indicates the significant impact of predictor variables.

3.3.5. Discriminant Analysis

Differential preferences of the species for the studied habitat variables are examined using discriminant analysis. It shows whether there is any niche partitioning between and among the species with respect to the studied habitat variables. The analysis was done using XL STAT.

RESULTS

RESULTS

4.1. SPECIES COMPOSITION OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

The current study reveals the presence of nine species of small carnivores in the Wayanad WLS. These nine species comes under four families *viz.*, Mustelidae (one species), Viverridae (three species), Herpestidae (three species) and Felidae (two species) (Table 2). All the nine species were detected in the camera traps.

Table 2. Small carnivores recorded from Wayanad Wildlife Sanctuary

Sl. No.	Species	Scientific Name	Family
1.	Asian Small-clawed Otter	*Aonyx cinereus*	Mustelidae
2.	Small Indian Civet	*Viverricula indica*	Viverridae
3.	Common Palm Civet	*Paradoxurus hermaphroditus*	Viverridae
4.	Brown Palm Civet	*Paradoxurus jerdoni*	Viverridae
5.	Indian Grey Mongoose	*Herpestes edwardsii*	Herpestidae
6.	Ruddy Mongoose	*Herpestes smithii*	Herpestidae
7.	Stripe-necked Mongoose	*Herpestes vitticollis*	Herpestidae
8.	Jungle Cat	*Felis chaus*	Felidae
9.	Leopard Cat	*Prionailurus bengalensis*	Felidae

The number of individuals of small carnivores recorded using camera traps and transect method (direct sighting) in Wayanad WLS is given in Table 3. In the transect method only the Indian Grey Mongoose was sighted, while all the nine species were captured in the camera traps, thus highlighting the efficiency of the camera trap method for studying the small carnivores.

Table 3. Number of individuals of small carnivores recorded using camera trap and transect method (direct sighting) in Wayanad Wildlife Sanctuary

Method of Study	Number of individuals								
	Asian Small-clawed Otter	Small Indian Civet	Common Palm Civet	Brown Palm Civet	Indian Grey Mongoose	Ruddy Mongoose	Stripe-necked Mongoose	Jungle Cat	Leopard Cat
Camera Trapping	3	46	15	10	5	11	39	1	3
Transect Method (Direct Sighting)	0	0	0	0	1	0	0	0	0

4.2. STUDY OF SMALL CARNIVORES USING CAMERA TRAP METHOD IN WAYANAD WILDLIFE SANCTUARY

There were 111 camera trap stations established in Wayanad WLS (Figure 3). These camera traps effectively covered 1932 camera trap days (46,368 hours) in five study locations of Wayanad WLS. Details are given the Table 4.

Table 4. Camera trap effort in the study locations of Wayanad Wildlife Sanctuary

Study Location in Wayanad Wildlife Sanctuary	Camera Trap Effort	
	Days	Hours
Kurichiat	294	7056
Muthanga 1	440	10560
Muthanga 2	462	11088
Sulthan Batheri	460	11040
Tholpetty	276	6624

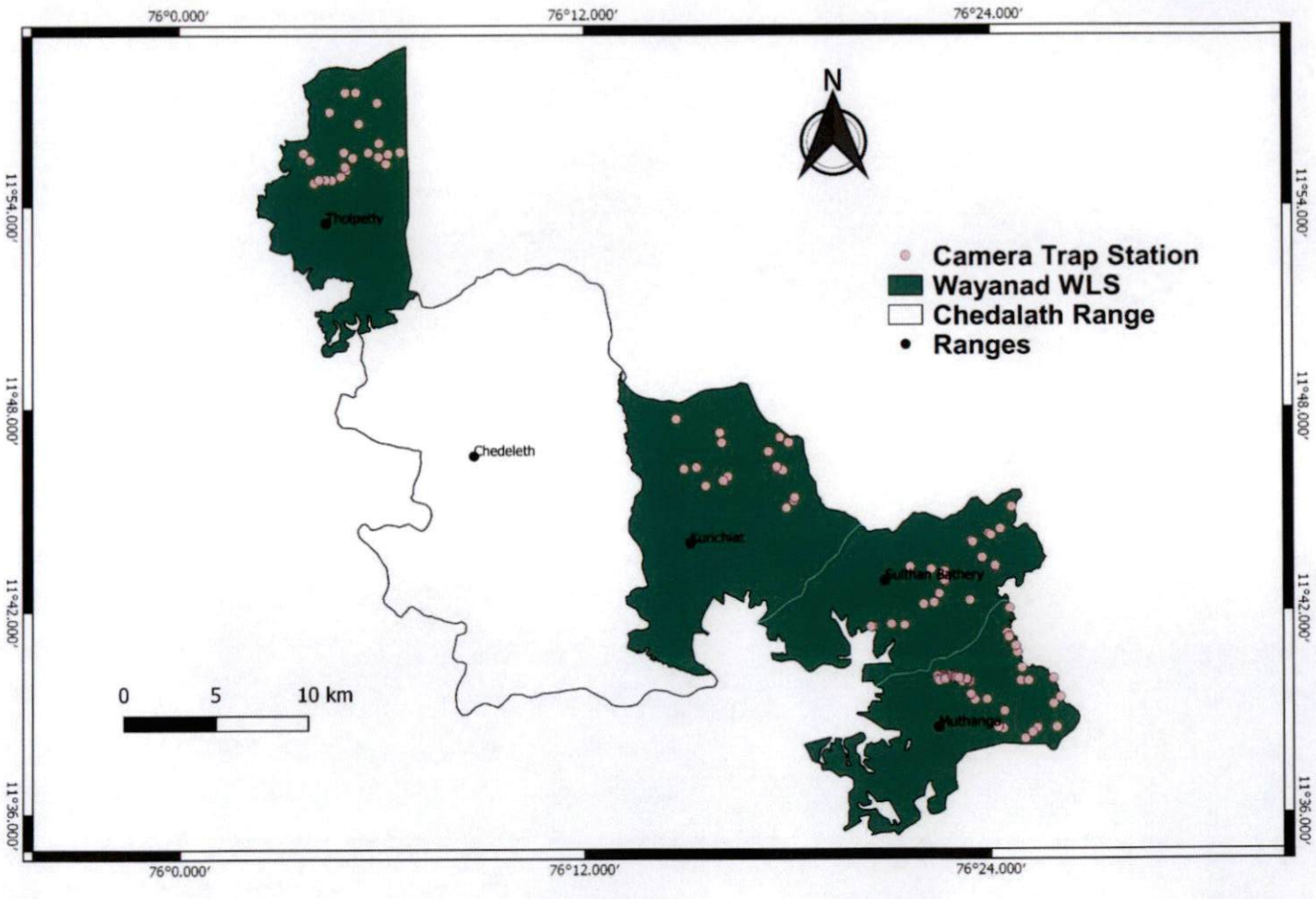


Figure 3. Camera trap stations in different study locations of Wayanad Wildlife Sanctuary

Plate 3. A – Asian Small-clawed Otter; B – Brown Plam Civet

Plate 4. C – Common Palm Civet; D – Small Indian Civet

Plate 5. E – Indian Grey Mongoose; F – Ruddy Mongoose

Plate 6. G – Stripe-necked Mongoose; H – Jungle Cat

Plate 7. Leopard Cat

A total of 4084 photographs were recorded and which includes 25 species of mammals, 18 species of birds and two species of reptiles. Out of twenty-five mammals 13 species comes under Order Carnivora and they represented in 395 photographs, among this 123 (31.14%) photographs (includes 132 individuals) were small carnivores in nine species. Small Indian Civet (34.6%) was the most common species in small carnivores of Wayanad WLS followed by Stripe-necked Mongoose (29.3%), Common Palm Civet (11.3%), Ruddy Mongoose (8.3%), Brown Palm Civet (7.6%), Indian Grey Mongoose (3.8%), Leopard Cat (2.3%), Asian Small-clawed Otter (2.3%) and Jungle Cat (0.8%) (Figure 4).

4.2.1. Camera Trap Success Rate in Wayanad Wildlife Sanctuary

The overall small carnivore success rate of camera traps in Wayanad WLS is 6.4% (124 images of small carnivores from 1932 camera trap days), recording nine species of small carnivores. When we look for species camera trap success, Small Indian Civet (2.38%) has maximum success rate and Asian Small-clawed Otter (0.1%) and Jungle Cat (0.1%) has minimum success rate (Table 5).

Table 5. Camera trap success rate of small carnivores of Wayanad Wildlife Sanctuary

Species	No. Images Captured	Camera Trap Success Rate (%)
Small Indian Civet	46	2.4
Stripe-necked Mongoose	33	1.7
Common Palm Civet	15	0.8
Brown Palm Civet	10	0.5
Ruddy Mongoose	10	0.5
Indian Grey Mongoose	5	0.3
Leopard Cat	3	0.2
Asian Small-clawed Otter	1	0.1
Jungle Cat	1	0.1
TOTAL	**124**	**6.4**

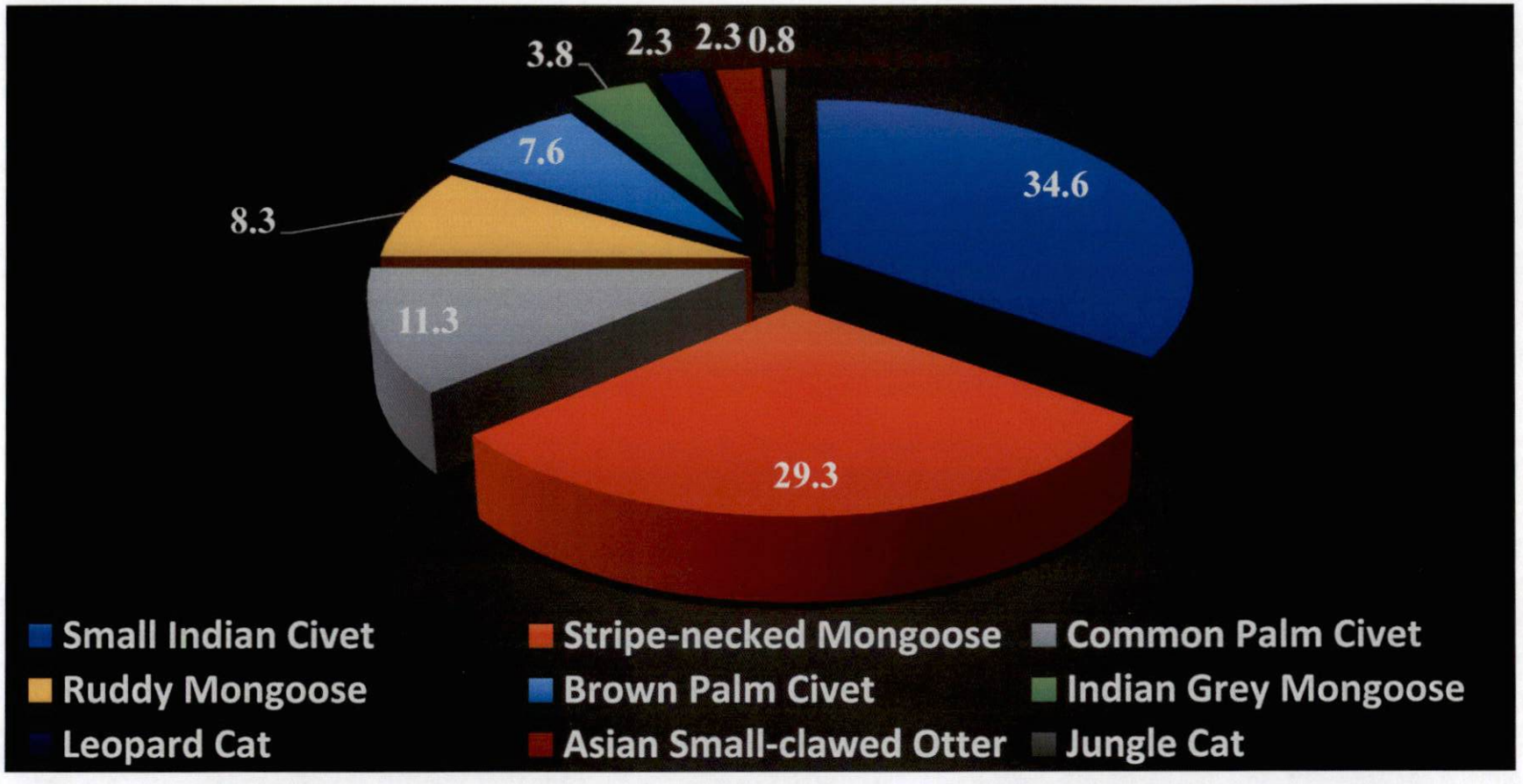


Figure 4. Relative abundance of small carnivores in Wayanad Wildlife Sanctuary

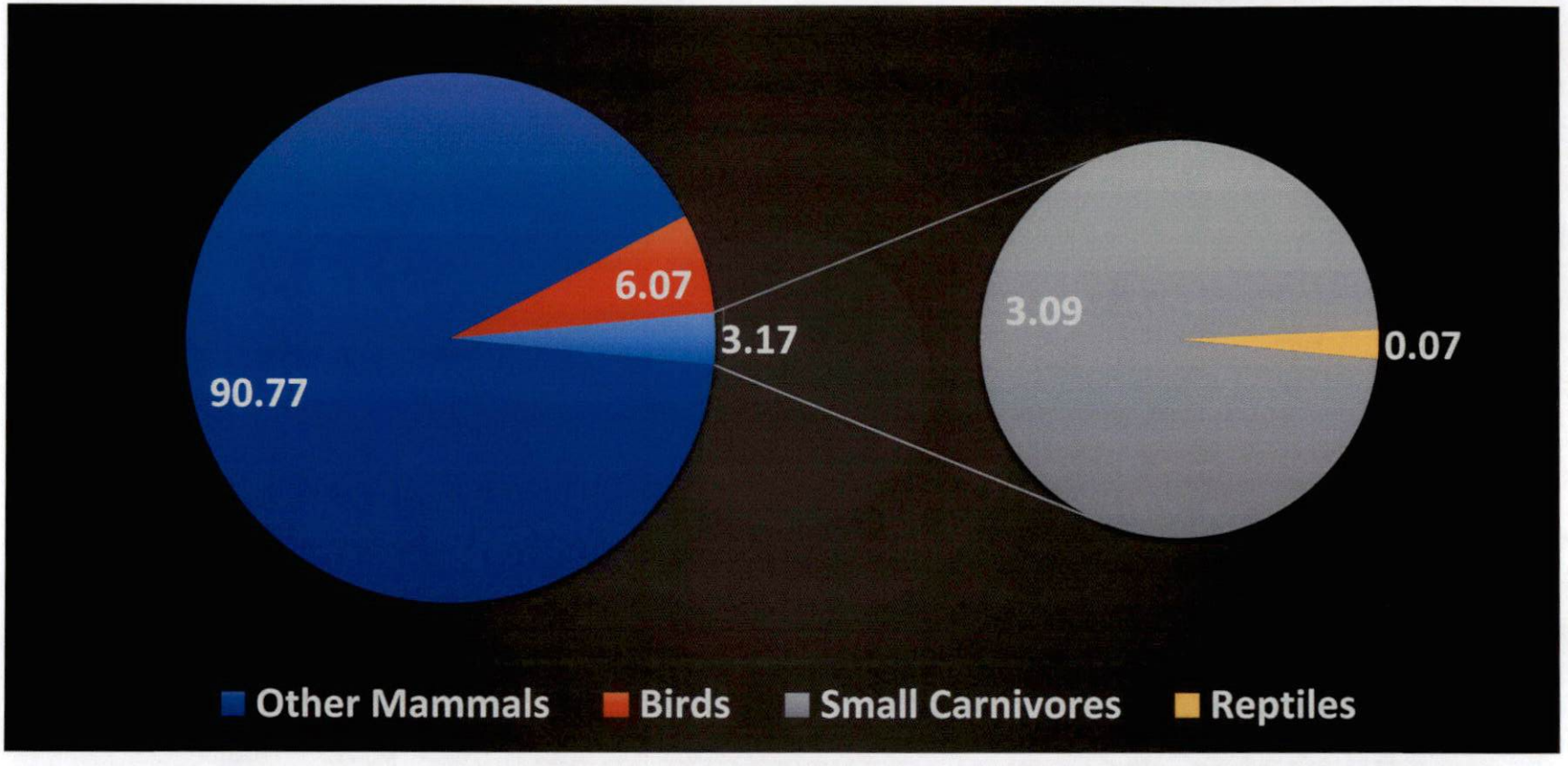


Figure 5. Relative abundance of the wildlife photo-captured in the camera traps in Wayanad Wildlife Sanctuary

The camera trap study also helps to reveal the diversity of other wildlife in Wayanad WLS. The camera trap recorded the images of 16 additional mammal species other than the nine species of small carnivores. Moreover, it also captured the images of 18 species of birds and two species of reptiles (Appendix II). These constitute ~91% of all the images obtained through the camera trapping (Figure 5).

4.2.2. Species diversity measures of the small carnivores in Wayanad WLS

The various diversity indices and species richness parameters such as number of taxa (S), number of individuals (n), Dominances, Shannon-Weiner index (H), Evenness_e^H/S, Margalef index (M) and Berger-Parker index were calculated for the two types of habitats *viz.*, natural forest and plantations (*Eucalyptus spp., Tectona grandis* and *Senna spectabilis*) (Table 6).

Greatest number of taxa were recorded from the natural forests when compared to the plantations. Asian Small-clawed Otter and Jungle Cat were recorded only from the natural forests. However, the Indian Grey Mongoose was found only from the plantation. The number of individuals was maximum in the natural forest. Shannon index and Margalef index were high in plantation habitat. Also, evenness and Berger-Parker index also high in plantation. Stripe-necked Mongoose was the most abundant species in natural forest, while the Small Indian Civet was the most abundant species in the plantation.

Diversity t-test was carried out for comparing the species diversity between the two habitats *viz.*, natural forest and plantation. Tabulated p-value (at 5% level of significance) indicates, there is no significant difference in species diversity between the natural forest and plantation.

Table 6. Indices of the diversity measures of the small carnivores of Wayanad Wildlife Sanctuary

Indices	Natural Forest	Plantation	Diversity t-test
Taxa (S)	8	7	• $t = 0.13^{ns}$ • $p = 0.90$
Individuals (n)	98	32	
Shannon (H)	1.60	1.62	
Evenness (e^H/S)	0.62	0.72	
Margalef (M)	1.52	1.73	
Berger-Parker	0.34	0.41	

4.2.2.1. Indices of the diversity measures of the wildlife in two different habitats of Muthanga Range, Wayanad Wildlife Sanctuary

Indices of diversity measures of small carnivores also calculated for two different habitats available in Muthanga *viz.*, natural forest and *Senna spectabilis* spread area. Table 7 shows the different diversity measures of the two habitats in Muthanga. All of the values of the indices were higher for natural forest except the evenness. Diversity t-test was carried out to know the significance of the species diversity between natural forest and Senna spread area. The p value shows that there is no significant difference between the small carnivore diversity between natural forest and Senna spread area.

The present study also compared the diversity indices of all animals (not even small carnivores) that captured during the camera trap survey in Muthanga. In that, all indices were higher for natural forest except the number of individuals. Diversity t-test proved that there is a significant difference in species diversity of natural forest and Senna spread area in Muthanga (Table 8).

Table 7. Indices of the diversity measures of the small carnivores in two different habitats of Muthanga Range, Wayanad Wildlife Sanctuary

Indices	Muthanga (NF)	Muthanga (Senna)	Diversity t-test
Taxa_S	7	5	• $t=0.80^{ns}$ • $p=0.43$
Individuals	63	23	
Shannon_H	1.46	1.32	
Evenness_e^H/S	0.62	0.75	
Margalef	1.45	1.28	
Berger-Parker	0.44	0.43	

Table 8. Indices of the diversity measures of the animals in two different habitats of Muthanga Range, Wayanad Wildlife Sanctuary

Indices	Muthanga (NF)	Muthanga (Senna)	Diversity t test
Taxa_S	38	21	• t=23.52** • p<0.01
Individuals	1569	1606	
Shannon_H	2.41	1.12	
Evenness_e^H/S	0.29	0.15	
Margalef	5.03	2.71	
Berger-Parker	0.37	0.76	

4.3. THE TIME ACTIVITY PATTERN OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

Time activity pattern of the small carnivores of the Wayanad WLS was also carried out. For this analysis, only those species of small carnivores, which has more than ten camera trapped images, alone were used. Small Indian Civet, Brown Palm Civet, Common Palm Civet, Ruddy Mongoose and Stripe-necked Mongoose were the species of small carnivores that captured at least ten times or more. Thus, a total of 114 images were used for the time activity pattern analysis.

Out of 114 images captured 71 images (62.3%) represented by Family Viverridae. Small Indian Civet (40.3%) was found to be most common small carnivore in Wayanad WLS followed by Stripe-necked Mongoose (28.9%), Common Palm Civet (13.1%), Brown Palm Civet (8.8%) and Ruddy Mongoose (8.8%).

For identifying the active period of small carnivores in Wayanad WLS, the camera trapping hours were split into 1hr interval classes and the data were analysed. Figure 6 represents the time activity pattern of Small Indian Civet, Common Palm Civet and Brown Palm Civet. All three species of small carnivores showed strict nocturnal activity and no activity during day time between 07:00hrs to 17:00hrs. Well defined pattern and exclusivity in the activity could be seen among the three species of viverrids at Wayanad WLS.

When the Small Indian Civet showed a bimodial activity pattern, with greater activity during post mid-night (05:00hrs to 06:00hrs), than pre-midnight hours (Fig. 5). The Common Palm Civet showed multiple peak activity, with at least three peaks in the post mid-night periods (01:00hrs, 03:00hrs and 05:00hrs) and its

activity was lower in the pre-midnight hours. The Brown Palm Civet however, has peak activity during the pre-midnight hours (21:00hrs.). (Fig. 5).

The activity patterns of the two species of herpestids such as the Ruddy Mongoose and Stripe-necked Mongoose are given in the Figure 7. Unlike the viverrids, the herpestids have been showing a diurnal activity pattern. Among the two species of the mongoose, the Ruddy Mongoose, can be considered as a strict diurnal species and its activity is confined between 07:00hrs to 16:00hrs, with the peak activity being in the mid-day at 12:00hrs to 13:00hrs. Whereas in the case of Stripe-necked Mongoose, the activity commences by 06:00hrs and it extends up to 20:00hrs. However, the peak activity of the Stripe-necked Mongoose is at 07:00hrs to 08:00hrs. Thus, in the case of herpestids also the two species mutually exclude competition by differential temporal mode of activity.

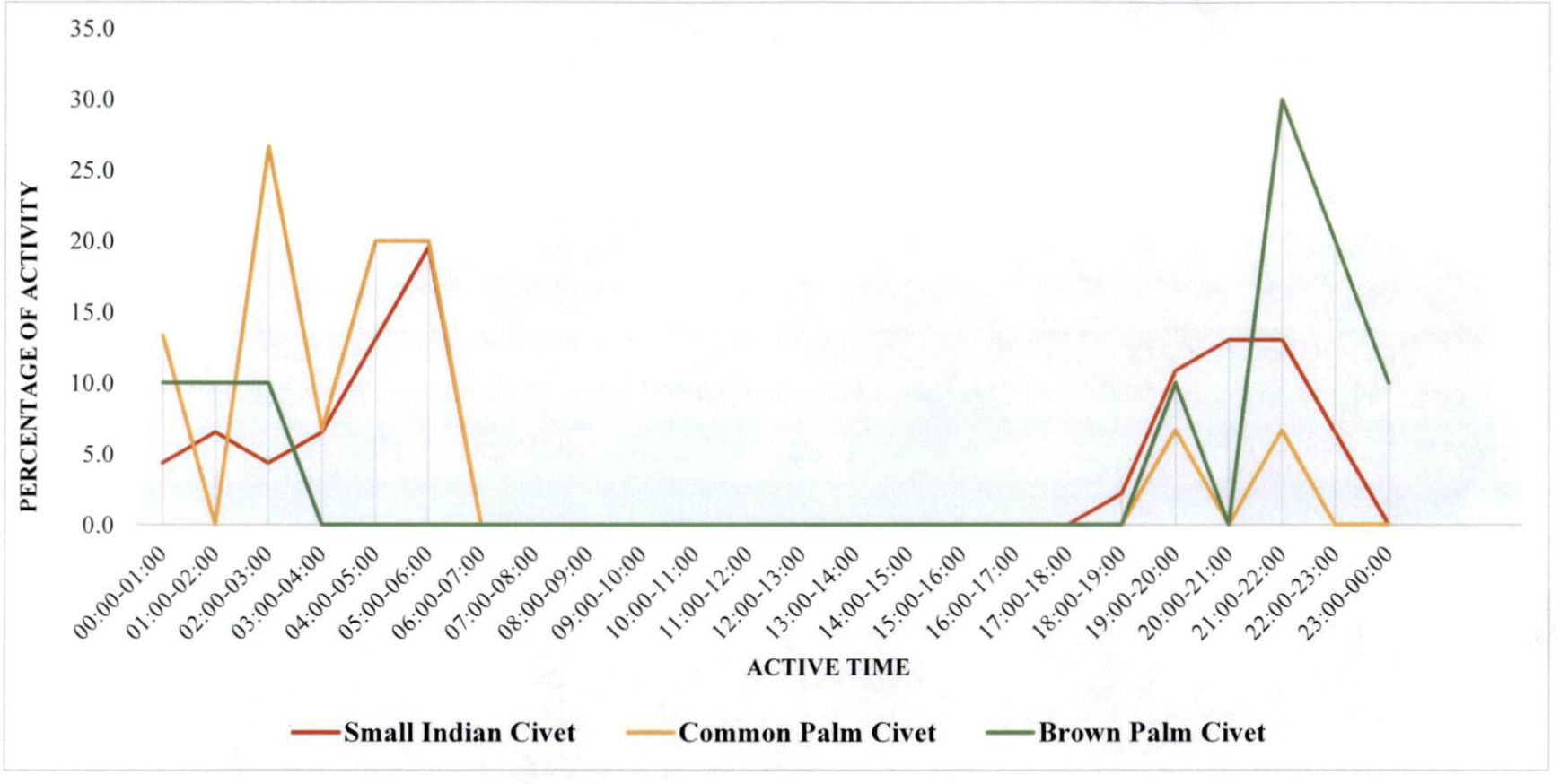


Figure 6. Time activity pattern of Small Indian Civet, Common Palm Civet and Brown Palm Civet in Wayanad Wildlife Sanctuary

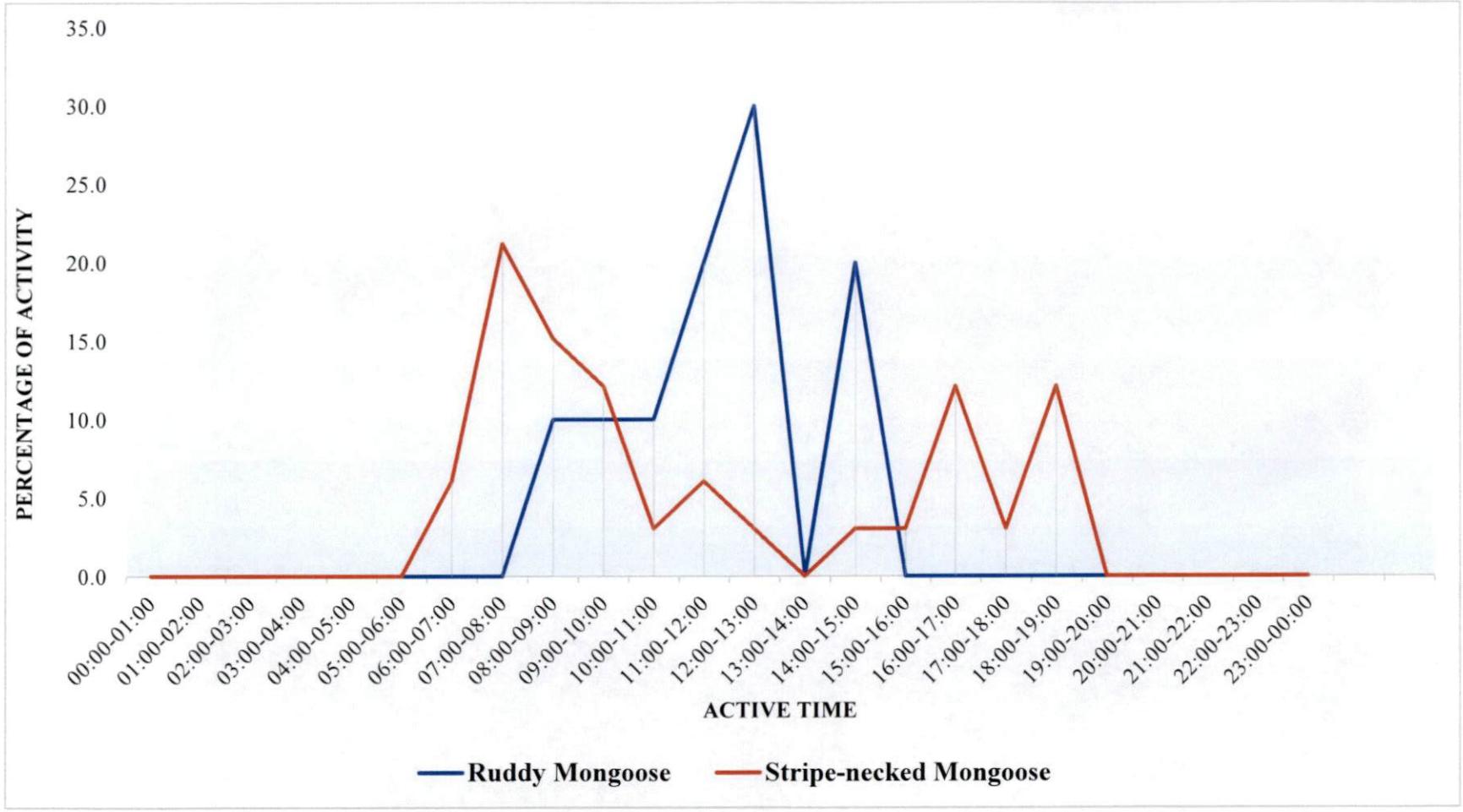


Figure 7. Time activity pattern of Ruddy Mongoose and Stripe-necked Mongoose in Wayanad Wildlife Sanctuary.

4.4. INFLUENCE OF MICRO-HABITAT PARAMETERS ON THE OCCURRENCE OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

4.4.1. Influence of microhabitat parameters on the occurrence of Small Indian Civet at Wayanad Wildlife Sanctuary

Binary logistic regression was carried out for the perdition of the occurrence of a species in a particular habitat, after assessing the micro-habitat parameters. The results of the binary logistic regression on the presence of the Small Indian Civet, at Wayanad Wildlife Sanctuary is given in Table 9. The model significant at 95% for the calculated p value. Range of coefficient of determination (R^2 value) gives the accuracy of this model is 30% to 43% (Table 9).

Table 9. Binary logistic regression model summary for Small Indian Civet at Wayanad Wildlife Sanctuary

Model	Cox & Snell R Square	Nagelkerke R Square
	0.29	0.43
Chi square = 39.45* Degrees of freedom = 22		

The prediction accuracy of the fitted logistic regression model for Small Indian Civet is explained by using the classification table of observed and predicted response given in Table 10.

It is evident from this model that the occurrence of Small Indian Civet at Wayanad WLS could be predicted with 80% accuracy when we have the studied micro-habitat parameters.

Table 10. Classification table for the occurrence of Small Indian Civet

Observed		Predicted		
		Species		Percentage Correct
		Absence	Presence	
Species	Absence	74	7	91.4
	Presence	15	15	50.0
Overall Percentage				80.2

Table 11. Effect of microhabitat parameters on the occurrence of Small Indian Civet at Wayanad Wildlife Sanctuary

Variables	Odds	95% Confident intervals for odds	
		Lower	Upper
Canopy Height	1.00	0.96	1.03
Canopy Closure*	0.97	0.94	0.99
Litter Depth	1.61	0.93	2.79
shrub Density	0.94	0.69	1.29
Tree Density*	0.68	0.47	0.97
Width of the Waterbody	1.05	0.81	1.38
Depth of Waterbody	0.99	0.94	1.05
Distance to Largest tree	1.02	0.99	1.04
GBH	1.00	1.00	1.01
Slope Degrees	0.93	0.82	1.05
Waterbody	2.79	0.10	77.64
Rock	0.51	0.06	4.34
Fruiting Tree	0.23	0.01	3.72
Roots	0.16	0.002	14.97
Roads	0.84	0.19	3.67
Log	1.45	0.33	6.31
* indicate the significant variables			

In Table 11, both canopy closure and tree density have significant negative relationship with the presence of the Small Indian Civet. The other micro habitat parameters did not have any significant relationship with the species presence.

4.4.2. Influence of microhabitat parameters on the occurrence of Common Palm Civet at Wayanad Wildlife Sanctuary

Binary logistic regression was carried out for the Common Palm Civet. The model was not significant for the calculated p value. Low Chi square value also reduces the goodness of fit of this model (Table 12).

Table 12. Binary logistic regression model summary for Common Palm Civet at Wayanad Wildlife Sanctuary

Model	Cox & Snell R Square	Nagelkerke R Square
	0.21	0.45
Chi square = 26.91 Degrees of freedom = 22		

4.4.3. Influence of microhabitat parameters on the occurrence of Stripe-necked Mongoose at Wayanad Wildlife Sanctuary

The results of the binary logistic regression on the occurrence of the Stripe-necked Mongoose at Wayanad Wildlife Sanctuary is given in Table 13. The calculated p value significant at 95%, which indicated that the prediction model fits significantly. Chi square value shows the goodness of fit of this model. The R square value give the accuracy of this model is 27% to 49% (Table 13).

Table 13. Binary logistic regression model summary for Stripe-necked Mongoose at Wayanad Wildlife Sanctuary

Model	Cox & Snell R Square	Nagelkerke R Square
	0.27	0.49
Chi square = 34.57* Degrees of freedom = 22		

The prediction accuracy of the fitted logistic regression model for Stripe-necked Mongoose is explained by using the classification table of observed and predicted response given in Table 14.

It is evident from this model that the occurrence of the Stripe-necked Mongoose from Wayanad WLS could be predicted with 90% accuracy when we have the studied micro-habitat parameters.

Table 14. Classification table for the occurrence of Stripe-necked Mongoose

Observed		Predicted		
		Species		Percentage Correct
		Absence	Presence	
Species	Absence	94	2	97.9
	Presence	9	6	40.0
Overall Percentage				90.1

When we look at the Table 15, only tree density has significant negative relationship in the occurrence of Stripe-necked Mongoose. All other micro habitat

parameters have not a significant relationship with the occurrence of Stripe-necked Mongoose.

Table 15. Effect of microhabitat parameters on the occurrence of Stripe-necked Mongoose at Wayanad WLS

Variables	Odds	95% Confident intervals for odds	
		Lower	Upper
Canopy Height	0.10	0.94	1.05
Canopy Closure	1.02	0.98	1.07
Litter Depth	1.12	0.51	2.43
shrub Density	0.10	0.57	1.73
Tree Density*	0.38	0.16	0.86
Width of Waterbody	1.16	0.77	1.76
Depth of Waterbody	0.95	0.88	1.04
Distance to Largest tree	0.10	0.96	1.04
GBH	1.00	0.99	1.01
Slope	1.02	0.94	1.12
Reeds or Bamboo	0.01	0	5.24
Waterbody	0.31	0.03	3.29
Rock	0.68	0.04	11.80
Fruiting Tree	0.21	0.01	6.07
Roots	0.19	0.01	10.89
Roads	0.26	0.03	2.59
Log	3.09	0.19	50.66
* indicate the significant variables			

4.5. DISCRIMINANT ANALYSIS

Differential preferences of the species for the studied habitat variables are examined using discriminant analysis. It shows whether there is any niche

partitioning between and among the species with respect to the studied habitat variables.

Table 16 below shows the pair wise Fisher's distances (blue cells) and associated P values (orange cells). There is no significant difference in the clusters indicating that the species show no significant niche partitioning (Figure 8).

Table 16. Fisher's distance matrix of the small carnivores of Wayanad WLS

	Brown Palm Civet	Common Palm Civet	Ruddy Mongoose	Small Indian Civet	Stripe-necked Mongoose
Brown Palm Civet		0.404	0.711	0.827	0.395
Common Palm Civet	0.978		0.930	0.976	0.841
Ruddy Mongoose	0.776	0.546		0.741	0.418
Small Indian Civet	0.656	0.498	0.746		1.030
Stripe-necked Mongoose	0.980	0.641	0.974	0.445	

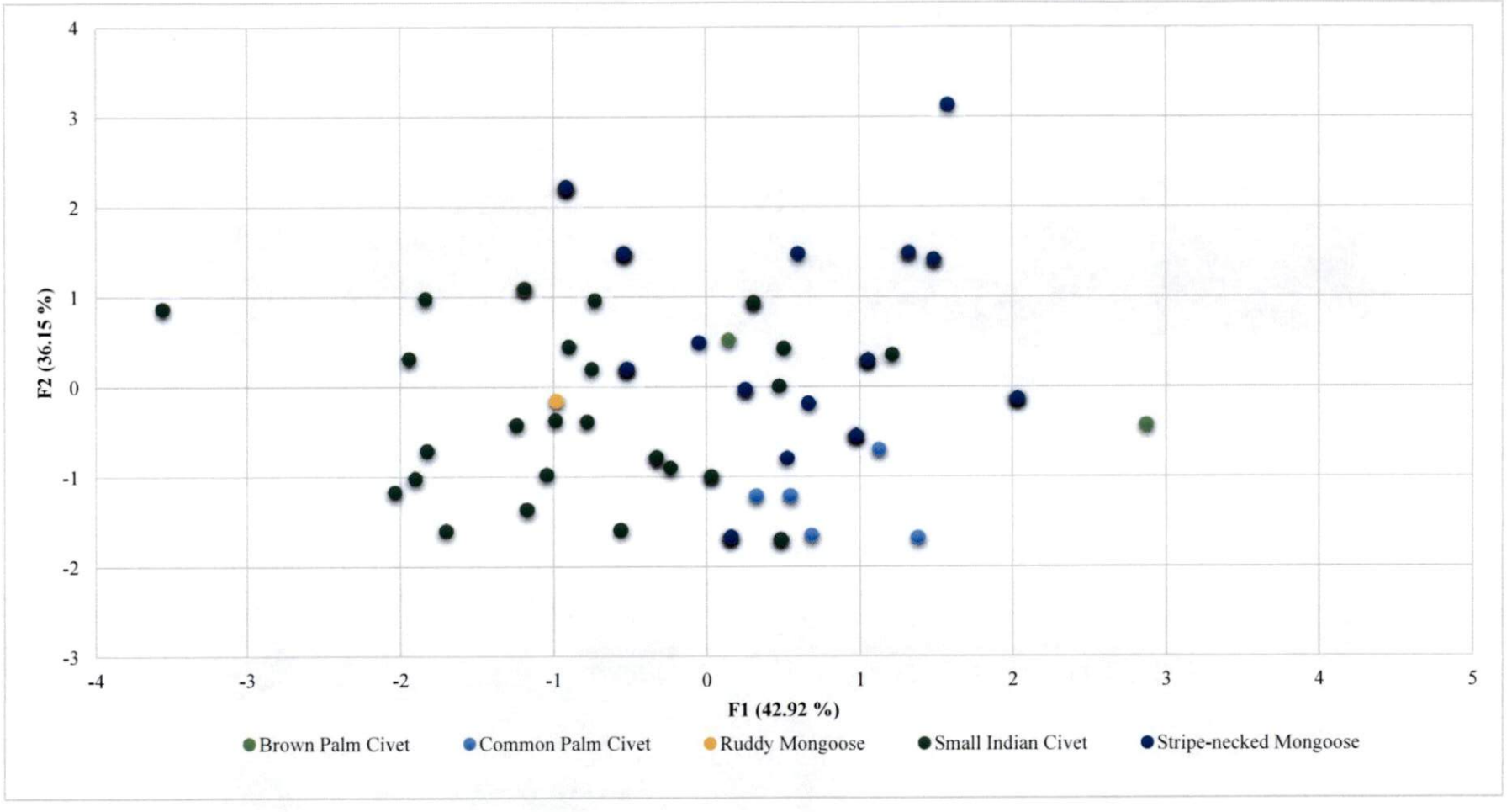


Figure 8. Niche partitioning of small carnivores of Wayanad Wildlife Sanctuary

4.6. DISTRIBUTION OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

The distribution of small carnivores in Wayanad WLS was done with camera trap data. Distribution of seven species given in the Figure 9 to Figure 15. Only a single record was available for both Asian Small-clawed Otter (Kurichiat) and Jungle Cat (Muthanga Natural Forest). Small Indian Civet was distributed in all the study locations (Figure 9), while Common Palm Civet was reported from all study locations except from Kurichiat (Figure 10). Though Brown Palm Civet was recoded from two study locations, it was primarily confined to the Muthanga area, and there was only a single report of the species from Tholpetty (Figure 11). Indian Grey Mongoose was only reported from Muthanga (Figure 12), while Ruddy Mongoose was present in all locations except Kurichiat (Figure 13). Stripe-necked Mongoose was reported from all locations except Sulthan Batheri (Figure 14). Leopard Cat was recorded from two study locations *viz.*, Muthanga and Kurichiat out of five (Figure 15).

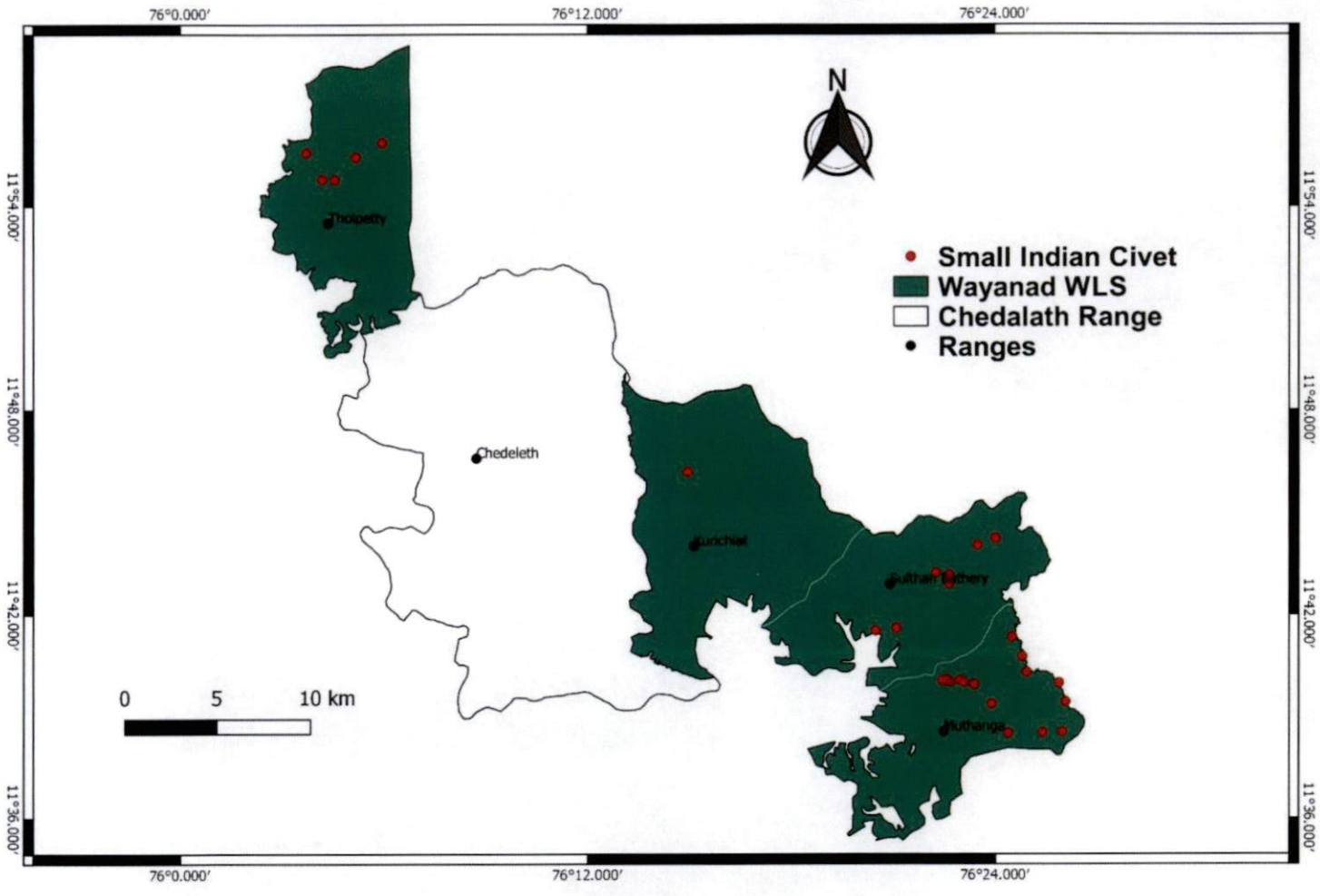


Figure 9. Distribution of Small Indian Civet in Wayanad Wildlife Sanctuary.

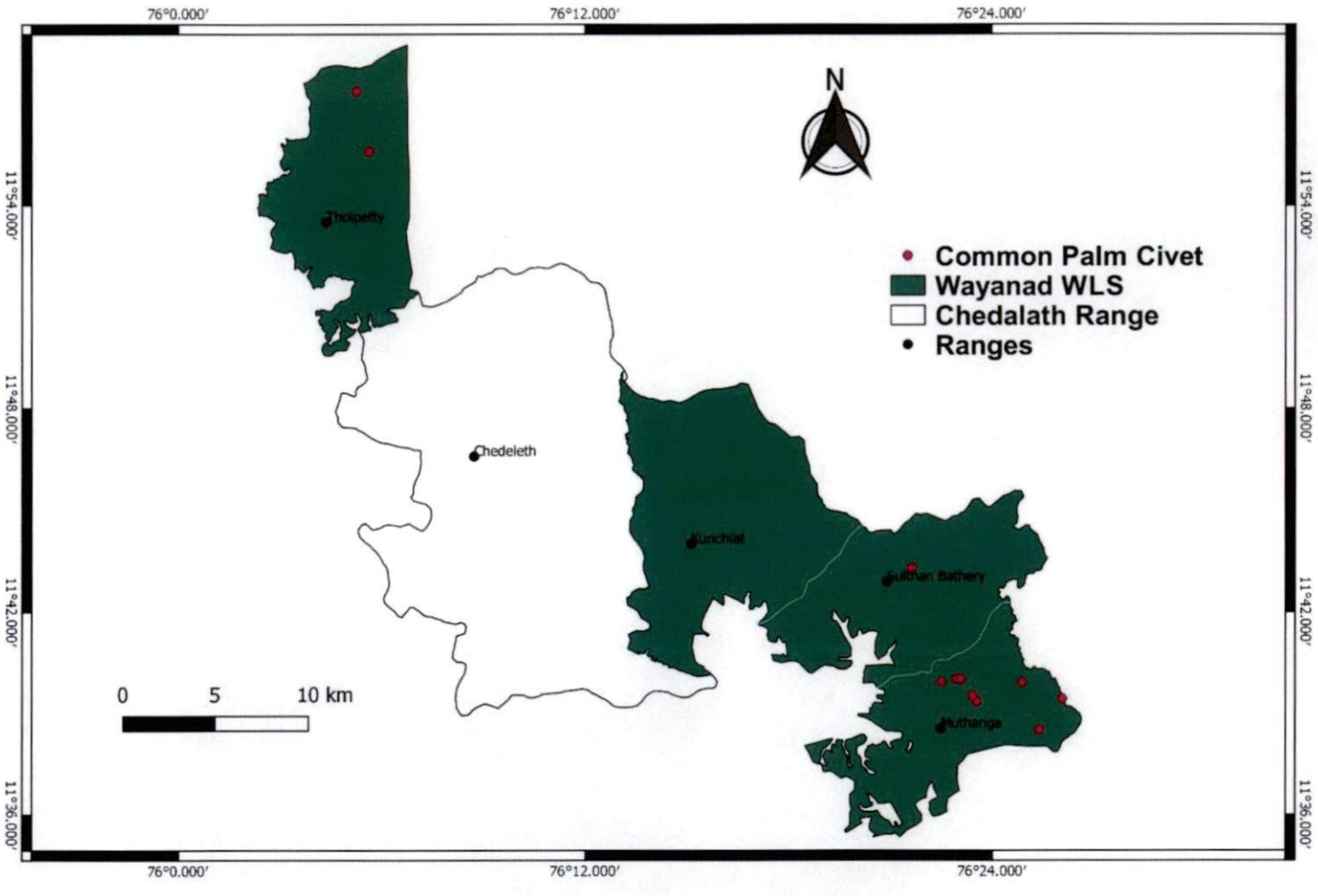


Figure 10. Distribution of Common Palm Civet in Wayanad Wildlife Sanctuary.

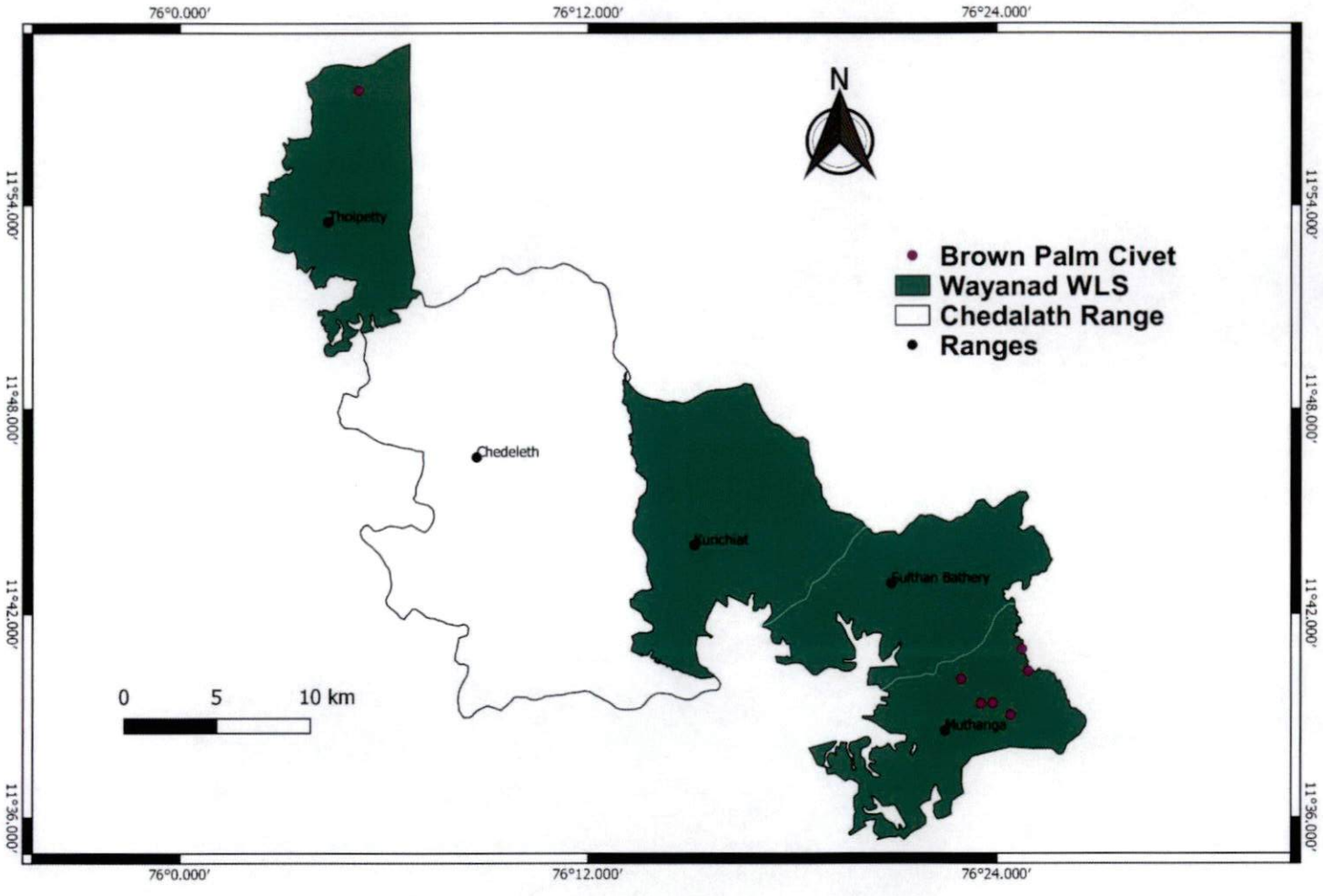


Figure 11. Distribution of Brown Palm Civet in Wayanad Wildlife Sanctuary.

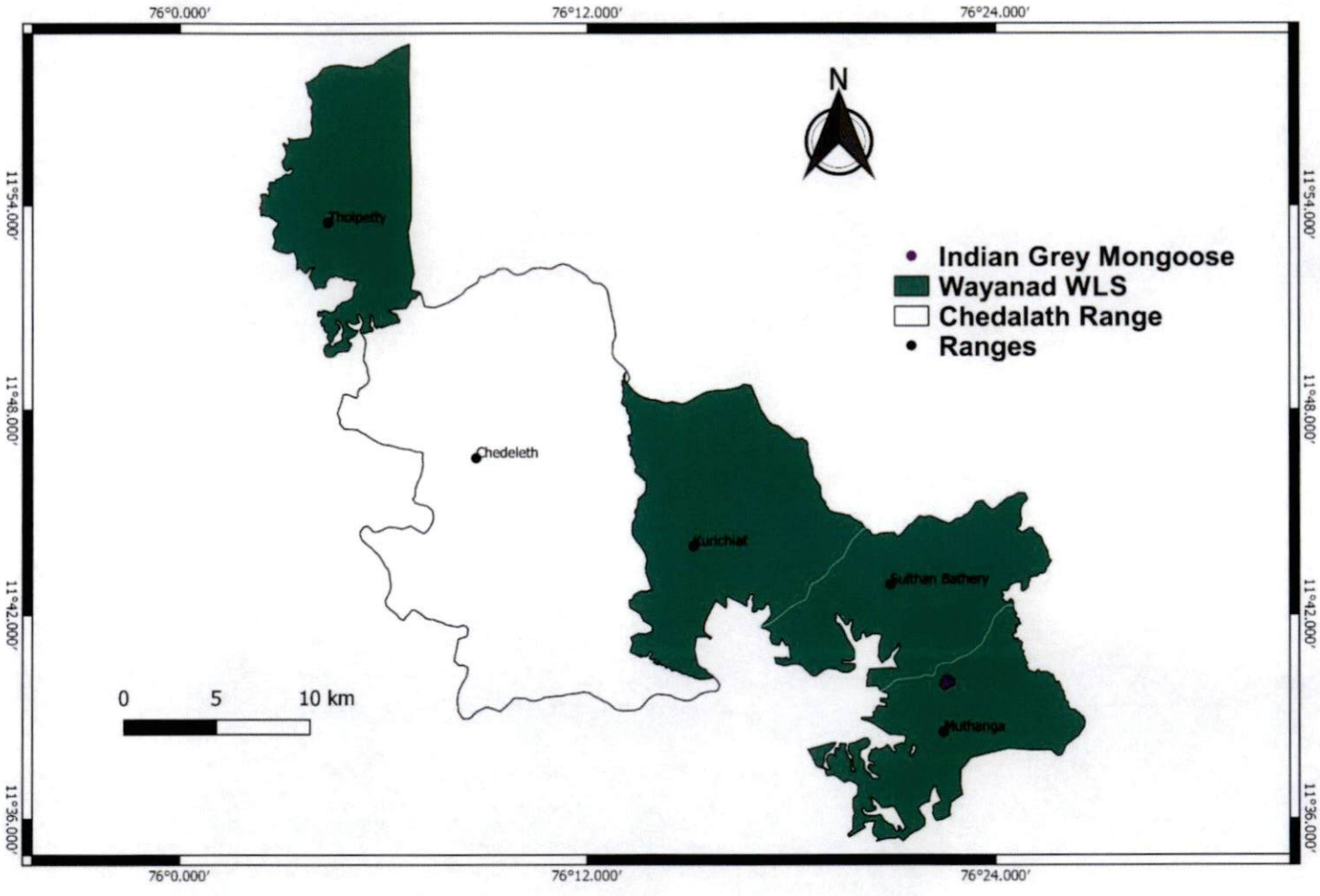


Figure 12. Distribution of Indian Grey Mongoose in Wayanad Wildlife Sanctuary.

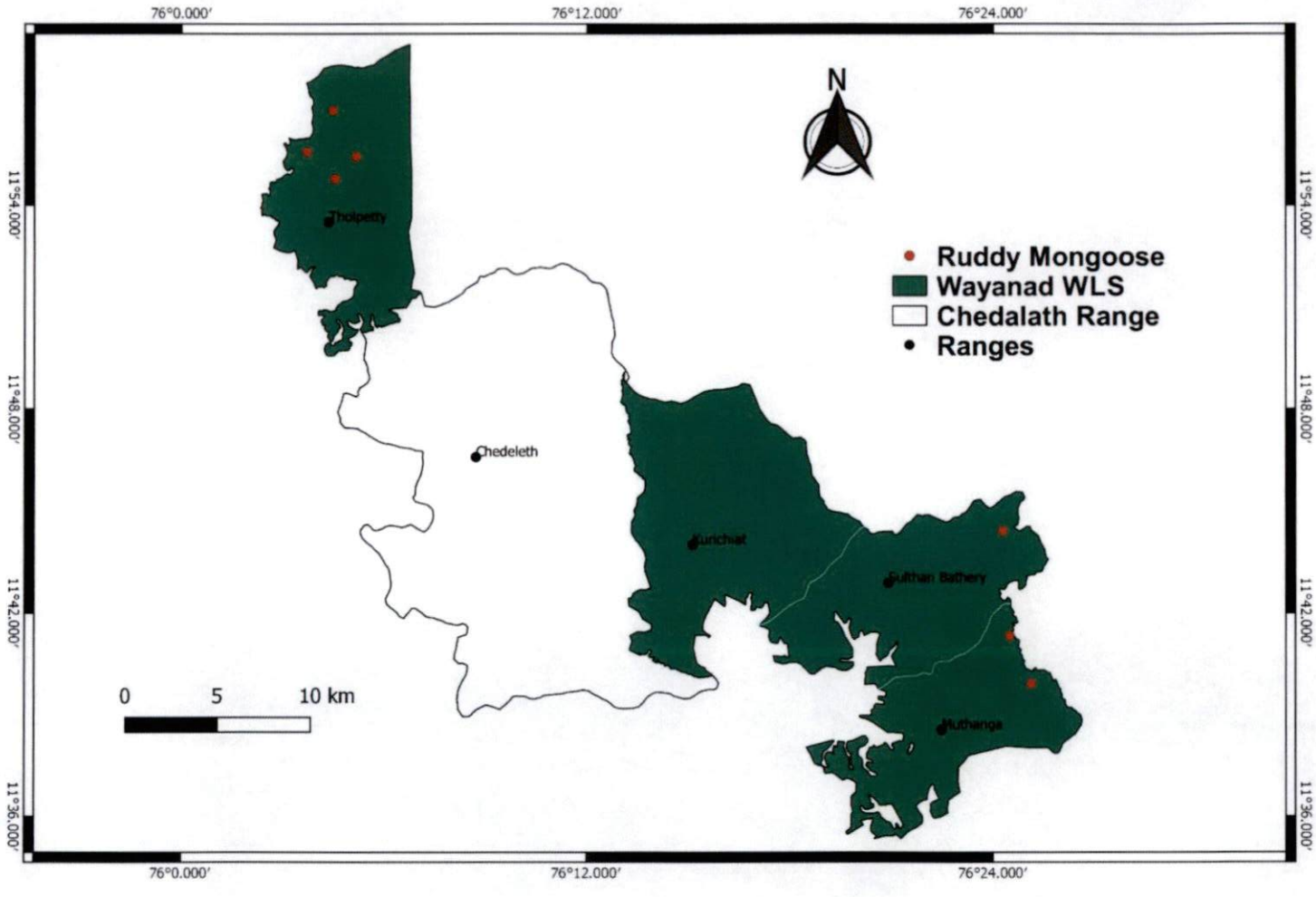


Figure 13. Distribution of Ruddy Mongoose in Wayanad Wildlife Sanctuary.

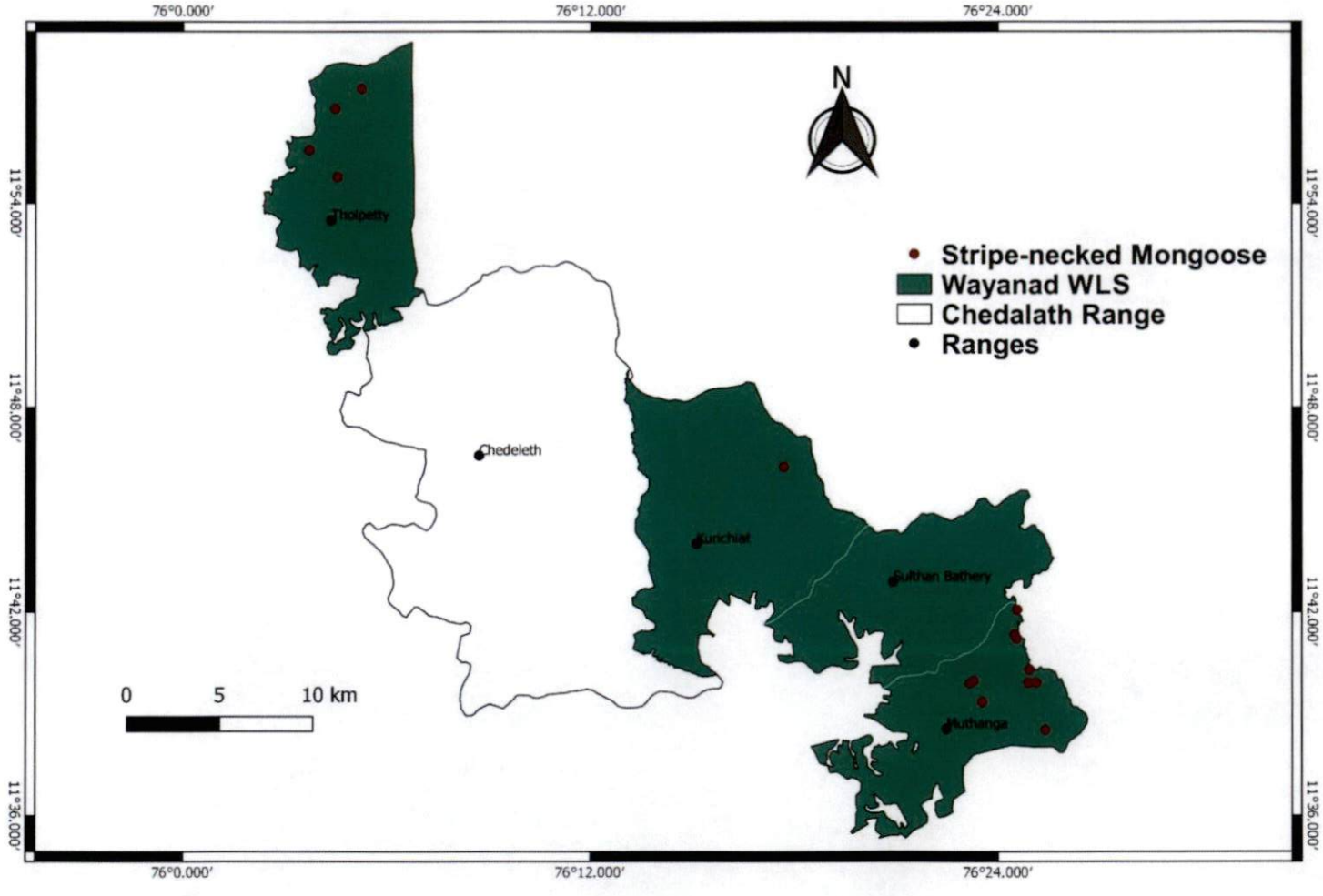


Figure 14. Distribution of Stripe-necked Mongoose in Wayanad Wildlife Sanctuary.

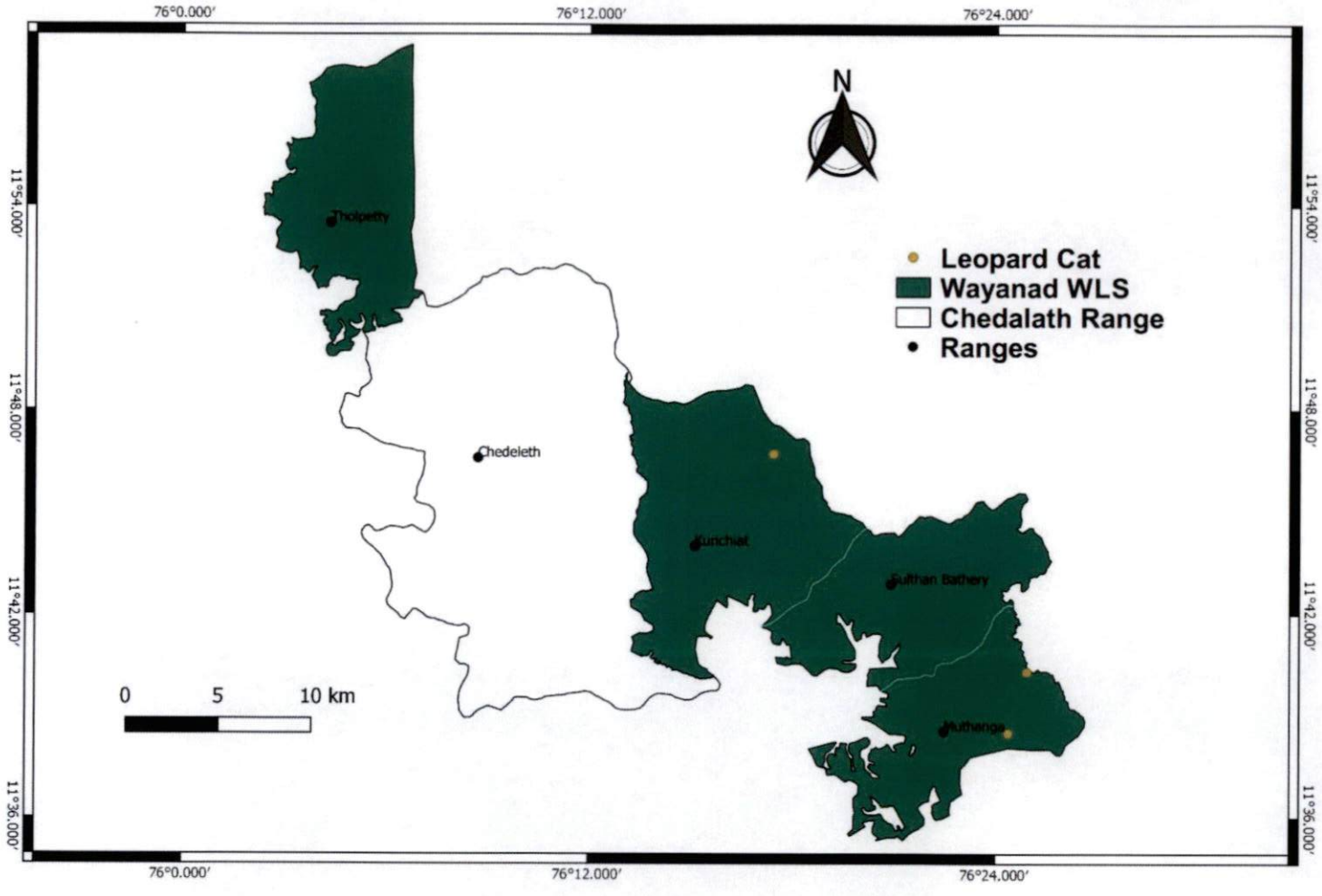


Figure 15. Distribution of Leopard Cat in Wayanad Wildlife Sanctuary.

DISCUSSION

DISCUSSION

5.1.DISTRIBUTION AND DIVERSITY OF THE SMALL CARNIVORES

The absence of Nilgiri Marten and Brown Mongoose in Wayanad WLS could be due to the lack of suitable habitat for these evergreen dependant small carnivores. The presence of the commensal species such as Common Palm Civet and Indian Grey Mongoose, could be due to the human habitations that is interspersed among the vegetation in the Wayanad WLS. The absence of Smooth-coated Otter, at Wayanad WLS could be due to the fact that there are no major perennial water bodies with high water level.

5.2.SPECIES DISTRIBUTION OF THE SMALL CARNIVORES

5.2.1. Family Mustelidae

The Mustelidae is the largest family in the Carnivora and including 57 species. The family comprising of weasels, martens, polecats, badgers and otters. Family Mustelidae having eight sub-families and 22 genera. Generally, the members are small to medium sized mammals with long bodied and short limbs. They are distributed in Holarctic, Neotropical, African and Oriental regions (Wilson and Mittermeier, 2009).

5.2.1.1. Asian Small-clawed Otter Aonyx cinereus

Head to body length (HBL) – 36cm to 44cm (males) 43.2cm to 46.8cm (females); tail length (TL) – 22.5cm to 27cm (males) 26cm to 27.5cm (females); weight (Wt.) – 2.4kg to 3.8kg; dental formula (DF) – I 3/3, C 1/1, P 3/3, M ½ (Wilson and Mittermeier, 2009).

Asian Small-clawed Otter is the smallest otter in the world. They have long body, short legs and dorsoventrally flattened tail. Coat is uniformly brown except

for the neck, throat and chin, which are greyish-silver or white. Small head and eyes are proportionally larger when compared to other otters. Claws are present but reduced on all the feet and webbing also incomplete in all feet. There are three subspecies identified in the world and two are occurring in India *viz.*, *A. cinereus concolor* (northeast India) and *A. cinereus nirnai* (hill ranges of southern India) (Wilson and Mittermeier, 2009).

Asian Small-clawed Otter generally preferred rocky streams with low water level. During the study period, the water availability in the sanctuary was very scare and the streams were not active. This may the reason of the low abundance of this species in the Wayanad WLS. There were only three published study on the otters in the Western Ghats *viz.*, Meena (2002), Anoop and Hussain (2004 and 2005) and Perinchery *et al.* (2011).

5.2.2. Family Viverridae

Family Viverridae comprising 34 species and further research may change the number. Viverridae having four sub-families and 14 genera. The characteristics of the members are small to medium sized animals, long and slender body shape, pointed face, small ears, fairly short legs and a long tail. The family includes civets, genets and oyans. The family distributed in Old World tropics throughout Asia and Africa and southern Europe (Wilson and Mittermeier, 2009).

5.2.2.1. Small Indian Civet Viverricula indica

HBL – 48.5cm to 68cm; TL – 30cm to 43cm; hindfoot length (HL) – 8.5cm to 10cm; ear length (EL) – 3.9cm to 5cm; Wt. – 2kg to 4kg; DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

The coat colour is grey, tawny or brown. No erectile dorsal crest. Small brown or black spots present in the flanks, which tend to run as three to five longitudinal

lines on the back. The tail has six to nine dark rings and a white tip. Dark brown or black feet with five digits. The perineal glands larger in males. Eleven subspecies were identified in the global level. There are four subspecies identified from India *viz.*, *V. indica indica* (Southern Peninsular India), *V. indica deserti* (Central India), *V. indica wellsi* (North-west India), and *V. indica baptistae* (upper Bengal and Northeast India) (Wilson and Mittermeier, 2009; Menon, 2014).

The species is very common in southern Western Ghats (Mudappa, 2002) and previous studies also reported this species (Mudappa, 2002; Nikhil, 2015; Sreehari and Nameer, 2016; Sanghamithra, 2016). With the camera trapping study, able to record 46 images of the species and all the images were of solitary animals.

5.2.2.2. ***Brown Palm Civet Paradoxurus jerdoni***

HBL – 51cm to 61.5cm; TL – 44cm to 50cm; Wt. – 2kg to 4.3kg; DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

The coat colour is uniform brown, but darker on the head, neck, shoulders, legs and tail. Paler patches in front of ears. Longer tail sometimes have white or pale-yellow tip. The hairs of the neck are directed forward, this feature is absent in Common Palm Civet. On the hindfoot, third and fourth digit fused at the base. The perineal gland is simple and consists of naked elongated area. The species is endemic to the Western Ghats and two subspecies are identified. *P. jerdoni jerdoni* (south of the Palghat gap) and *P. jerdoni caniscus* (north of the Palghat gap) are two subspecies identified (Wilson and Mittermeier, 2009; Menon, 2014).

Brown Palm Civet is very common in high altitudes of Western Ghats (Mudappa, 1998) and Wayanad landscape situated in ~900 m altitude. Ten individuals were recorded from the current study and majority records from the

Muthanga area, which shared the boundary with the protected areas of Tamil Nadu and Karnataka.

5.2.2.3. Common Palm Civet Paradoxurus hermaphroditus

HBL – 42cm to 71cm; TL – 33cm to 66cm; HFL – 7cm to 9cm; EL – 4.1cm to 4.9cm; Wt. – 2kg to 5kg; DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

The animal has dark mask with long tail and coat colour is grey, greyish brown or rusty. Brown or black body stripes and spots. The rhinarium is large and has a deep groove in the middle. There are black spots along the back and merge to form three lines, which run longitudinally from the shoulders to the base of the tail. The spots on the flanks are well separated and tend to be in rows. The feet have five digits. On the hindfoot, third and fourth digit fused at the base. The number of subspecies under debate and required a taxonomic revision (Wilson and Mittermeier, 2009).

During this study, 15 individuals were camera trapped and all image have one individual each. The present study location is highly disturbed with human activities and some individuals were camera captured from near to the human active areas.

5.2.3. Family Herpestidae

The Herpestidae family includes mongooses. Family Herpestidae having two sub-families and 15 genera. The family comprising of 34 species and distributed in Old World tropics throughout Asia and Africa, also Middle East and southern Europe. They are small sized mammals with relatively uniform morphology, long

face and body, short legs, small rounded ears and long, tapering bushy tails (Wilson and Mittermeier, 2009).

5.2.3.1. Indian Grey Mongoose Herpestes edwardsii

HBL – 35.5cm to 45cm; TL – 32cm to 45cm; HL – 7cm to 9cm; EL – 2.2cm; Wt. – 1.4kg; DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

Indian Grey Mongoose is a small mongoose with a slender body, short legs, pointed muzzle and short ears. Males are larger than females. The skin is tawny or yellowish-grey in colour and light and dark rings on the body hairs gives the coat grizzled appearance. A reddish colouration particularly on the extremities, more prominent in northern forms. Short-orange coloured hairs are present in underparts. The tail tip is yellowish red or white and never black. The tail length is 90% to 100% of the head to body length. Four subspecies identified globally and India has three subspecies. *H. edwardsii nyula* (north and central India) with a fuller somewhat darker coat, *H. edwardsii ferrugineus* (desert) with reddish fur, and *H. edwardsii edwardsii* (south India) (Wilson and Mittermeier, 2009; Menon, 2014).

The present study got five images and one direct sighting of Indian Grey Mongoose during the study period. All individuals were recorded from *Senna spectabilis* infected areas of Muthanga. The area has high human disturbance.

5.2.3.2. Ruddy Mongoose Herpestes smithii

HBL – 39cm to 47cm; TL – 35.1cm to 47cm; HL – 8cm to 8.6cm; Wt. – 2.7kg; DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

Endemic to India and Sri Lanka. The coat colour is brown with rufous tinge on the underparts. Tail tip is black. The feet are darker than the body and webbed up to the last joint. The sole of the hind feet is naked. There are two subspecies

reported in world. *H. smithii smithii* occurs in India and *H. smithii zeylanius* found in Sri Lanka (Wilson and Mittermeier, 2009; Menon, 2014).

During this study 10 individuals were camera trapped. The species is forest loving in nature and all images get from the natural forest area in the current study location.

5.2.3.3. Stripe-necked Mongoose Herpestes vitticollis

HBL –52.9cm (males) 47.4cm (females); TL –31.5cm (males) 29.7cm (females); Wt. – 3.4kg (males) 2.7kg (females); DF – I 3/3, C 1/1, P 4/4, M 2/2 (Wilson and Mittermeier, 2009).

Stripe-necked Mongoose is a large mongoose with long guard hairs and a neck stripe. The head iron-grey to purplish brown, finely speckled with yellow, darkest on the fore head and paler on the sides. A black band runs from behind the ears along the sides of the neck to the shoulders. The ears are rounded and covered with short, fine, reddish-brown hairs. The under fur is sparse and pale yellow-brown. The tail colour is orange-red except for the tail tip. Five digits on all the feet. There are two subspecies available *viz.*, *H. vitticollis vitticollis* (SW India and Sri Lanka), characterized by the dominance of chestnut red on its coat and *H. vitticollis inornatus* (Kanara) has no red tinge on the upper side of the body (Wilson and Mittermeier, 2009; Menon, 2014).

During current study 33 images of Stripe-necked Mongoose recorded from Wayanad WLS. Three images include two individuals of the species. The species is typically a forest dwelling species (Wilson and Mittermeier, 2009) and reported from all type habitats in the study location with more individuals recorded from natural forest areas.

5.2.4. Family Felidae

Family Felidae coming under Sub-Order Feliformia. The Felidae comprises 37 species under 14 genera and two sub-families. They are small to quiet large mammals with rounded head and rather flat face, facial whiskers, large eyes and ears, sleek and streamlined body and muscular legs. The members of the family distributed all over the world except in Australia and Polar regions (Wilson and Mittermeier, 2009).

5.2.4.1. Jungle Cat Felis chaus

HBL – 61cm to 85cm; TL – 20cm to 31cm; Wt. – 5.7kg to 12kg (males) 2.6kg to 9kg (female) (Wilson and Mittermeier, 2009).

Coat colour is varying from reddish to sandy-brown to tawny grey. Coat is plain and unspotted. Black tips on guard hairs impart a slightly speckled appearance. Tail tip is black and face is long and slim. White lines above and below eyes. Ears are long, rounded, set close together and tipped with tuft of black hairs. Six subspecies reported in world and three identified from India. *F. cahus affinis* (Sub-Himalayan region), F. cahus kelaarti (S. India and Sri Lanka) and *F. cahus kutas* (N. India, Pakistan and Bangladesh) are the subspecies available in India (Wilson and Mittermeier, 2009; Menon, 2014).

Only one individual was recorded from the Muthanga natural forest.

5.2.4.2. Leopard Cat Prionailurus bengalensis

HBL – 45cm to 75cm; TL – 19.5cm to 31.5cm; Wt. – 1.7kg to 7.1kg (Wilson and Mittermeier, 2009).

Males are larger than females and considerable geographic variation in size. Coat colour is also varied according to geographic variation. The species is very adaptable like Leopard and colour and marking on the body similar to Leopard.

Body colour is yellow to brownish below and silvery grey on the tip of coat hairs, and black markings on the body. Two to four distinct bands running from the crown over the neck which breaks up into short bars and elongate spots on the shoulders. The spots on the tail form cross bars towards its end. The species is arboreal and nocturnal in nature, and preys on small birds and animals. There are 12 subspecies identified globally and two subspecies known from India. *P. bengalensis bengalensis* (Indian and Indo-Chinese region, Malay Peninsula) and *P. bengalensis horsfieldi* (Sub-Himalayan region) are the Indian subspecies (Wilson and Mittermeier, 2009; Menon, 2014).

Three images were captured by camera trap study from Wayanad WLS. All images captured from natural forests in the study location.

5.3.SPECIES RICHNESS AND ABUNDANCE OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY USING THE CAMERA TRAP STUDIES

The number of species of small carnivores that are reported in the previous studies are all dependant on the effort. The present study, which involved a camera trapping of effort of 1932, reported nine species of small carnivores from Wayanad WLS. In Kalakad-Mundanthurai Tiger Reserve 295 trap nights were covered and only three species of small carnivores were recorded (Mudappa, 2002). Similarly, a study on the small carnivores of Anamalai Hills (Mudappa *et al.*, 2007), with 95 camera trap efforts, reported three species.

Rao *et al.* (2007) did a small carnivore survey in the coastal regions of Kerala and Karnataka, with a camera trap effort of 1084 reported only four species of small carnivores. Datta *et al.* (2008), who studied the small carnivore of Namdapha National Park and Pakke Wildlife Sanctuary in Arunachal Pradesh, reported six (1537 camera trap days) and four (231 camera trap days) species of small carnivores respectively.

Nine species of small carnivores were reported from 7380 camera trap days from Mudumalai Tiger Reserve (Kalle *et al.,* 2013). Nikhil (2015) recorded eight species from 855 camera trap days from Eravikulam National Park. In Parambikulam Tiger Reserve, eleven species of small carnivores were recorded from 1350 camera trap days (Sreehari and Nameer, 2016). At Silent Valley National Park, seven species of small carnivores have been captured in the camera trapped from 1450 trap days (Sanghamithra, 2016).

A study done in Thailand with an effort of 1,224 trap-nights, only five species of small carnivores were reported (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 from 6,337 trap-nights (Long and Hoang, 2006). In peninsular Malaysia 24 camera trap stations identified and open for one year. They got eight species of small carnivores out of 2,226 images (Azlan, 2003). 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.

The camera trap success rate for the present study was 6.4%. However, in the previous studies from the Western Ghats region, the success rates were varying between 10.89% to 2.1% (Sanghamithra, 2016 and Nikhil, 2015). The camera trap success rate in Eravikulam National Park and Parambikulam Tiger Reserve were 2.1% (Nikhil, 2015) and 4.1% (Sreeahri and Nameer, 2016) respectively. While in Silent Valley National Park, the camera trap success rate was 10.89% (Sanghamithra, 2016). When we look at the success rate in Wayanad WLS (6.4%), it is more comparable to the studies in Parambikulam Tiger Reserve.

5.4.INDICES OF DIVERSITY MEASUREMENTS OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

The various diversity measures *viz.*, number of taxa (S), number of individuals (n), Shannon (H) index, species evenness (e^H/S), margalef (M) index and Berger-Parker index were calculated for the different habitats of Wayanad WLS. Diversity t-test was carried out for comparing the diversity between natural forest and plantations in Wayanad WLS. There is no significant difference between small carnivore diversity in natural forest and plantations in the study area. Similar protection strategy applied to both natural areas and human modified areas in the sanctuary and this may be the reason for the similar diversity of species in both habitats. Very low human intervention in the core areas of the wildlife sanctuary may also be the reason for the same.

The diversity measures of natural forest and *Senna spectabilis* spread area for the small carnivores shows no significant difference in species diversity. But when considering all animals for the analysis, the diversity t-test shows a significant difference in the species diversity between natural forest Senna spread area in Muthanga. This shows the importance of conserving natural areas for the survival of the wildlife.

5.5.THE TIME ACTIVITY PATTERN OF CAMERA TRAPPED SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY

In order to avoid predation from diurnal predators, the ancestors of modern-day mammals evolved nocturnal characteristics. Many modern mammals not active at night, but they try to retain the nocturnal behaviour. The leading answer is that the high visual acuity that comes with diurnal characteristics isn't needed anymore due to the evolution of compensatory sensory systems, such as a heightened sense of smell and more astute auditory systems (Hall *et al.*, 2012).

The activity pattern of an animal is very important in the dimension of the niche. Different activity pattern of various species helps to reduce the interspecific

competition and predation risk. This also help to the proper segregation of the niche (Gerber *et al.*, 2012).

When analysing the activity pattern of small carnivores in Wayanad WLS and it was found that the species in Family Viverridae, includes Small Indian Civet, Brown Palm Civet and Common Palm Civet, have nocturnal activity and completely inactive in day time. The radio-collared studies in Thailand, the activity time of Small Indian Civet found out as 16:30hrs to 04:30hrs with peak activity between 19:30hrs to 01:30hrs. other studies in Myanmar also proposes the peak activity from 19:30hrs to 22:00hrs and 00:30hrs to 03:00hrs. Azlan and Azad (2005) studied the activity pattern of Common Palm Civet using camera trapping method in Malaysia. They also found out the complete inactive behaviour of Common Palm Civet during day hours, with peak activity between 06:00hrs and 07:00hrs and 20:30hrs to 22:30hrs. Radio-collared studies in Thailand reveals the peak activity between 19:30hrs and 01:30hrs. In Nepal, the activity period of Common Palm Civet found as 18:00hrs to 04:00hrs. The active period of Brown Palm Civet was identified as 18:00hrs to 06:00hrs (Wilson and Mittermeier, 2009). In Silent Valley National Park same activity pattern was observed during the study of small carnivores (Sanghamithra, 2016). Current study also follows the same activity pattern of small carnivores.

The Herpestidae members such as, Ruddy Mongoose and Stripe-necked Mongoose, follow a diurnal mode of activity (Wilson and Mittermeier, 2009).

5.6.BINARY LOGISTIC REGRESSION FOR THE PREDICTION OF PRESENCE OR ABSENCE OF SPECIES USING HABITAT PARAMETERS

Twenty micro habitat parameters were studied and proposed to do a binary logistic regression for predicting the species occurrence. The model was proposed for three species of small carnivores *viz.*, Small Indian Civet, Common Palm Civet and Stripe-necked Mongoose. The model was significant for both Small Indian Civet and Stripe-necked Mongoose for the calculated p value. In the case of Common Palm Civet, the model was not significant for the calculated p value and the R square value was very low in magnitude. Canopy closure and tree density were found to be significant for the prediction of Small Indian Civet, while only tree density was significant for the prediction of Stripe-necked Mongoose. The reason for not effecting remaining variable to the occurrence of these species could not be explain due to the lack of previous similar studies.

Sanghamithra (2016) studied the effect of microhabitat parameter on the occurrence of small carnivores in Silent Valley National Park. In that study, all parameters were not significant except cane density, fruiting tree, and swamp for the prediction of Small Indian Civet in Silent Valley National Park. In the case of Stripe-necked Mongoose, tree density was not having any significant relationship with the prediction of the species in the Silent Valley NP. Why this contradictory in prediction model is unknown because we don't have similar studies for discussing the result of current study except from Silent Valley National Park.

5.7.DISCRIMINAT ANALYSIS

Differential preferences of the species for the studied habitat variables are examined using discriminant analysis. The species did not show any significant difference in the clusters indicating that the species show overlapped niche in Wayanad WLS. When we look at the conservation point of view, this result indicates that the animals have to share same limited resources in the small protected area increasing conflict among them. But from the analysis of activity patterns of the small carnivores of Wayanad WLS, it was found that they have

distinct distributes of activities which is an important niche dimension. The interspecific competition and predation risk are reduced by reducing this temporal overlap between similar species (Gerber *et al.,* 2012).

5.8.CONSERVATION STATUS OF SMALL CARNIVORES OF WAYANAD WILDLIFE SANCTUARY

Out of nine species of small carnivores reported from the Wayanad WLS, Brown Palm Civet is endemic to Western Ghats and Stripe-necked Mongoose is endemic to Western Ghats and Sri Lanka. Leopard Cat and Asian Small-clawed Otter included in the Schedule I of the Wildlife (Protection) Act, 1972 and Leopard Cat listed in the Appendix I of the CITES. According to IUCN Redlist, Asian Small-clawed Otter categorised as *Vulnerable* (VU) and all other eight species are *Least Concern* (LC) (Nameer, 2015b; CITES, 2017; IUCN, 2017).

The current study on the small carnivores of Wayanad WLS observed some threats to small carnivores as well as other mammals in the sanctuary include human-animal conflict, habitat fragmentation, high invasion of exotic weeds (*Lantana camara, Chromolaena odorata* and *Senna spectabilis*) and habitat degradation, and high scarcity of water in the summer season. Lack of awareness about the biology of wildlife and importance of biodiversity are other problems that affects the biodiversity in the sanctuary understand during the study period.

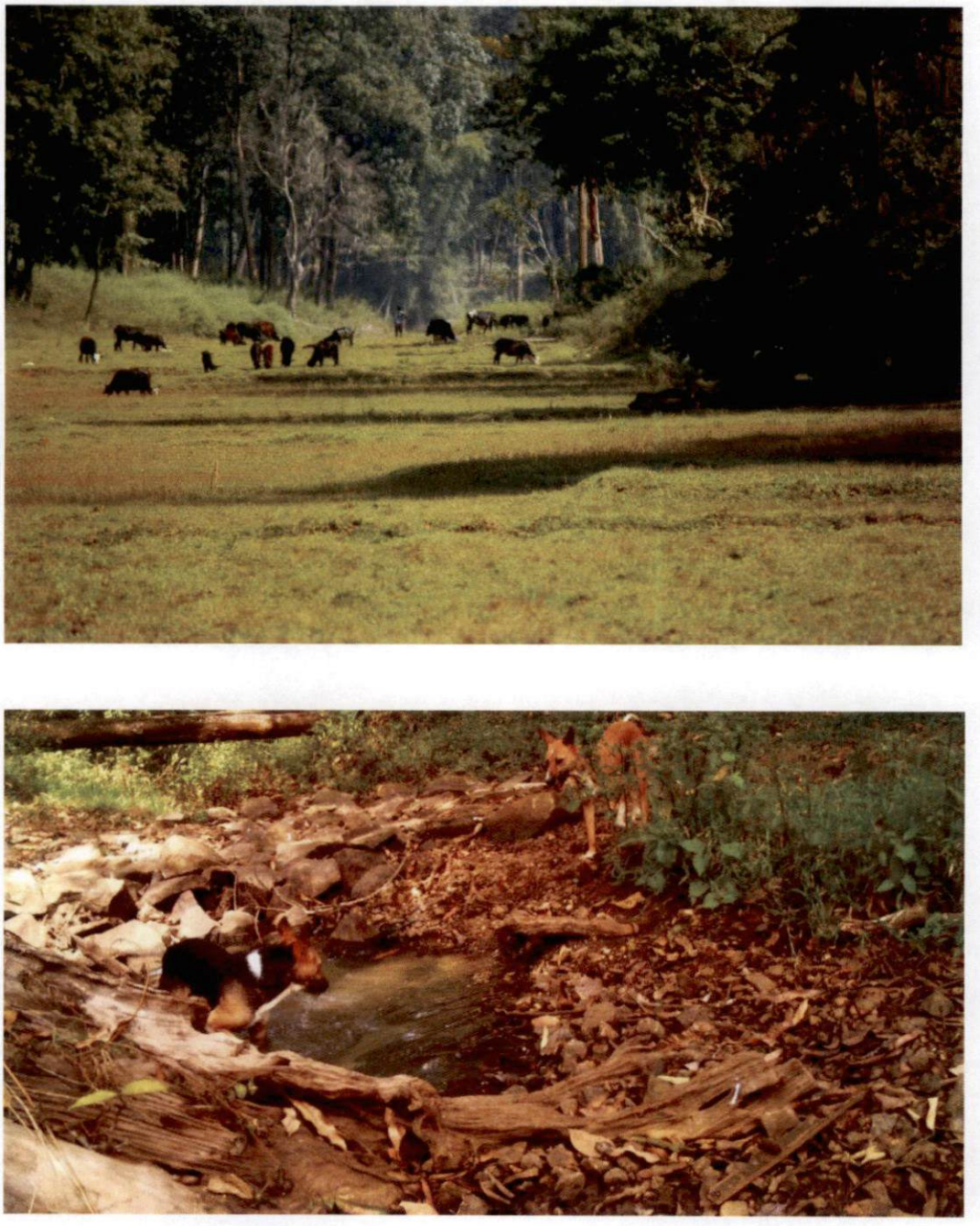


Plate 8. Activity of domestic animals in the Wayanad Wildlife Sanctuary

SUMMARY

SUMMARY

Small carnivores are one of the least explored taxa and do not have a comprehensive inventory. Very few information is available about the ecology, behaviour, habits, taxonomy, conservation threats etc. of the small carnivores. In Kerala, we don't have species specific studies of small carnivores except in the case of otters in Periyar Tiger Reserve by Anoop and Hussain during 2004-2005. The present study is the first-ever study on the small carnivores of Wayanad Wildlife Sanctuary (Wayanad WLS). The objectives of the study were to understand diversity, status, distribution and habitat preference of the small carnivores of Wayanad WLS. The methods applied to study the small carnivores in Wayanad WLS includes camera trap survey and day transect survey for the direct and indirect evidences. A total of 1932 camera trap days consisting of 46,368hrs of trapping and 50 km of transect walk were done. The salient findings are summarized below.

1. Nine species of small carnivores were recorded from the Wayanad WLS. This comprise three species from both Family Viverridae and Family Herpestidae, two species from Family Felidae and one species from Family Mustelidae
2. All members available in the Western Ghats of Family Viverridae were recorded from Wayanad WLS. That includes Small Indian Civet, Brown Palm Civet and Common Palm Civet
3. Three members of Family Herpestidae reported from Wayanad WLS, includes Indian Grey Mongoose, Ruddy Mongoose and Stripe-necked Mongoose
4. Jungle Cat and Leopard Cat were recorded from Wayanad WLS, and species comes under Family Felidae
5. Only one member from Family Mustelidae, Asian Small-clawed Otter, was photo captured from the Wayanad WLS
6. Small Indian Civet *Viverricula indica* found as most common species followed by Stripe-necked Mongoose *Herpestes vitticollis*, Common Palm Civet *Paradoxurus hermaphroditus*, Brown Palm Civet *Paradoxurus jerdoni*, Ruddy Mongoose *Herpestes smithii*, Indian Grey Mongoose *Herpestes edwardsi*,

Leopard Cat *Prionailurus bengalensis*, Asian Small-clawed Otter *Aonyx cinereus* and Jungle Cat *Felis chaus*

7. Other mammals also photographed in the camera trap study. These includes Asian Elephant *Elephas maximus*, Barking Deer *Muntiacus muntjak*, Black-naped Hare *Lepus nigricollis*, Bonnet Macaque *Macaca radiata*, Indian Crested Porcupine *Hystrix indica*, Leopard *Panthera pardus*, Indian Chevrotain *Moschiola indica*, Sambar Deer *Rusa unicolor*, Sloth Bear *Melursus ursinus*, Spotted Deer *Axis axis*, Three-striped Palm Squirrel *Funambulus palmarum*, Tiger *Panthera tigris*, Tufted Gray Langur *Semnopithecus priam*, Wild Boar *Sus scrofa*, Wild Dog *Cuon alpinus* and Wild Gaur *Bos gaurus*. These mammals represented in 44.6% of photographs recorded.
8. The success rate of camera trapping of small carnivores in Wayanad WLS is 6.4%
9. The time activity pattern study reveals the activity of some small carnivores in the study area. All the members in Viverridae shows nocturnal activity and Stripe-necked Mongoose and Ruddy Mongoose were more diurnal activity.
10. Binary logistic regression analysis was done for predicting the presence of Small Indian Civet, Common Palm Civet and Stripe-necked Mongoose. Also observed that selected microhabitat variables like canopy closure and tree density were negatively influencing the occurrence of *Viverricula indica*. However, the tree density was the only significant variable influencing the occurrence of *Herpestes vitticollis*
11. Discriminant analysis shows niche overlapping among the small carnivores in Wayanad WLS

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STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN WAYANAD WILDLIFE SANCTUARY, KERALA

by

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ABSTRACT

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ABSTRACT

Status, distribution and habitat preference of small carnivores in Wayanad Wildlife Sanctuary (Wayanad WLS) was studied using camera traps during November 2016 to February 2017. The present work recorded 25 species of mammals during the study period that included 1932 camera trap days using 111camera trap stations. Out of that nine species were small carnivores belonging to four families (Mustelidae, Viverridae, Herpestidae and Felidae). This included Asian Small-clawed Otter *Aonyx cinereus*, Brown Palm Civet *Paradoxurus jerdoni*, Common Palm Civet *Paradoxurus hermaphroditus*, Small Indian Civet *Viverricula indica*, Indian Grey Mongoose *Herpestes edwardsii*, Ruddy Mongoose *Herpestes smithii*, Stripe-necked Mongoose *Herpestes vitticollis*, Jungle Cat *Felis chaus* and Leopard Cat *Prionailurus bengalensis*. The most common and abundant small carnivore in Wayanad WLS was *Viverricula indica*, followed by *Herpestes vitticollis* and *Paradoxurus hermaphroditus*. Among these *Aonyx cinereus* and *Prionailurus bengalensis* are rare species. The time activity pattern of small carnivores revealed that, all the viverrids were having exclusively nocturnal activity pattern while the *Herpestes smithii* and *Herpestes vitticollis* were showing diurnal activity pattern.

An attempt was also made during the study to predict the occurrence of the small carnivores using 20 selected microhabitat variables by binary logistic regression analysis. The goodness of fit of the model well explained that the binary logistic regression is not suitable for predicting the occurrence of small carnivores using microhabitat variables studied. The present study also observed that selected microhabitat variables like canopy closure and tree density were negatively influencing the occurrence of *Viverricula indica*. However, the tree density was the only significant variable influencing the occurrence of *Herpestes vitticollis*. An attempt was also made to compare the small carnivore diversity in the natural habitat and the *Senna spectabilis* dominated landscape in Wayanad WLS. However, no significant difference in the small carnivore diversity was observed between these two habitats.

Wayanad WLS supports one endemic species of small carnivore, the *Paradoxurus jerdoni* and one threatened species, the *Aonyx cinereus*. Therefore, the present study highlights the significance of the Wayanad WLS as a prime habitat for the conservation of the small carnivores.

APPENDIX

APPENDIX

APPENDIX I: Camera trap data on small carnivores in Wayanad Wildlife Sanctuary from November 2016 to February 2017

Sl. No.	Place	Date	Habitat	Latitude (N)	Longitude (E)	Altitude (m)
I.	**FAMILY MUSTELIDAE**					
A.	**Asian Small-clawed Otter**					
1.	Kurichyad	19-11-2016	Natural Forest	11.77	76.26	815
II.	**FAMILY VIVERRIDAE**					
A.	**Small Indian Civet**					
1.	Kurichyad	29-11-2016	Teak Plantation	11.77	76.25	816
2.	Tholpetty	07-12-2016	Teak Plantation	11.93	76.06	847
3.	Tholpetty	04-12-2016	Natural Forest	11.93	76.10	836
4.	Tholpetty	01-12-2016	Natural Forest	11.91	76.08	794
5.	Tholpetty	06-12-2016	Natural Forest	11.91	76.08	794
6.	Tholpetty	03-12-2016	Natural Forest	11.92	76.09	788
7.	Tholpetty	04-12-2016	Natural Forest	11.92	76.09	788
8.	Tholpetty	07-12-2016	Natural Forest	11.92	76.09	788
9.	Tholpetty	07-12-2016	Teak Plantation	11.91	76.07	749
10.	Muthanga (NF)	16-12-2016	Natural Forest	11.67	76.43	878
11.	Muthanga (NF)	29-12-2016	Natural Forest	11.67	76.43	878
12.	Muthanga (NF)	20-12-2016	Natural Forest	11.64	76.41	916
13.	Muthanga (NF)	31-12-2016	Natural Forest	11.64	76.41	916
14.	Muthanga (NF)	31-12-2016	Natural Forest	11.64	76.42	910
15.	Muthanga (NF)	26-12-2016	Natural Forest	11.68	76.41	838
16.	Muthanga (NF)	31-12-2016	Natural Forest	11.68	76.41	838
17.	Muthanga (NF)	01-01-2017	Natural Forest	11.66	76.40	906
18.	Muthanga (NF)	26-12-2016	Natural Forest	11.66	76.43	882
19.	Muthanga (NF)	25-12-2016	Natural Forest	11.69	76.41	847
20.	Muthanga (NF)	30-12-2016	Natural Forest	11.69	76.41	847
21.	Muthanga (NF)	31-12-2016	Natural Forest	11.69	76.41	847
22.	Muthanga (NF)	19-12-2016	Natural Forest	11.64	76.43	940
23.	Muthanga (NF)	27-12-2016	Natural Forest	11.64	76.43	940

24.	Muthanga (NF)	20-12-2016	Natural Forest	11.67	76.42	880
25.	Muthanga (NF)	02-01-2017	Natural Forest	11.67	76.42	880
26.	Muthanga (NF)	03-01-2017	Natural Forest	11.67	76.42	880
27.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.39	787
28.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.39	787
29.	Muthanga (Senna)	10-01-2017	*Senna spectabilis*	11.67	76.38	796
30.	Muthanga (Senna)	11-01-2017	*Senna spectabilis*	11.67	76.38	787
31.	Muthanga (Senna)	11-01-2017	*Senna spectabilis*	11.67	76.38	775
32.	Muthanga (Senna)	04-01-2017	*Senna spectabilis*	11.67	76.38	774
33.	Muthanga (Senna)	04-01-2017	*Senna spectabilis*	11.67	76.38	780
34.	Muthanga (Senna)	06-01-2017	*Senna spectabilis*	11.67	76.37	770
35.	Muthanga (Senna)	15-01-2017	*Senna spectabilis*	11.67	76.37	770
36.	Muthanga (Senna)	11-01-2017	*Senna spectabilis*	11.67	76.38	789
37.	Sulthan Batheri	13-02-2017	Natural Forest	11.69	76.34	794
38.	Sulthan Batheri	27-01-2017	Natural Forest	11.69	76.35	798
39.	Sulthan Batheri	09-02-2017	Natural Forest	11.69	76.35	798
40.	Sulthan Batheri	26-01-2017	Natural Forest	11.72	76.38	802
41.	Sulthan Batheri	01-02-2017	Natural Forest	11.74	76.40	752
42.	Sulthan Batheri	29-01-2017	Natural Forest	11.73	76.39	738
43.	Sulthan Batheri	27-01-2017	Natural Forest	11.72	76.38	805
44.	Sulthan Batheri	31-01-2017	Natural Forest	11.72	76.37	823
45.	Sulthan Batheri	01-02-2017	Natural Forest	11.72	76.37	823
46.	Sulthan Batheri	02-02-2017	Natural Forest	11.72	76.37	823
B.	**Common Palm Civet**					
1.	Tholpetty	08-12-2016	Natural Forest	11.96	76.09	848
2.	Tholpetty	11-12-2016	Natural Forest	11.93	76.09	823
3.	Muthanga (NF)	22-12-2016	Natural Forest	11.64	76.42	910
4.	Muthanga (NF)	17-12-2016	Natural Forest	11.66	76.39	876
5.	Muthanga (NF)	29-12-2016	Natural Forest	11.67	76.41	862
6.	Muthanga (NF)	20-12-2016	Natural Forest	11.66	76.43	882
7.	Muthanga (NF)	20-12-2016	Natural Forest	11.66	76.39	858
8.	Muthanga (Senna)	08-01-2017	*Senna spectabilis*	11.67	76.37	768
9.	Muthanga (Senna)	22-01-2017	*Senna spectabilis*	11.67	76.38	799
10.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.38	789
11.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.38	789
12.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.38	789
13.	Muthanga (Senna)	12-01-2017	*Senna spectabilis*	11.67	76.38	789

14.	Sulthan Batheri	26-01-2017	Natural Forest	11.72	76.36	823
15.	Sulthan Batheri	26-01-2017	Natural Forest	11.72	76.36	823
C.	**Brown Palm Civet**					
1.	Tholpetty	04-12-2016	Natural Forest	11.96	76.09	848
2.	Muthanga (NF)	16-12-2016	Natural Forest	11.65	76.41	943
3.	Muthanga (NF)	27-12-2016	Natural Forest	11.66	76.39	876
4.	Muthanga (NF)	19-12-2016	Natural Forest	11.66	76.40	906
5.	Muthanga (NF)	31-12-2016	Natural Forest	11.66	76.40	906
6.	Muthanga (NF)	02-01-2017	Natural Forest	11.66	76.40	906
7.	Muthanga (NF)	31-12-2016	Natural Forest	11.68	76.41	847
8.	Muthanga (NF)	28-12-2016	Natural Forest	11.67	76.42	880
9.	Muthanga (NF)	31-12-2016	Natural Forest	11.67	76.42	880
10.	Muthanga (Senna)	13-01-2017	*Senna spectabilis*	11.67	76.38	796
III.	**FAMILY HERPESTIDAE**					
A.	**Indian Grey Mongoose**					
1.	Muthanga (Senna)	15-01-2017	*Senna spectabilis*	11.67	76.38	787
2.	Muthanga (Senna)	18-01-2017	*Senna spectabilis*	11.67	76.38	787
3.	Muthanga (Senna)	05-01-2017	*Senna spectabilis*	11.67	76.38	775
4.	Muthanga (Senna)	10-01-2017	*Senna spectabilis*	11.67	76.38	780
5.	Muthanga (Senna)	20-01-2017	*Senna spectabilis*	11.67	76.37	768
B.	**Ruddy Mongoose**					
1.	Tholpetty	08-12-2016	Natural Forest	11.95	76.07	832
2.	Tholpetty	09-12-2016	Natural Forest	11.95	76.07	832
3.	Tholpetty	02-12-2016	Teak Plantation	11.93	76.06	847
4.	Tholpetty	08-12-2016	Teak Plantation	11.93	76.06	847
5.	Tholpetty	09-12-2016	Natural Forest	11.91	76.08	794
6.	Tholpetty	09-12-2016	Natural Forest	11.91	76.08	794
7.	Tholpetty	06-12-2016	Natural Forest	11.92	76.09	788
8.	Muthanga (NF)	02-01-2017	Natural Forest	11.69	76.41	847
9.	Muthanga (NF)	02-01-2017	Natural Forest	11.67	76.42	849
10.	Sulthan Batheri	01-02-2017	Natural Forest	11.74	76.40	746
C.	**Stripe-necked Mongoose**					
1.	Kurichyad	20-11-2016	Natural Forest	11.77	76.29	897
2.	Kurichyad	24-11-2016	Natural Forest	11.77	76.29	897
3.	Tholpetty	07-12-2016	Natural Forest	11.95	76.07	832
4.	Tholpetty	04-12-2016	Teak Plantation	11.93	76.06	847
5.	Tholpetty	04-12-2016	Teak Plantation	11.93	76.06	847

6.	Tholpetty	06-12-2016	Teak Plantation	11.93	76.06	847
7.	Tholpetty	05-12-2016	Natural Forest	11.96	76.09	848
8.	Tholpetty	02-12-2016	Natural Forest	11.91	76.08	794
9.	Tholpetty	05-12-2016	Natural Forest	11.91	76.08	794
10.	Tholpetty	09-12-2016	Natural Forest	11.91	76.08	794
11.	Muthanga (NF)	01-01-2017	Natural Forest	11.64	76.42	910
12.	Muthanga (NF)	21-12-2016	Natural Forest	11.64	76.42	910
13.	Muthanga (NF)	14-12-2016	Natural Forest	11.67	76.39	870
14.	Muthanga (NF)	18-12-2016	Natural Forest	11.66	76.39	876
15.	Muthanga (NF)	30-12-2016	Natural Forest	11.66	76.39	876
16.	Muthanga (NF)	03-01-2017	Natural Forest	11.66	76.39	876
17.	Muthanga (NF)	16-12-2016	Natural Forest	11.67	76.41	862
18.	Muthanga (NF)	23-12-2016	Natural Forest	11.67	76.41	862
19.	Muthanga (NF)	15-12-2016	Natural Forest	11.70	76.41	852
20.	Muthanga (NF)	29-12-2016	Natural Forest	11.69	76.41	847
21.	Muthanga (NF)	18-12-2016	Natural Forest	11.67	76.42	849
22.	Muthanga (NF)	18-12-2016	Natural Forest	11.67	76.42	849
23.	Muthanga (NF)	29-12-2016	Natural Forest	11.67	76.42	849
24.	Muthanga (NF)	29-12-2016	Natural Forest	11.67	76.42	849
25.	Muthanga (NF)	01-01-2017	Natural Forest	11.67	76.42	849
26.	Muthanga (NF)	15-12-2016	Natural Forest	11.69	76.41	847
27.	Muthanga (NF)	15-12-2016	Natural Forest	11.67	76.42	880
28.	Muthanga (NF)	15-12-2016	Natural Forest	11.67	76.42	880
29.	Muthanga (NF)	28-12-2016	Natural Forest	11.67	76.42	880
30.	Muthanga (NF)	01-01-2017	Natural Forest	11.67	76.42	880
31.	Muthanga (NF)	01-01-2017	Natural Forest	11.67	76.42	880
32.	Muthanga (NF)	02-01-2017	Natural Forest	11.67	76.42	880
33.	Muthanga (Senna)	05-01-2017	*Senna spectabilis*	11.67	76.39	766
IV.	**FAMILY FELIDAE**					
A.	**Jungle Cat**					
1.	Muthanga (NF)	19-12-2016	Natural Forest	11.64	76.41	916
B.	**Leopard Cat**					
1.	Kurichyad	23-11-2016	Teak Plantation	11.78	76.29	940
2.	Muthanga (NF)	18-12-2016	Natural Forest	11.64	76.41	916
3.	Muthanga (NF)	16-12-2016	Natural Forest	11.67	76.42	880

APPENDIX II: List of animals (except small carnivores) camera trapped from Wayanad Wildlife Sanctuary between November 2016 and February 2017

Sl. No.	Class/Species	Scientific Name	Total No. Individuals
I.	**Class Reptilia**		
1.	Indian Black Turtle	*Melanochelys trijuga*	1
2.	Bengal Monitor	*Varanus bengalensis*	2
II.	**Class Aves**		
1.	Indian Peafowl	*Pavo cristatus*	50
2.	Grey Junglefowl	*Gallus sonneratii*	40
3.	Red Spurfowl	*Galloperdix spadicea*	26
4.	Greater Coucal	*Centropus sinensis*	1
5.	Woolly-necked Stork	*Ciconia episcopus*	2
6.	Indian Pond Heron	*Ardeola grayi*	32
7.	Cattle Egret	*Bubulcus ibis*	64
8.	Intermediate Egret	*Ardea intermedia*	1
9.	Little Egret	*Egretta garzetta*	5
10.	Red-wattled Lapwing	*Vanellus indicus*	18
11.	Brown Fish Owl	*Ketupa zeylonensis*	9
12.	White-throated Kingfisher	*Halcyon smyrnensis*	1
13.	Black Drongo	*Dicrurus macrocercus*	1
14.	Large-billed Crow	*Corvus macrorhynchos*	2
15.	Forest Wagtail	*Dendronanthus indicus*	3
16.	Common Myna	*Acridotheres tristis*	4
17.	Jungle Myna	*Acridotheres fuscus*	25
18.	Orange-headed Thrush	*Geokichla citrina*	1
III.	**Class Mammalia**		
1.	Asian Elephant	*Elephas maximus*	808
2.	Bonnet Macaque	*Macaca radiata*	183
3.	Tufted Gray Langur	*Semnopithecus priam*	204
4.	Three-striped Palm Squirrel	*Funambulus palmarum*	2
5.	Indian Crested Porcupine	*Hystrix indica*	167
6.	Black-naped Hare	*Lepus nigricollis*	278
7.	Indian Wild Dog	*Cuon alpinus*	83
8.	Sloth Bear	*Melursus ursinus*	49
9.	Leopard	*Panthera pardus*	38

10.	Tiger	*Panthera tigris*	151
11.	Wild Boar	*Sus scrofa*	135
12.	Indian Chevrotain	*Moschiola indica*	48
13.	Spotted Deer	*Axis axis*	4774
14.	Barking Deer	*Muntiacus muntjak*	61
15.	Sambar Deer	*Rusa unicolor*	241
16.	Gaur	*Bos gaurus*	339