STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK, KERALA

by

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(2014-17-101)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN FORESTRY

Faculty of Forestry

Kerala Agricultural University

DEPARTMENT OF WILDLIFE SCIENCES

COLLEGE OF FORESTRY

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2016

DECLARATION

I hereby declare that this thesis entitled "**Status, distribution and habitat preferences of small carnivores in Silent Valley National Park, Kerala**" is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled **"Status, distribution and habitat preferences of small carnivores in Silent Valley National Park, Kerala"** is a record of research work done independently by **Miss. Devika Sanghamithra (2014-17-101)** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ACKNOWLEDGEMENT

With at most respect and immense admiration I wish to place on record the heartfelt gratitude to my major advisor ***Dr. P.O. Nameer****, Associate professor and Head, Department of Wildlife Sciences, for his sustained and amiable support, help, warm concern, encouragement, constant evaluation and guidance throughout the period of research work.*

I owe my sincere thanks to my advisory committee members ***Dr. T.K. Kunhamu*** *Professor and Head, Department of Silviculture and Agroforestry,* ***Dr. E.V. Anoop****, Professor and Head, Department of Wood Science, and* ***Dr. Siby Philip,*** *Assistant Professor, Department of Zoology, Nirmalagiri College, Kannur, for their timely interventions, valuable advice and suggestions, friendly co-operation and constant encouragement during the study.*

I express my deep sense of gratitude to ***Kerala Agricultural University*** *for the financial assistance and granting permission for field study. I take this opportunity to render my sincere gratitude to* ***Dr. K. Vidyasagaran,*** *Dean, College of Forestry for extending the available facilities in the college for conducting the present study.*

I am extremely grateful to Principal Chief Conservator of Forests (WL) & Chief Wildlife Warden, Kerala Forest Department for granting the permission to study the small carnivores of Silent Valley National Park. We thank Wildlife Warden of Silent Valley National Park and all other staffs of the Forest Department for helping with the logistics and other supports.

Words are not enough to express my heartfelt acknowledgement towards ***Miss. Devipriya, K. S. and Miss. Aswathy Chandran, U. B.,*** *my work would be an incomplete one without their help and support. Words cannot convey my gratefulness to* ***Mr. Sachin, K. Aravind*** *whose constant support and encouragement lead me to this achievement.*

Words cannot really express my gratefulness to ***Mr. Aby Crucha, Mr. Vishnu, M., Mr. Niyas, P., Mr. Akhil Das, A., and Mr. Jobin Joseph*** *who had been with me in*

the field making the most strenuous task the least one. I extend my sicere thanx to my juniors ***Miss. Syamili, M. S., Miss. Abhirami, M. J., and Mr. Sreekumar, E. R.*** *for their help and support.*

I accord my sincere thanks to ***Miss. Nimisha Cherian*** *Research Assistant, Wildlife Forensic Unit, for their help. I wish to express my gratitude to* ***Dr. Neelesh Dahanukar,*** *Indian Institute of Science Education and Research, Pune, for the timely help in analysis part. I wish to thank* ***Mr. M. Shaji****, Assistant Professor, Department of Wildlife sciences, for his timely support, suggestions and help.*

Help provided by ***Mr. Sreehari, R*** *for giving me some valuable suggestions and* ***Mrs. Jayasree K.****, Teaching Assistant, Department of Wildlife Sciences in will always be remembered with great sincerity for her valuable guidance and timely help to carry out statistical analysis.*

Words cannot really express the power of relations that I experienced from ***Miss. Lakshmy J Rajan, Miss. Neenu, P., Miss. Kavya, S. Raysad., Miss. Devika, V. S., Mr. Nikhil, S., and Mr. Aneesh, C. R.*** *I was in need, they gave the mental strength and support and that really encouraged me to successfully complete this task without facing any hurdles. I am also grateful to* ***all other classmates, juniors and seniors*** *for their co-operation and moral support.*

The support and help rendered by ***Mrs. Mini, J****.,* ***Mrs. Jyothy Haridas****,* ***Mrs. Sheeja****, and* ***Mrs. Sindhu*** *will always be remembered.*

A word of apology to those have not mentioned in person and a note of thanks to one and all who worked for the successful compilation of this endeavor.

Above all I bow my head before ***my father, mother, and my chechyamma*** *whose blessings and care enabled me to complete this programme with a great success.*

Devika Sanghamithra

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Introduction

INTRODUCTION

Western Ghats is a 1,600km long stretch of mountain range starting from the southern tip of India to river Tapti of Gujarat and covers an area of 1,60,000km^2. High diversity of plants and animals makes the Western Ghats one of the global biodiversity hotspots of the world (Myers *et al.,* 2000). The forests in Western Ghats are rich in endemic flora and fauna. About 60 genera, mostly monotypic and 2,100 species are endemic to the Western Ghats, mostly to the rainforests. The rest of India has only 84 endemic genera. The southern Western Ghats lying between 8^0 and 11^0 N is the important ecological subunit of the Western Ghats (Myers *et al.,* 2000). The region harbors higher levels of biodiversity and endemism than the rest of the Western Ghats (Vasudevan *et al.,* 2001).

Mammals are considered to be the most successful animals on earth. Mammals encompass approximately 5,416 species, spread in about 1,229 genera, 153 families and 29 orders (Wilson and Reeder, 2005). Four hundred and twenty species of mammals (7.75%) are identified from India (Nameer, 2008). Around 145 species of mammals have been recognized within the political boundaries of Kerala state (Easa *et al.,* 2001 and Nameer, 2015). Out of the 281 species of carnivores of the world (Wilson and Mittermeier, 2009) small carnivores account for 194 species (Wilson and Mittermeier, 2009 and Mudappa, 2013). Carnivores less than about five kg in body weight belonging to the order Carnivora are generally called the small carnivores (Yoganand and Kumar, 1999). There are 41 species of small carnivores in India (Menon,2003) belonging to six families (Wilson and Mittermier, 2009; Mukherjee, 2013) This includes 15 species of mustelids, eight species of Viverrids, six species of herpestids, one species of Prionodontids, one species of Ailurid (Yonzon, 2013) and 10 species of Felids (SmallCats) (Mudappa, 2013; Mukherjee, 2013; Hussain, 2013). The facts of small carnivores of India, Western Ghats and Kerala in relation to the world over are given in Table 1

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

Family	**Kerala**	**Western Ghats**	**India**	**World**
Ailuridae (Red Panda)	-	-	1	1
Eupleridae (Fossa)	-	-	-	9
Felidae (small cats only)	3	3	10	30
Herpestidae (Mongoose)	4	4	6	34
Mephtidae (Skunk)	-	-	-	12
Mustelidae (Otters, Martens)	3	4	15	59
Nandinidae (African Palm-civet)	-	-	-	1
Prionodontidae (Linsangs)	-	-	1	2
Procyonidae (Olingo)	-	-	-	14
Vivveridae (Civets)	3	3	8	33
Total	**13**	**14**	**41**	**195**

Source: Schipper *et al*. (2008); Nandini and Mudappa (2010); Janardhanan *et al.* (2014), and Nameer (2015)

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

Out of the 14 small carnivores of Western Ghats, The lesser carnivore community shows a high degree of endemism in the Western Ghats. The Brown Palm Civet, and the Nilgiri Marten are endemic to species level while Stripe-necked Mongoose and the Brown Mongoose are endemic to sub-species level. Among the various small carnivores of Western Ghats, the taxonomic status of Malabar Civet has been questioned by Nandini and Mudappa (2010) and a study on Fishing Cat by Janadhanan *et al* (2014) concluded that the species could have been extirpated from the area or they hypothesize that the Fishing Cat perhaps never occurred along the western coast of India due to higher salinity levels as compared to the eastern coast.

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

Species	**Scientific name**	**Family**	**IUCN threat category**
Brown Palm civet	*Paradoxurus jerdoni*	Viverridae	LC
Common Palm Civet	*Paradoxurus hermaphroditus*	Viverridae	LC
Small Indian civet	*Viverricula indica*	Viverridae	LC
Indian Grey Mongoose	*Herpestes edwardsi*	Herpestidae	LC
Brown Mongoose	*Herpestes fuscus*	Herpestidae	LC
Ruddy Mongoose	*Herpestes smithii*	Herpestidae	LC
Stripe-necked Mongoose	*Herpestes vitticollis*	Herpestidae	LC
Jungle Cat	*Felis chaus*	Felidae	LC
Leopard Cat	*Prionailurus bengalensis*	Felidae	LC
Rusty-spotted Cat	*Prionailurus rubiginosus*	Felidae	VU
Smooth-coated Otter	*Lutrogale perspicillata*	Mustelidae	VU
Asian Small-clawed Otter	*Aonyx cinereus*	Mustelidae	VU
Nilgiri Marten	*Martes gwatkinsii*	Mustelidae	VU
Honey Badger	*Mellivora capensis*	Mustelidae	LC

Source: Schipper *et al*. (2008); Nandini and Mudappa (2010); Janardhanan et.al (2014), and Nameer (2015)

1.1. ROLE OF SMALL CANIVORES IN ECOSYSYTEM SERVICES

The lesser known mammals engage in significant ecological roles in the ecosystem functioning in tropical forests and their exclusion has a cascading effect on entire communities. Small carnivores are an integral component of forest animal communities, contributing to energy flow and nutrient cycling, and playing enormously important roles as predators and pollination agents in tropical forests (Nandini and Karthik, 2007). Many of them play a major role in seed dispersal (Engel, 1992; Mudappa *et al.*, 2010; and Jothish, 2011) and thereby in the vegetation dynamics of their habitat. They also form an important prey base for medium sized carnivores and raptors (Mudappa *et al.*, 2010).

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

Due to the resemblance in body size, they often share more or less the same variety of food items that contain small mammals, birds, amphibians, reptiles, fishes, invertebrates and often fruits and seeds. Unlike the large carnivores which depend on a relatively narrow prey base, the survival of a large assemblage of the small carnivores depends on the availability of an equally large assemblage of prey species and food plants. The richness, abundance and distribution of the small carnivores, therefore, are very good indicators of biodiversity both in terms of species and habitat.

There are several constraints in studying the small carnivores. Most of these animals besides being small are also rare, nocturnal, solitary and often inhabit areas with poor visibility due to thick vegetation. This makes tough to find and monitor these animals for studying their behavior and habits. Because of these

reasons camera-trapping is preferred to observational studies to document species richness and assess status. However, very few studies have used this method specifically to survey small carnivores (Mudappa, 1998). Apart from the camera trapping method, line transect method for collecting indirect evidences and night transect using vehicles for estimating encounter rates or densities can also be used.

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

Most of the Protected Areas of the country in general and Kerala in particular do not have a comprehensive inventory of the small carnivores. Even basic information such as the distributional range of these species is not known (Nameer, 2000). No studies have been done on the small carnivores of Silent Valley National Park (henceforth SVNP), except for the studies on the sighting records of Nilgiri Marten (Christopher and Jayson, 1996) and habitat characterization of Nilgiri Marten (Balakrishnan, 2005). But a firsthand knowledge about the mammalian fauna, especially the small carnivores of SVNP is not available and hence the present study. It is hoped that the study would help to strengthen the scientific management of the small carnivores of SVNP.

The **objectives** of the present study are,

1. To study the diversity of small carnivores of SVNP
2. To study the status and distribution of small carnivores of SVNP
3. Habitat preference of small carnivores of SVNP

Review of literature

REVIEW OF LITERATURE

Most of the studies and researches on the mammals of India are confined to the charismatic mega mammals and very little studies have been done on the small carnivores. Small carnivores depend on a relatively large assemblage of prey species and food plants. The small carnivores are good indicators of biodiversity both in terms of species and habitat due to their richness, abundance, and distribution (Fasil, 2010). But, due to the obstacles to conduct studies on these animals (mongooses, civets, otters, martens and small cats), like small size, their low density and nocturnality, they have not gathered enough attention from the research community. Though, the conservation status of many species is fetching great concerns (Yoganand and Kumar, 1999) and lack of quality data and research, as stated above, could prove detrimental for devising sensible conservation measures for the small carnivores.

Most of the studies pertaining to small carnivores in India are from North Eastern India and from Western Ghats (Johnsingh and Manjrekar, 2013). The studies in North Eastern India was pioneered by a study on Mustelid and Viverrid wealth in Sikkim by Ganguli-Lachungpa(1989). She found seven species of Small carnivores from the Area. Small Carnivores were studied using camera traps and found it is an efficient tool for surveying these animals (Mudappa, 1998).

2.1.FAMILY MUSTELIDAE

2.1.1. Mustelidae studies in India and Western Ghats

Ramakantha (1995) found that Hog badgers shares the same habitat type of Ferret Badgers in Manipur. He also observed that this animal was hunted for food and medical preparations. Hog Badgers are frequent in the forests and woodlands of Nagaland, perchance the most common of all badgers or ferret badgers (Choudhury, 2000).

. Two species of *Melogale* (ferret badgers) have a mutual, 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). Natural distribution and ecological study of mustelids and viverrids in Manipur by Ramakantha (1995) found that ferret Badgers were killed for food in North Eastern. India.Burmese or Large-toothed Ferret Badger *Melogale personata* andChinese or Small-toothed Ferret Badger *Melogale moschata* are found all over Nagaland, however, exact rank is unclear as their detection is very complicated due to their nocturnal habit. They occur in both hill forests as well as grassland in the abandoned *jhums* (Choudhury, 2000). Ferret badgers were photo captured in India for the first time from Arunachal Pradesh (Datta *et al.*, 2008). To establish species identity visually, present knowledge mandates examination of the skull. Large-toothed Ferret Badger identity from the South Garo Hills, in Meghalaya was confirmed, as a carcass of the animals was obtained, which enabled the cranial examination of the species (Kakati *et al.*, 2014).

A pair of Yellow-throated Marten *Martes flavigula* was sighted at an altitude of 1500m MSL in Sikkim by Ganguli-Lachungpa (1989). It is usually found in dense tropical forest in the Western part of Manipur as well as in the Teak-Gurjan type forests in the Indo-Myanmar border areas (Ramakantha, 1994). Common all over Nagaland, but, its allocation is restricted to the forest areas (Choudhury, 2000). The animal is photo captured from Arunachal Pradesh (Datta *et al.*, 2008), later it was also photo captured from Kyongnosla Alpine Sanctuary, East Sikkim (Khatiwara and Srivastava, 2014).

Nandini and Karthik (2007) observed an individual of Yellow-throated Marten feeding on flowers in Balpakram National Park in Meghalaya. Among the four species of small carnivores were recorded from Barsey Rhododendron Sanctuary, Yellow-throated Marten was the most commonly camera trapped small carnivore during the survey. It is also reported that this animals involvement in human wildlife conflicts in villages (Ghose *et al*., 2014).

2.1.1.1. *Honey Badger or Ratel Mellivora capensis* Schreber, 1776

The Ratel or Honey Badger *Mellivora capensis* (Mustelidae) is common across parts of Western Asia and the Indian peninsula, Africa, and the Arabian Peninsula. Owing to its indefinable nature, there is very minor dependable, current knowledge on its status and distribution from the Indian subcontinent. In meticulous, there are quite few recent records from the southern India (Begg *et al.* 2008). Joshi and Andavan (2008) reported the Ratel from Gujarat. The Ratel was camera trapped from Cauvery Wildlife Sanctuary, Karnataka (Gubbi *et al*., 2014). The species feeds largely on flesh and the diet is supplemented by other vegetarian diets (Menon, 2014). Globally it is scheduled as Least Concern under *The IUCN Red List of Threatened Species*, (Begg *et al.* 2008).

2.1.1.2. *Nilgiri Marten Martes gwatkinsii* Horsfield, 1851

Most of the published reports on martens were the opportunistic sighting reports from the various Protected Areas of Western Ghats. Yoganand and Kumar (1995) reported Niligiri Marten *Martes gwatkinsii* from Nilgiri Biosphere Reserve and Madhusudan (1995) from Eravikulam National Park. Christopher and Jayson (1996) reported it from Peppara Wildlife Sanctuary. Kurup and Joseph (2001) made definite observations on the behavior of Nilgiri Marten from the Periyar Tiger Reserve. Balakrishnan (2005) reported the sighting of the Nilgiri Marten from Silent Valley National Park, Muthikkulam South Reserve Forest, Attappadi Reserve Forest, and Nilambur South Reserve Forests. A study by Krishna and Karnad (2010) reported the sightings of Nilgiri Marten from Anamalai Tiger Reserve, Nelliampathy Reserve forest and Pambadum Shola Natinal Park. Sreehari and Nameer (2013), reported the Nilgiri Marten from Parambikulam Tiger Reserve, while it was reported from Peppara Wildlife Sanctuary, among a tea plantation at an altitude of 400 m (Raj, 2013). Nilgiri Marten is a Near Threatened as per IUCN red listing (Mudappa *et al.*,2015).

2.1.1.3. *Smooth-coated Otter Lutrogale perspicillata* Saint-Hilaire, 1826

A detailed study on the ecology of Smooth-coated Otter (*Lutrogale perspicillata*) in National Chambal Sanctuary was conducted by Hussain (1993). Food and feeding habitats of Smooth-coated Otter under captivity was reported by Haque and Vijayan (1995). Hussain and Choudhury (1995, 1997 and 1998) reported that the fishes are the major food of otters and they constitute majority (>80%) of the food. Hussain (1996, 1998) studied the group size of the otters, their group structure and breeding behavior in the lower Himalayas. Meena (2002) reported on the killing of otters in the Palni Hills. The first comprehensive study on the otters of Western Ghats was done by Anoop and Hussain (2004), who studied the ecology and feeding behavior of Smooth-coated Otter in Periyar Tiger Reserve. The spraint analysis showed that the major prey of otters is fishes followed by frogs, birds, crabs and insects. A study of the factors affecting the habitat selection by otters found that the otters select areas with low water depth and width with a gentle slope and more number of streams joining the lake and a less rockiness (Anoop & Hussain, 2005). Shenoy (2006) studied on the factors influencing the habitat preference of the Smooth-coated Otter. The non-otter sites varied from otter habiting sites. A higher percentage of loose sand on the river banks was a potential factor for te site selection by otters. The areas having high anthropogenic disturbances were avoided by them. This species is Vulnerable under *The IUCN Red List of Threatened Species* (de Silva *et al.,* 2015).

2.1.1.4. *Eurasian Otter Lutra lutra* Linnaeus, 1758

Eurasian Otters were commonly seen in large streams in Sikkim (Ganguli-Lachungpa, 1989). First confirmed report on the occurrence of Eurasian Otter in Manipur is by Ramakantha (1995). It is uncommon or rare in the regions of Ladakh (Shawl *et al.,* 2008). It is Near Threatened under *The IUCN Red List of Threatened Species* (Ross *et al.,* 2015).

2.1.1.5. *Asian Small-clawed Otter Aonyx cinereus* Illiger, 1815

Asian Small-clawed Otter *Aonyx cinereus* is naturally occurring in India, Nepal, Bhutan, Malaysia, Myanmar, Bangladesh, South China, Thailand, Hainan Islands, Laos PDR, Brunei, Vietnam (Sumatra, Java, Borneo), Taiwan, Indonesia, and Philippines (Wozencraft, 1993). Perinchery (2011) and Aneesh (2012) studied the feeding and behavior of Small- clawed otter in Eravikulam National Park. The habitation and concentration of habitat use of Asian Small-clawed Otter in the Western Ghats was examined by Prakash (2012). He discovered that the otters have a fairly high habitation in protected areas and neighboring human landscapes. To support persistence of otters in human personalized landscapes bordering protected areas the conservation and re-establishment of riparian vegetation along with control over extractive activities of humans are desirable. The new records of the species from Maharashtra and Goa, provides evidence for the northern extension of their distribution from the Western Ghats, as there was no prior records of Small-clawed Otter from the north Western Ghats (Punjabi *et al.,* 2014). This species is Vulnerable under *The IUCN Red List of Threatened Species* (Wright *et al.,* 2015).

2.2. FAMILY VIVERRIDAE

2.2.1. Viverridae studies in India and Western Ghats

2.2.1.1. *Malabar Civet Viverra civettina* Blyth, 1862

Malabar Civet *Viverra civettina* is endemic to Western Ghats and is as large as the Large Indian Civet *Viverra zibetha* (Pocock, 1933). The original description about the Malabar Civet was given by Blyth (1862). The next available information about Malabar Civet was by Jerdon (1874). He also reported that the species was common all over the Malabar cost from Travancore.

Disquiet about this species began early this century as several expeditions failed to obtain specimens (Pocock, 1939). The last (and perchance only) live specimen of the Malabar Civet in a zoo was at the Thiruvananthapuram Zoo in 1929. In recent times only two possible sightings have been reported: Karanth (1986) in Bhagavathy Valley, Karnataka and Kurup (1989) in Tiruvalla, Kerala. In 1987, after a gap of 58 years, two skins of recently killed animals were obtained by the Zoological Survey of India, Calicut of a species long suspected extinct (Kurup, I989). Most of the past records of the species were from the coastal tracks (Jerdon, 1874; Pocock, 1939; Prater, 1971) and from Kanyakumari in the farthest south to Karnataka in the north. Moreover, there were two records of its presence in the upper elevations of the Western Ghats (Hutton, 1949), and in Kudremukh (Karanth, 1986). But for these reports, the Malabar Civet has remained unknown to the scientific community (Rai and Kumar, 1993).

Ashraf *et al*. (1993) during a survey in Kerala obtained a skin and a stuffed specimen of the animal from a tribal settlement. Rai and Kumar (1993) who surveyed the Nilambur and adjoining forests of Kerala could not get any evidence of the species. They however, suggested the presence of Malabar Civets in few locations in Kerala and Karnataka based on indirect evidences. The most recent survey on Malabar Civet by Rao *et al.,* (2007) and Ashraf *et al.,* (2009), could not get any direct evidence to prove the presence of Malabar Civet in south India. Jayson (2007) also did a status study of Malabar Civet in the southern Western Ghats under Kerala Forest Research Institute which also failed to obtain any direct evidences. Nandini and Mundappa (2010), after reviewing the records of its collection, published and unpublished writing on this species, derived at two conclusions that the species is an extremely rare species that is extinct or nearly so and the other conclusion is that of a more original one that the possibility of the species as an manufactured article and did not exist at all. The reason to derive the later conclusion is that the specimens kept in museums have no reliable data about its location and collectors name. Moreover, most of them were not obtained as alive from the wild. Most of the records of the species were from coastal areas

and areas near to trading ports. This suggest a novel possibility that the Large-spotted Civet *Viverra megaspila* that was traded to India for the use in perfume industries and a few individuals might have escaped into the wild, resulting in the little number of reports and skins.

2.2.1.2. *Small Indian Civet Viverricula indica* Saint-Hilaire, 1803

The Small Indian Civet is found throughout India (Menon, 2014). It is wide spread in Manipur and the animal is occasionally hunted for food (Ramakantha, 1995). First record of Small Indian Civet from Kashmir Himalaya, India is stated by Charoo *et al* (2010).

The major threats faced by the Small Indian Civets *Vivericula indica* are the illegitimate hunting for meat and civetone, habitat destruction, along with other anthropogenic causes (Gupta, 2000). The skin of the civets is also used for the preparation of Ayurvedic medicines against epilepsy (Gupta, 2004). Balakrishnan and Sreedevi (2007) studied on the Small Indian Civets under captivity. They also reported that the practice of capturing civets for keeping under captivity is the major reason for the depletion of civet's population in south India.Under *The IUCN Red List of Threatened Species* it is reported as Least Concerned (Choudhury *et al.,* 2015).

2.2.1.3. *Common Palm Civet Paradoxurus hermaphrodites* Pallas, 1777

Common Palm Civet is found all over India except Himalayas and arid western parts of the country (Menon, 2014). This species is the commonest of viverrids in Manipur. The animal found in North Eastern India is quite distinctive from the south Indian form in both its summer and winter coats and the spot on the flanks being larger and clearer in the former (Ramakantha, 1995). Krishnakumar and Balakrishnan (2003) studied the feeding ecology of Common Palm Civet *Paradoxurus hermaphroditus* in the semi urban areas of Kerala. Borah

and Deka (2011) reported the mating behavior of the species. The study reported that the Common Palm Civet feed on 18 fruit species as a minimum. The study also reported the high germination rate of the seeds collected from the scat of Common Palm Civet. The animal is photo captured in from Arunachal Pradesh (Datta *et al.,* 2008). Fruits were the predominant vegetable matter in the faeces. Seeds from faeces had high percentage germination. Taking into account the movement patterns of Common Palm Civets studied and the higher germination rates of seed frem faeces, Common Palm Civet is plausibly an effective seed disperser of forests (Jothish, 2011). It was camera trapped during the camera trap survey as component of a programme to assess carnivore and prey species abundance in Namdapha National Park, Arunachal Pradesh (Datta *et al*., 2008).It is reported to be Least Concerned in *The IUCN Red List of Threatened Species* (Duckworth *et al.,* 2008).

2.2.1.4. *Brown Palm Civet Paradoxurus jerdoni* Blanford, 1885

The Brown Palm Civet or Jerdon's Palm Civet *Paradoxurus jerdoni* is an endemic carnivore constrained to the rainforests of the Western Ghats. The species had been reported within an altitudinal range of 500-1,300m, and more frequent in higher altitudes (Mudappa, 1998). They are well-known to occur in tropical rainforests of the Western Ghats (Ashraf *et al*., 1993).

Recent reports include photographs or sight reports from Nilgiris, Anamalais, and Coorg (Schreiber *et al*., 1989), Silent Valley (Ramachandran, 1990), and Kalakad- Mundanthurai Tiger Reserve (KMTR) (Ganesh, 1997; Mudappa, 1998). Brown Palm Civet possibly occurs in small densities all throughout its range (Ashraf *et al*., 1993). But, the species seems to be quite common in Kakachi-Upper Kodayar (Ganesh, 1997) and other areas above 1,000m in the KMTR and also in the Anamalai hills (Mudappa, 2001). Recent studies recommend that the species were not as unusual as they were thought to be (Mudappa, 2001). A detailed study about the status and distribution of Brown Palm Civet was carried out by Nandini *et al*. (2002), reported illegal hunting and

the conversion of rainforest into tea and coffee plantations were the major threats to the species. Mudappa and Chellam (2002) made some capture and immobilization studies of wild individuals of this species in Western Ghats. Mudappa (2002b; 2006) also made extensive studies on the Brown Palm Civets of Western Ghats. Mudappa *et al* (2007) reported this species from Kalakkad-Mundanthurai Tiger reserve and Anamali Hills. It occurs all over the southern Western Ghats, from Achankovil Reserved Forest (Kerala) to the Bhagwan Mahaveer Wildlife Sanctuary (Goa), however until now was not recorded in the northern parts of the Western Ghats. Two records from the state of Maharashtra expand its recognized range north by about 200 km. The northern form is reported to be lighter in colour with paler under abdomen and markings on the face (Bhosale *et al*., 2013). An wholly white-coated individual spotted at Amboli hill station, Maharashtra, and it is markedly the first record of this pelage aberration (Chunekar, 2014). It is reported to be Least Concerned in *The IUCN Red List of Threatened Species* (Mudappa & Choudhury, 2008).

2.3. FAMILY HERPESTIDAE

2.3.1. Herpestidae studies in India and Western Ghats

2.3.1.1. *Indian Grey Mongoose Herpestes edwardsii* Saint-Hilaire, 1818

The Indian Grey Mongoose is found throughout India except in high Himalayas (Menon, 2014, and Mudappa, 2013). Choudhary (1981) reported that Indian Grey Mongoose *Herpestes edwardsii* predate on Gharial eggs. It is sighted throughout central India and majority of the sightings occurred near human settlements. These animals were often captured and sold as pets, but evidently not at high enough levels to threaten the species (Shekhar, 2003). It is considered as Least Concerned in *The IUCN Red List of Threatened Species* (Choudhury *et al.*, 2013).

2.3.1.2. *Ruddy Mongoose Herpestes smithii* Gray, 1837

This animal is an excellent tree climber. It hunts in trees and carries prey into trees for feeding (Shekhar, 2003). Two individuals of the species were spotted at the time of foraging under rocks, around the trunks of trees and on the forest floor (Shekhar, 2008). Sreehari *et al* (2013) reported the presence of Ruddy Mongoose in Parambikulam Tiger Reserve and Chinnar Wildlife Sanctuary. Photo captured record of Ruddy Mongoose in the Eserna hill range, in the western part of the Aravalli Hills, represent a north-westward expansion of its known range from the adjacent known population (Dookia, 2013). It is considered as Least Concerned in *The IUCN Red List of Threatened Species* (Choudhury *et al.*, 2008).

2.3.1.3. *Brown Mongoose Herpestes fuscus* Waterhouse, 1838

Mudappa (2002a) reported the occurrence of Brown Mongoose *Herpestes fuscus* in KMTR, Tamil Nadu. Sreehari *et a.l* (2013) reported the occurrence of Brown Mongoose in Parambikulam Tiger Reserve and Eravikulam National Park. It is Vulnerable as per *The IUCN Red List of Threatened Species* (Mudappa and Jathanna, 2015).

2.3.1.4. *Stripe-necked Mongoose Herpestes vitticollis* Bennett, 1835

Rompaey and Jayakumar (2003) did a comprehensive study on the Stripe-necked Mongoose *Herpestes vitticollis*. They studied the distribution, status, food and feeding habits, reproduction and various threats. There are only a few previous records of Stripe-necked Mongoose from the north-central Western Ghats. Stripe-necked Mongoose was known only from the southern Western Ghats of India and Sri Lanka. Recent records contain both direct sightings and camera trap images of the animal come from the north-central Western Ghats in the states of Maharashtra and Goa (Punjabi *et al*., 2014). There is a report well

outside the range of other records, from Horsley Konda in the Eastern Ghats (Allen, 1911). Six records now confirm Stripe-necked Mongoose occurrence in Similipal Tiger Reserve, Odisha, and Eastern India. These Stripe-necked Mongoose records from Similipal TR suggest that systematic surveys in and near the Eastern Ghats might find this mongoose elsewhere in the hill range (Nayak *et al*., 2014). It is Least Concerned as per *The IUCN Red List of Threatened Species* (Choudhury *et al.,* 2008).

2.4. FAMILY FELIDAE

2.4.1. Felidae studies in India and Western Ghats

2.4.1.1. *Jungle Cat Felis chaus* Schreber, 1777

Chavan (1987) studied the status of lesser cats in Gujarat. Some studies on the melanism in Jungle Cat *Felis chaus* were carried out by Chakraborty *et al*. (1988). Gogate (1997) surveyed the lesser cats of Maharashtra and listed five species of lesser cats including Jungle Cat. Jha (2000) reported the species from Sikkim. Gupta (2000) reported the illegal trade of Jungle Cat for meat in the Nilgiri Biosphere Reserve. Duckworth *et al*. (2005) studied the population status of Jungle Cat in Indo-China border. They reported that Jungle Cats have a threatened population over there. They also found out that the Jungle Cat is a widespread and adaptable species. Mukherjee and Groves (2007) studied on the geographic variations in Jungle Cat. Patel (2011) recorded three species of small cats, includes Jungle Cat *Felis chaus*, Rusty-spotted Cat *Prionailurus rubiginosus* and Asiatic wild Cat *Felis silvestris* from eastern Gujarat. He also recorded the major diet of the three small cats. Mukherjee *et al*. (2013) studied the significance of rodents in the diet of Caracal *Caracal caracal* and Jungle Cat *Felis chaus*. They found that the rodents provides up to 70% of the daily metabolizable energy in lesser cats. The study shows that the conversion to agriculture destroys the natural cover of the area which is essential for the hunting of felids. This cover

should be protecting in order to conserve our lesser cats as they play very important role in controlling the rodent pests. It is reported as Least Concerned *The IUCN Red List of Threatened Species* (Duckworth *et al.,* 2008).

2.4.1.2. *Rusty-spotted Cat Prionailurus rubiginosus* Saint-Hilaire, 1831

Almost all the published literature on Rusty-spotted Cat *Prionailurus rubiginosus* were occurrence reports. Very minute knowledge was available on the ecology and habitat of the species (Jackson 1998; Mukherjee 1998). The Rusty-spotted Cat has been reported from Jammu and Kashmir (Chakraborty, 1978), Gujarat (Chavan *et al*., 1991), Rajasthan (Tehsin, 1994), Madhya Pradesh (Digveerendrasinh, 1995), Tamil Nadu (Christopher and Jayson, 1996), Orissa (Acharjyo *et al*., 1997), Maharashtra (Dubey, 1999), Tadoba (Karnat, 1999) and Andhra Pradesh (Rao *et al*., 1999; Manikadan and Sivakumar, 2005). It is a Vulnerable species under *The IUCN Red List of Threatened Species* (Khan and Mukherjee, 2008).

2.4.1.3. *Leopard CatPrionailurus bengalensis* Kerr, 1792

Jayson and Christopher (1996) reported the Leopard Cat *Prionailurus bengalensis* from Peppara Wildlife Sanctuary in Trivandrum. They also reported that the sighting of nocturnal mammals has become rare in the Western Ghats. Jha (2000) reported the Leopard Cat from Sikkim. Khan (2004) studied the food habits of Leopard Cat in the Sunderbans. The study found that Leopard Cat prefer rodents in their diet followed by insects, birds, plant materials, agamids and crabs. It was camera trapped during from Namdapha National Park, Arunachal Pradesh (Datta *et al*., 2008). Among the five species of felids, Leopard Cat was the most abundant during a distribution and abundance study of mammals in Khangchendzonga Biosphere Reserve (Sathyakumar *et al*., 2011). The animal is photo captured during a camera trap survey at Kyongnosla Alpine Sanctuary, Sikkim (Khatiwara and Srivastava, 2014). The species is absent in the major parts

of plateau and arid areas of Rajasthan and Gujarat (Menon, 2014). It is reported as Least Concerned *The IUCN Red List of Threatened Species* (Ross *et al.,* 2015).

2.4.1.4. *Fishing Cat Prionailurus viverrinus* Bennett, 1833

Fishing cats *Prionailurus viverrinus* are common in the Sunderbans, but rare in other parts of the state, due to destruction of their habitat. Bhattacharya (1989) reported the status and their distribution in West Bengal. The species is primarily reported from the Terai region, Himalaya and from the northeastern India (Choudhury, 2003). Nayerul and Vijayan (1993) studied the feeding habits of the Fishing Cat in Keoladeo National Park. Jha (2000) reported the species from Sikkim. Scavenging habits of Fishing Cats in Rajasthan was studied by Haque and Nayerul (1998). Janardhanan *et al.* (2014) studied the status of Fishing Cat in the Western Ghats. After conducting an extensive study along the potential habitats of Fishing Cat (*Prionailurus viverrinus*) in coastal Kerala, they concluded that the species could have been extirpated from the area or they hypothesize that the Fishing Cat perhaps never occurred along the western coast of India due to higher salinity levels as compared to the eastern coast.It is reported as Endangered *The IUCN Red List of Threatened Species* (Mukherjee *et al.,* 2010)

2.5. OTHER SMALL CARNIVORE STUDIES IN INDIA

Ramakantha(1995) studied the natural distribution and ecology of mustelids and viverrids in Manipur. Four species of Mustelids have been reported from Ladakh (Shawl *et al.,* 2008). Yoganand and Kumar (1995) open up the study on the distribution of small carnivores in the Nilgiri Biosphere Reserve in Western Ghats. Choudhury (1997a, 1997b, 2002) also studied the small carnivores of Arunachal Pradesh and Assam and reported 23 species including Red Panda *Ailurus fulgens* and Spotted Linsang *Prionodon pardicolor*. Bahuguna (1998) studied the small carnivores of Darjeeling with special reference to Red Panda. Small Carnivores were studied using camera traps and found it is an efficient tool

for surveying these animals (Mudappa, 1998). Choudhury (1999 and 2000) recorded 22 species of small carnivores of Bengal. He also gave a description on the small carnivores of Nagaland and reported nine species of mustelids, seven viverrids and three herpestids.

Sunita *et al*. (2001) did the primary exhaustive study on the ecology of the Red Panda in India. Bamboo leaves of *Actinidia maling* and *A. aistata* formed the major food item of the Red Panda. The diet was supplemented by bamboo shoots, fruits or berries. The cattle communities present inside and near to the National Park causes enormous trouble to the Red Panda and their habitat. Mudappa (2002a) gave a detailed account of the eight species of small carnivores of Kalakad-Mundanthurai Tiger Reserve (KMTR), Tamil Nadu. Choudhury (2004) gave detailed account on the small carnivores of different sanctuaries in Assam. Kumara and Singh (2006a, 2006b) conducted an extensive survey and reported 11 species of small carnivores from Karnataka. More lately, Mudappa *et al*. (2007) studied the responses of small carnivores to rainforest fragmentation in southern Western Ghats. The study found that limited endemic species are more affected by the habitat fragmentation and disturbances. The disturbed habitats are susceptible to invasion by more wide spread and common species at the cost of these endemic species. Alteration of the composition might also occur due to this. Nandini and Karthik (2007) reported on the Yellow-throated Martens *Martes flavigula* of North East India. Datta *et al*. (2008) studied the occurrence and conservation status of small carnivores in two Protected Areas in Arunachal Pradesh and reported 18 species of forest-dwelling small carnivores including three other otter species from the region. A very recent study was conducted by Pillay (2009) on small carnivores of southern Western Ghats and observed five species of small carnivores during the study.

The status of Red Panda *Ailurus fulgens* of West Bengal was studied by Mallick (2010) more recently. The study also identified various threats faced by the species and suggested some recommendations for the conservation of Red Panda. Lyngdoh *et al*. (2011) observed that the Spotted Linsang is extensively

hunted in Arunachal Pradesh for its fur and meat and thus the species is uncommon. Kumara *et al* (2014) studied the status of small carnivores in Biligiri Rangaswamy temple Tiger Reserve and reported nine species from BRT.

Materials and methods

MATERIALS AND METHODS

3.1. STUDY AREA

The area lies within the latitudes 11^{o}, 2' N and 11^{o}, 13' N and longitudes 76^{o}, 24' E and 76^{o}, 32' E. The initial area under the Division which constituted the core zone of the National Park was only 89.52 sq. km. An area of 148 sq. km. was included as buffer zone in 2007 to the Division, vide G.O. (MS) 36/07/F&WLD dated 07.02.2007 making the total area of the Division at present to 237.52 sq km. The area is situated at the southwest corner of the Nilgiris. Ecologists have described this area as the sole surviving bit of evergreen forests in the *Sahya* ranges. The outline map of Silent Valley National Park is given in Figure 1.

The name 'Silent Valley' may have originated from a mispronunciation of the local name 'Sairandrivanam' by the Britishers who had come to these forests to raise plantations. Another reason contributing to the name 'Silent Valley' is the absence of Cicada insects which are known to produce typical sounds and are usually found abundant in tropical forests. These forests were declared as Reserve Forest in the year 1914.

3.1.1. Geology

The park's east, north and northeast borders are filled with high and continuous ridges while the western and southern borders have comparatively lower ridges. The whole plateau slopes toward the bed of Kunthipuzha along its length which divides it into two halves.

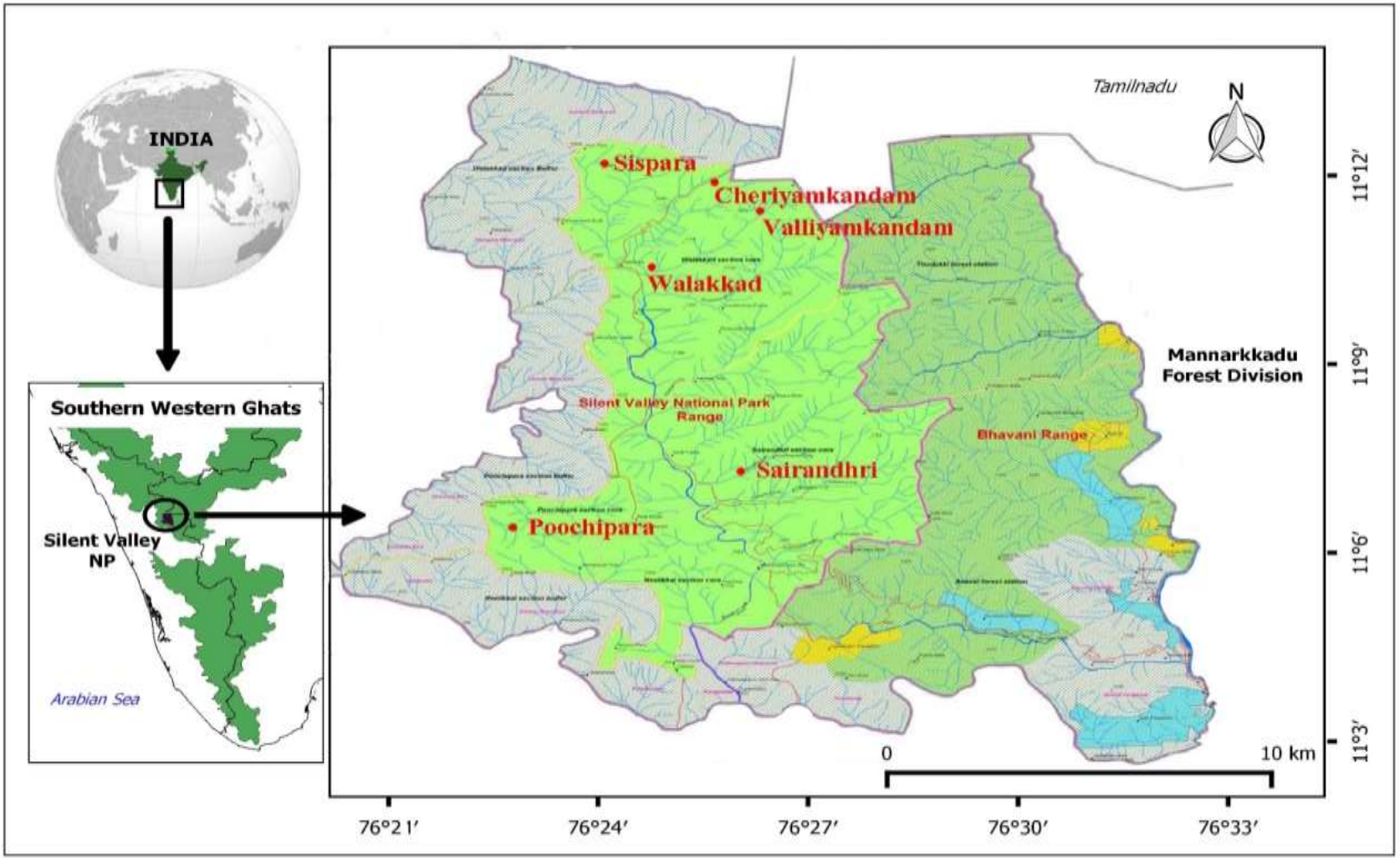


Figure 1. Location map of Silent Valley National Park

3.1.2. Terrain, Rock, and Soil

The rock formation mainly consists of Nilgiri Gneiss and its metamorphic variations and is from the Archaean age. The gneiss composed of Quartz, Feldspar and Mica is delicately foliated and has undergone metamorphism during the passage of time. Laterite is a ferruginous red soft rock with irregular galleries filled with yellow clay running through its mass and it has the property of hardening on exposure to the air. It supports a comparatively shallow layer of top soil mostly. Hence the sub soil cap of laterite is found to be not suitable for the growth of certain species.

Soils in common are loam in the surface as well as in deeper layers and are also strongly acidic. Soil organic Carbon content is found to decrease with depth in all forest types found there except in Reed- *Calophyllum* and Reed-*Poeciloneuron* where no such trend is observed.

The terrain is continuously rising and falling, and filled with steep escarpments and many hillocks. Altitude ranges from 900 M to 2,300 M above MSL with the highest peak Anginda at 2,383 M.

3.1.3. Climate

The change in elevation from the plains to the Ghats causes significant variation in climate. The plains are found to be humid and hot while the Ghats are drier and cooler comparatively. Prevailing winds arrive from west and southwest during April to September while during the period from October to March they come from the east. The area receives rain during both the south west monsoon and the north eastern monsoon. The temperature variation in the plains is between 20^{o}C to 40^{o} C compared as opposed to a range of 10^{o} C to 30^{o} C in the hilly areas.

3.1.4. Hydrology & Water sources

A perennial river named *Kunthipuzha* passes through the western side of the park, from north to south direction, and flows till it joins with the *Bharathapuzha*. Main tributaries of this river are *Kunthancholapuzha, Karingathodu, Madrimaranthode, Valiaparathodu and Kummathanthode*. All major tributaries of *Kunthipuzha* start off from the upper slopes of the eastern side of the Valley. The streams from the western slopes are dry in summer.

The *Bhavani* River is a tributary of the Cauvery, one of the largest rivers in India. The river originates in Nilgiris, and drains the south slope of the Nilgiri Hills. After flowing for a few kilometers southward it enters Kerala through a deep gorge and continues south for another 20 km, between two high, forested ridges till Mukkali. At Mukkali, Bhavani takes an abrupt turn towards the northeast and flows for another 25 km through Attappady plateau and for 7 km. along the inter-State border. Kottapuzha, Cherumbapuzha, Kalampotti thode, Chokkad Puzha, Kalikavuthode, Kalkundu puzha, Olipuzha, Palakazhipuzha, Arimanalpuzha, Karuvarathode, and Cherunalipotti are the major streams draining to different important rivers of the area.

Plate 1. A & B: Evergreen Forest of Silent Valley National Park

Forest types and composition

Forest types in Silent Valley National Park has been classified in to four.

- West-coast tropical evergreen forest
- Southern subtropical broad leaved hill forest
- Southern montane wet temperate forest
- Grasslands

3.1.4.1. Wet-coast tropical Evergreen Forest

West-coast tropical evergreen forest lies between altitudes from 600-1100m MSL. The west-coast tropical evergreen forest is a climax vegetation with three storeys. The top canopy is 40-45m in height and comprise of *Artocarpus heterophyllus, calophyllum elatum, Bischofia javanica, Canarium strictum, Cullenia exarillata* etc. Fifteen to 30m high second storey consist of trees like *Actinodaphne hookeri, Cinnamomum malabatrum, Garcinia morella, Dimocarpus longan* etc. The third storey which is less tha 15m high comprise of small trees

like *Agrestistachys meeboldii, Jambosa munroni, Trupinia malabarica etc. Shrubs Dendrocnidia sinulata, Lasianthus* species., *Strobilanthus* species., etc dominate the under growth. Six distinct associations may be recognised as important within our rain forest formation.They are Cullenia – Palaquim association, the Palaquim – Mesua association, thePoceilienuron- Palaquium association, theMesua- Calophyllum association, Ochlandra- Calophyllum association, and Ochlandra- Poecilenuron association

3.1.4.2.Southern subtropical broad leaved hill forest

This type of forest is encountered between 1300 to 1800m MSL.The trees in this forest type does not go beyond 20m high. The mosses, lichens, ferns, and aroids cover the trunks and branches. Major species found here are *Calophyllus elatum, Cinnamomum sulphuratum, Flaeocarpus munronii, Dimocarpus longan, Garcinia* species. Etc.

3.1.4.3.Southern montane wet temperate forest

The southern montane wet temperate forest is always found in cliffs and sheltered folds above 1900m. The growth is very stunted due to the effect of wind and altitude. They are found mostly interspersed with grasslands. The trees seldom attain a height of 10m.

3.1.4.4.Grasslands

Two types of grasslands are seen in SVNP. They are low level grasslands seen below 1500m MSL and high level grasslands found above 1500m MSL.

Plate 2. Grass land of Silent Valley National Park

3.1.5. Fauna

Silent Valley NP has a rich treasure of fauna. Mammals like Lion-tailed Macaque, Nilgiri Tahr, Elephant, Tiger, Leopard, Wild Dog, Nilgiri Languor, and the lesser known carnivores Small Indian Civet, Brown Palm Civet, Leopard Cat, Nilgiri Marten, Asian Small-clawed Otter, Strip-necked Mongoose, and Brown Mongoose are present. Bird communities of Silent Valley NP include 127 species (Pramod, 1999). A count of 35 species of snakes is present in SVNP (Whitaker & Martin, 1999, & Easa & Shaji, 1999). Ninty six species of butterflies and 249 species of moths are identified from SVNP (Mathew, 1999).

3.2. METHODS

3.2.1. Period of observation

Reconnaissance of the study area was done during September 2015. An intensive field study was done from September 2015 to April 2016. The whole study period is divided into two broad seasons such as rainy season (September to December) and non-rainy season (January to April). We spent at least 10 days each in each of the three blocks of the National Park.

3.2.2. Site Selection

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

3.2.3. Camera Trap Survey

Camera trapping is one of the best methods to study the small carnivores. Digital scout cameras having passive infra-red sensors for heat and motion detection (Bushnell Trophy Cam model no. 119436 and Cuddeback Attack model C1) were used for this survey. Overall 100 trapping stations were identified based on the presence of the indirect evidence of the small carnivores (Mudappa *et al.*, 1998). The camera traps were set at a height of 30cm above the ground and at least 150m apart from each other. 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 recorded with a Garmin GPS etrex 30. The cameras were kept open for 24 hours a day. The date and time of exposure were automatically recorded by the camera on the images, as and when the images were taken. At each trapping stations, each camera was opened for 10 days. Thus, a total of 1450 camera-trap

days with 34,800 trapping hours were carried out in the Silent Valley National Park. The camera trap data is given in Appendix I.

Plate 3. A-Camera trap in the field; B- Fixing camera trap in trek path

3.2.4. Line transect survey for both direct and indirect evidence

Several one km transectswere walked in the study locations. Each transect was tracked using the GPS. Appendix II provides the summary of indirect evidence recorded from transects in different vegetation types. A total of 45 transects were laid covering a length of 45km. A single transect can include more than one vegetation type. All transects were walked at least once and most of them were walked more than once. During the transect walk, the indirect evidence primarily the scats of the small carnivores were recorded. Direct sightings if any were also noted. Encounter rates of different species of small carnivores were estimated from the data collected through this method. The scats were identified to the family level of small carnivores such as civet, mongoose, lesser cat etc or to the species level (Silviera *et al.,* 2003; Su, 2005, and Sridhar *et al.,* 2008).

3.2.5. Micro-habitat parameters

Micro-habitat parameters were documented at each of the study sites. All these observations were made within five-meter radius circular plot taking camera trap station as the center of the circle. Micro-habitat parameters such as,

- Canopy height- 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- 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- The thickness of the litter layer is measured around the trap using calibrated probe. An average of four measurements taken
- 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
- 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

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

3.3. DATA ANALYSIS

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

3.3.1. Margalef Species Richness Index

Margalef index is calculated by the formula given below,

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

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

3.3.2. Diversity Indices

3.3.2.1. Simpson's Index, λ

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

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

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

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

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

3.3.2.2. Shannon-Wiener Index, H

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

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

$$\mathbf{H' = \Sigma\ (p_i .\ ln\ p_i)}$$

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

3.3.3. Estimation of Abundance

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

3.3.3.1. Abundance of Small Carnivores

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

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

3.3.4. Habitat Use Assessment

3.3.4.1. Habitat Use Index (HUI)

This index was used to understand the habitat preference of a species in an area. This index was developed from the indirect evidences recorded from different habitats of the Silent Valley National Park. The HUI is calculated by the formula given below.

$$\textbf{Habitat Use Index (HUI)} = \frac{N_{HI}}{N_H} \textbf{ X100}$$

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

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

3.3.5. Statistical Analysis

The data analysis was primarily done using the statistical packages such as the XL STAT (Version 2016.03.30846), and PAST (Hammer *et al.*, 2001).

3.3.5.1 . Logistic Regression for the Prediction of Presence or Absence of Species Using Habitat Parameters

Logistic regression measures the relationship between a categorical dependent variable and one or more independent variables, which are usually (but not necessarily) continuous, by using probability scores as the predicted values of the dependent variable. Here it is used to check whether the prediction of presence

or absence of the species using habitat parameters is possible. Twenty micro-habitat parameters were used in this regression analysis.

3.3.5.2. 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.

Results

RESULTS

4.1. SPECIES COMPOSITION OF SMALL CARNIVORES IN SILENT VALLEYNATIONAL PARK

The present study at Silent Valley National Park recorded seven species of small carnivores representing four families such as Viverridae, Herpestidae, Mustelidae and Felidae (small cats) (Table 3). This comprise of two species each of herpestids, viverrids, mustelids, and one species from felidae. All of these species were camera trapped from the Silent Valley National Park.

Table 3 . Small carnivores recorded from Silent Valley National Park

Common Name	**Scientific name**	**Family**
1.Small Indian Civet	*Viverricula indica*	Viverridae
2.Brown Palm Civet	*Paradoxurus jerdoni*	
3.Brown Mongoose	*Herpestes fuscus*	Herpestidae
4.Stripe-necked Mongoose	*Herpestes vitticollis*	
5.Asian Small-clawed Otter	*Aonyx cinereus*	Mustelidae
6.Nilgiri Marten	*Martes gwatkinsii*	
7.Leopard Cat	*Prionailurus bengalensis*	Felidae

Table 4. Evidences showing the presence of small carnivores in Silent Valley National Park

Evidences	**SIC**	**BPC**	**SNM**	**BM**	**NM**	**ASCO**	**LC**
Camera Trap	72	33	29	10	2	5	10
Direct sightings	0	1	2	0	0	0	0

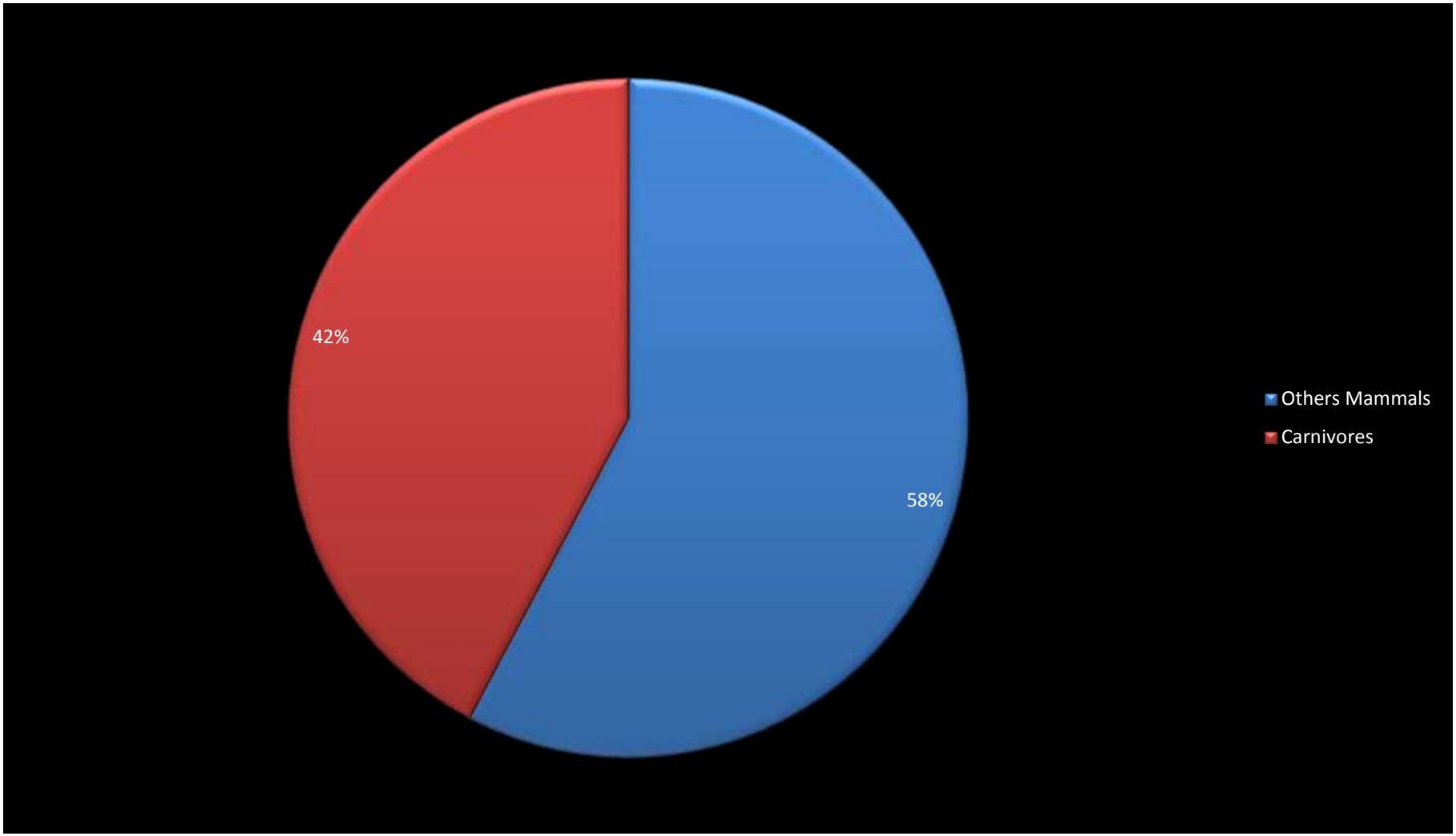
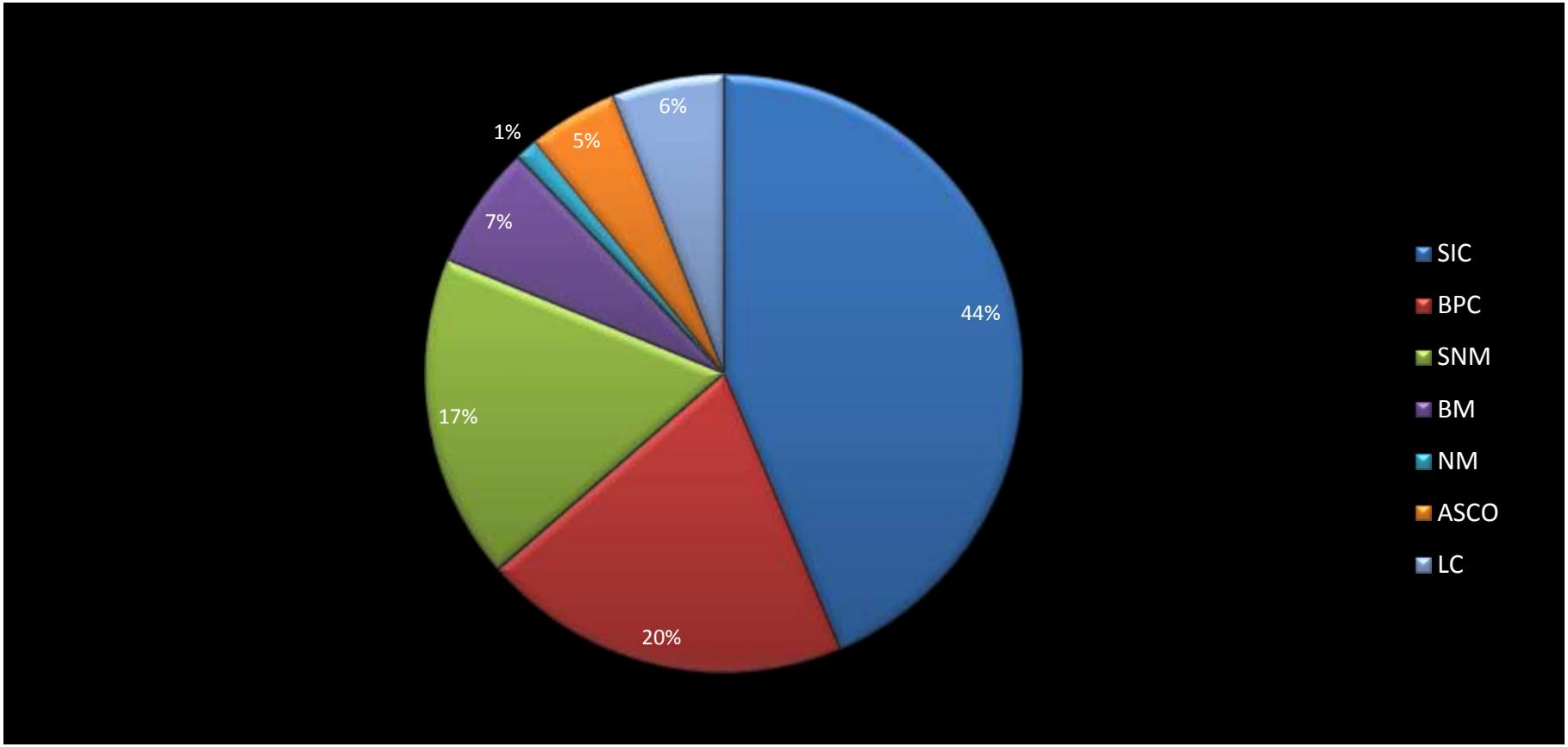


Figure 2. Percentage of Carnivores photographed from Silent Valley National Park



SIC: Small Indian Civet; BPC: Brown Palm Civet; SNM: Stripe-necked Mongoose; BM: Brown Mongoose; ASCO: Asian Small-clawed Otter; NM: Nilgiri Marten; LC: Leopard Cat.

Figure 3. Relative abundance of small carnivores of Silent Valley National Park

SIC: Small Indian Civet; **BPC**: Brown Palm Civet; **SNM**: Stripe-necked Mongoose; **BM**: Brown Mongoose; **ASCO**: Asian Small-clawed Otter; **NM**: Nilgiri Marten; **LC**: Leopard Cat.

4.2.CAMERA-TRAPPING ON SMALL CARNIVORES AT SILENT VALLEY NATIONAL PARK

One hundred trap stations were established in the Silent Valley National Park. The camera trap sampling was done for an effective total of 1450 days, monitoring 34,800 hours. The details of the trapping effort in Silent Valley National Park are shown in Table 5.

Table 5. Camera trapping effort during two different seasons of Silent Valley National Park

Seasons	**Efforts (Days)**	**Effort (Hours)**
Rainy season (Sept-Dec)	850	20400
Non-rainy season (Jan-April)	600	14400
Total Efforts	1450	34800

A total of 607 photographs obtained included 21 mammal species, seven bird species and one monitor lizard. Out of these, the carnivores accounted for 229(42.25%) (Figure 2) photographs, among that 69% were small carnivores in seven species. The most common species recorded was Small Indian Civet *Viverricula indica* (45.57%) followed by Brown Palm Civet *Paradoxurus jerdoni* (20.89%), Stripe-necked Mongoose *Herpestes vitticollis* (17.09%), Brown Mongoose *Herpestes fuscus*(6.33%), Leopard Cat *Prionailurus bengalensis* (6.33%) and Asian Small Clawed Otter *Aonyx cinereus* (3.16%) . The Nilgiri Marten *Martes gwatkinsii* was captured only once (1%) in the camera traps during the study period. Figure 3 shows the relative abundance of small carnivore of SVNP.

Plate 4. A- Brown Mongoose; B-Stripe-necked Mongoose; C-Brown Palm Civet; D-Small Indian Civet; E-Asian Small-clawed Otter; F-Leopard Cat

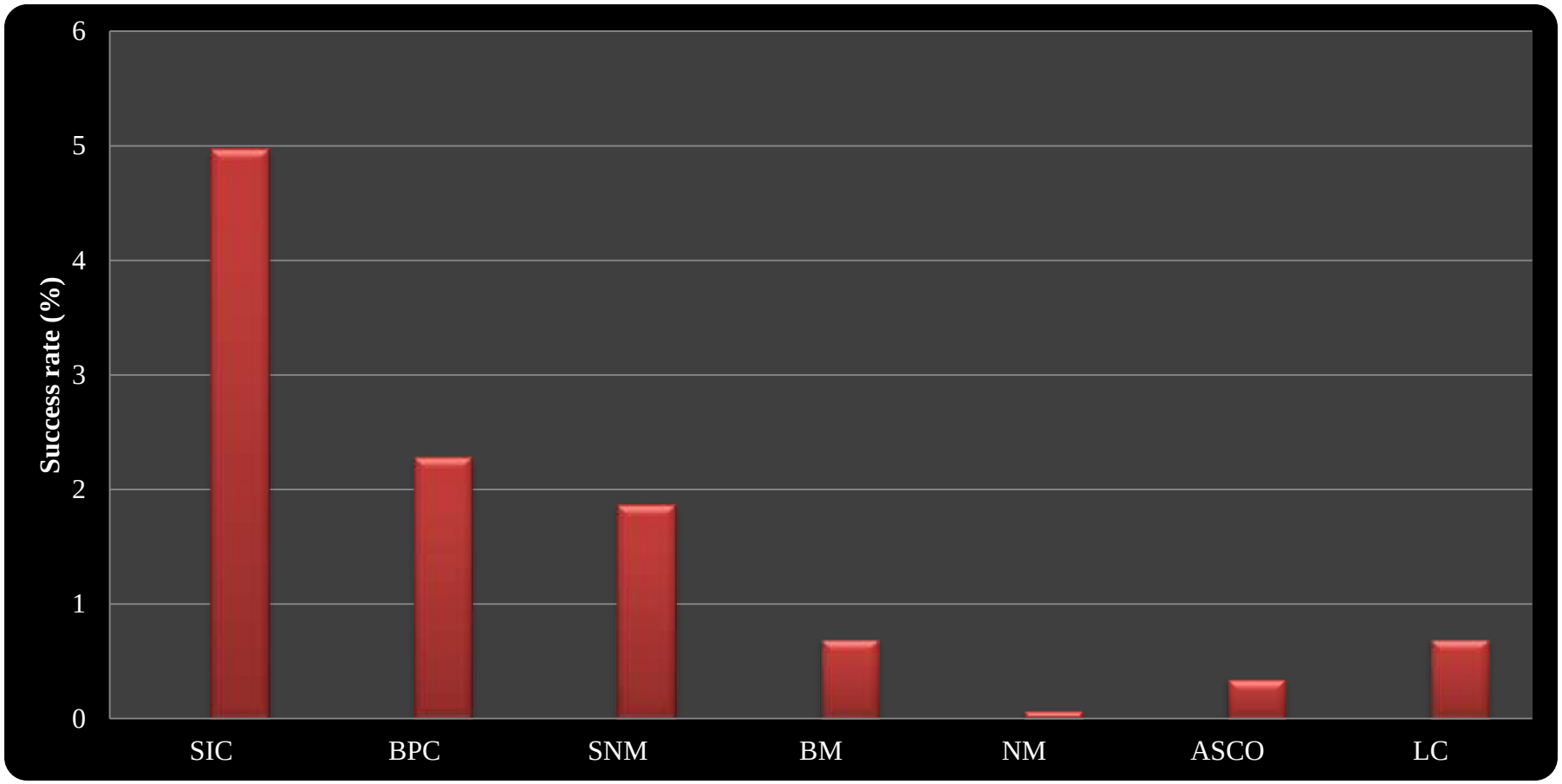
4.2.1. Success rate of camera traps in various locations in Silent Valley National Park

The camera trap success rates of small carnivores of Silent Valley NP during two seasons are presented in Table 6. The overall small carnivore success rate is 10.90% (158 of 1450 trap-days), capturing seven species of small carnivores. Out of these small carnivores capture success rate was maximum during the non-rainy season (65.83%) (Table 6). In bothe the seasons Small Indian Civet Showed a higher success rate (45.57%) than the other small carnivores of SVNP. Small Indian Civet was photo-trapped on 72 days accounting for about 45.57% of the success, followed by Brown Palm Civet on 33 days (20.89%) and Stripe-necked Mongoose on 27 days (17.09%).The success rates of Brown Mongoose (3.8% and 2.53%) and Nilgiri Marten (0.7% and 0%) showed a reduction during the non-rainy season. The graphical representation of camera trap success rate in terms of species and season are given in Figure 4 and Figure 5 respectively.

Table 6. Success rate (%) of small carnivore detections in camera traps in Silent Valley National Park

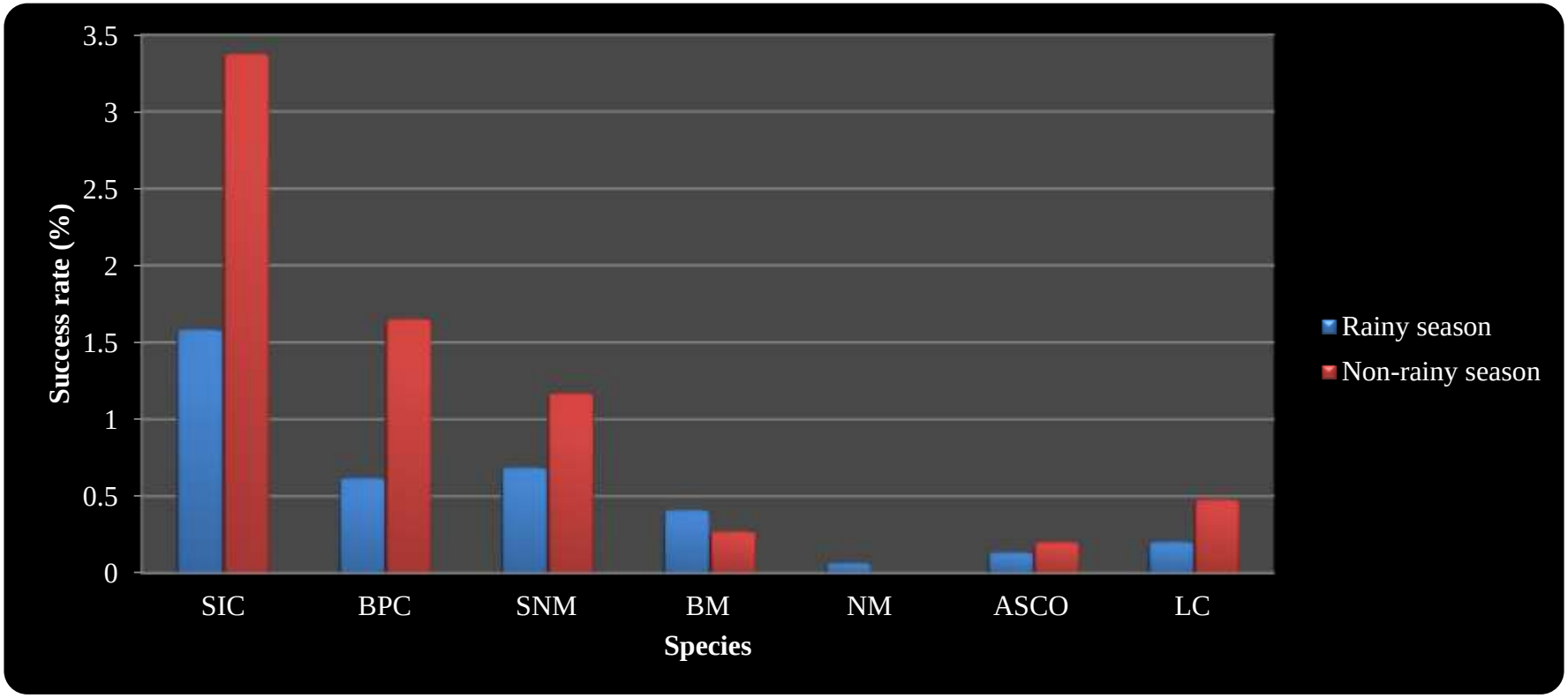
	SIC	**BPC**	**SNM**	**BM**	**NM**	**ASCO**	**LC**
Rainy season	14.56	5.70	6.33	3.80	0.63	1.27	1.90
Non-rainy season	31.01	15.19	10.76	2.53	0.00	1.90	4.43

SIC: Small Indian Civet; **BPC**: Brown Palm Civet; **SNM**: Stripe-necked Mongoose; **BM**: Brown Mongoose; **NM**: Nilgiri Marten; **ASCO**: Asian Small-clawed Otter; **LC**: Leopard Cat



SIC: Small Indian Civet; BPC: Brown Palm Civet; SNM: Stripe-necked Mongoose; BM: Brown Mongoose; NM: Nilgiri Marten; ASCO: Asian Small-clawed Otter; LC: Leopard Cat

Figure 4. Camera trap success rate in Silent Valley National Park



SIC: Small Indian Civet; BPC: Brown Palm Civet; SNM: Stripe-necked Mongoose; BM: Brown Mongoose; NM: Nilgiri Marten; ASCO: Asian Small-clawed Otter; LC: Leopard Cat

Figure 5. Camera trap success rate in two different seasons in Silent Valley National Park

Table 7. Species wise comparison of success rate (%) during rainy season and non-rainy season

	SIC	**BPC**	**SNM**	**BM**	**ASCO**	**LC**
Rainy season	42.59	16.67	18.52	11.11	3.70	5.56
Non-rainy season	47.12	23.08	16.35	3.85	2.88	6.73
|Z|	0.54^{ns}	0.98^{ns}	0.34^{ns}	1.55^{ns}	0.27^{ns}	0.30^{ns}

ns – non-significant at 5% level

SIC: Small Indian Civet; **BPC**: Brown Palm Civet; **SNM**: Stripe-necked Mongoose; **BM**: Brown Mongoose; **NM**: Nilgiri Marten; **ASCO**: Asian Small-clawed Otter; **LC**: Leopard Cat

The computed Z-values are greater than the significant level= 0.05. That implies there is no significant difference between the success rates small carnivore detection in camera traps in two seasons.

The camera traps also documented the presence of 12 other mammals such as Tiger *Panthera tigris,* Leopard *Panthera pardus,* Wild Dog *Cuon alpines,* Sambar Deer *Rusa unicolor*, Barking Deer *Muntiacus muntjak*, Indian Chevrotain *Moschiola indica*, Gaur *Bos gaurus*, Wild Boar *Sus scrofa,* Indian Crested Porcupine *Hystrix indica*, Lion-tailed Macaque *Macaca silenus*, Nilgiri Langur *Semnopithecus johnii,* Jungle Striped Squirrel *Funambulus tristriatus* and an unidentified rodent species from the Silent Valley National Park. During the camera trap survey photograph of a Black Panther was also obtained. These species have accounted for the 73.26% of the camera trap pictures in the National Park.

4.2.2. Species richness and diversity of the small carnivores in Silent Valley National Park

The various diversity indices and species richness parameters such as number of taxa (S), number of individuals (n), Dominances, Shannon-Weiner index (H), Simpson's index (1-D), Berger Parker index and Margalef index (M) were calculated for the two seasons such as rainy season (September to December) and non-rainy season (January to April) (Table 8).

Table 8. Species richness and diversity indices for the small carnivores of Silent Valley National Park

Indices	**Rainy Season (Sept-Dec)**	**Non-rainy Season (Jan-April)**
Taxa (S)	7	6
Individuals (n)	61	104
Dominances	0.23	0.31
Simpson (1-D)	0.77	0.69
Shannon	1.68	1.40
Margalef	1.46	1.08
Berger Parker	0.38	0.47

Table 9. Comparison of diversity between the two seasons of Silent Valley National Park in the rainy and non-rainy seasons

	Rainy Season (Sept-Dec)	**Non-rainy Season (Jan-April)**
Species	7	6
Index Shannon	1.68	1.4
Variance	0.008	0.006
t=2.16		
p-value= 0.03		

Diversity t-test was carried out to compare the diversity of species during the two seasons of Silent Valley NP (Table 9). The t-value was found to be significant at 0.05 levels. Rainy season showed greater species diversity and species richness when compared to non-rainy season.

4.2.3. The Time Activity Pattern of Camera Trapped Small Carnivores in Silent Valley National Park

A time-activity analysis of the small carnivores that were camera trapped was done at Silent Valley NP. For this analysis, only those species of small carnivores that were captured for more than 10 times alone were used. These included Small Indian Civet, Brown Palm Civet, Stripe-necked Mongoose, Brown Mongoose and Leopard Cat. Out of the 158 camera trap images obtained during the study period 105 (66.46%) were of viverrids. Small Indian Civet was the commonest small carnivore in Silent Valley NP accounting for 45.57% of the camera trap images, followed by Brown Palm Civet (20.89%) and Stripe-necked Mongoose (17.09%). For studying the active period, the camera trapping hours were divided into 1hr interval classes.

The Figure 6 shows the activity pattern of Small Indian Civet and Brown Palm Civet. The Small Indian Civet have an active period from 1700hrs to 0700hrs with a peak activity from 2100hrs to 2200hrs and from 0300hrs to 0400hrs. The active period of Brown Palm Civet was between 1800hrs to 0600hrs. It has a peak activity from 1900hrs to 2200 from 0000hrs to 0100hrs, and from 0300hrs to 0500hrs. During the 0000hrs to 0100hrs the activity of Small Indain Civet is lower to that of Brown Palm Civet. Even though these two species are nocturnal they have varying peak activity periods reducing the competition for the resources.

The Figure 7 shows the activity pattern of Stripe-necked Mongoose and Brown Mongoose in SVNP. From this we could see that the two sympatric species shows clear distinction in their activity pattern, that is, the activity pattern of Stripe-necked Mongoose has found to be just reverse as that of Brown

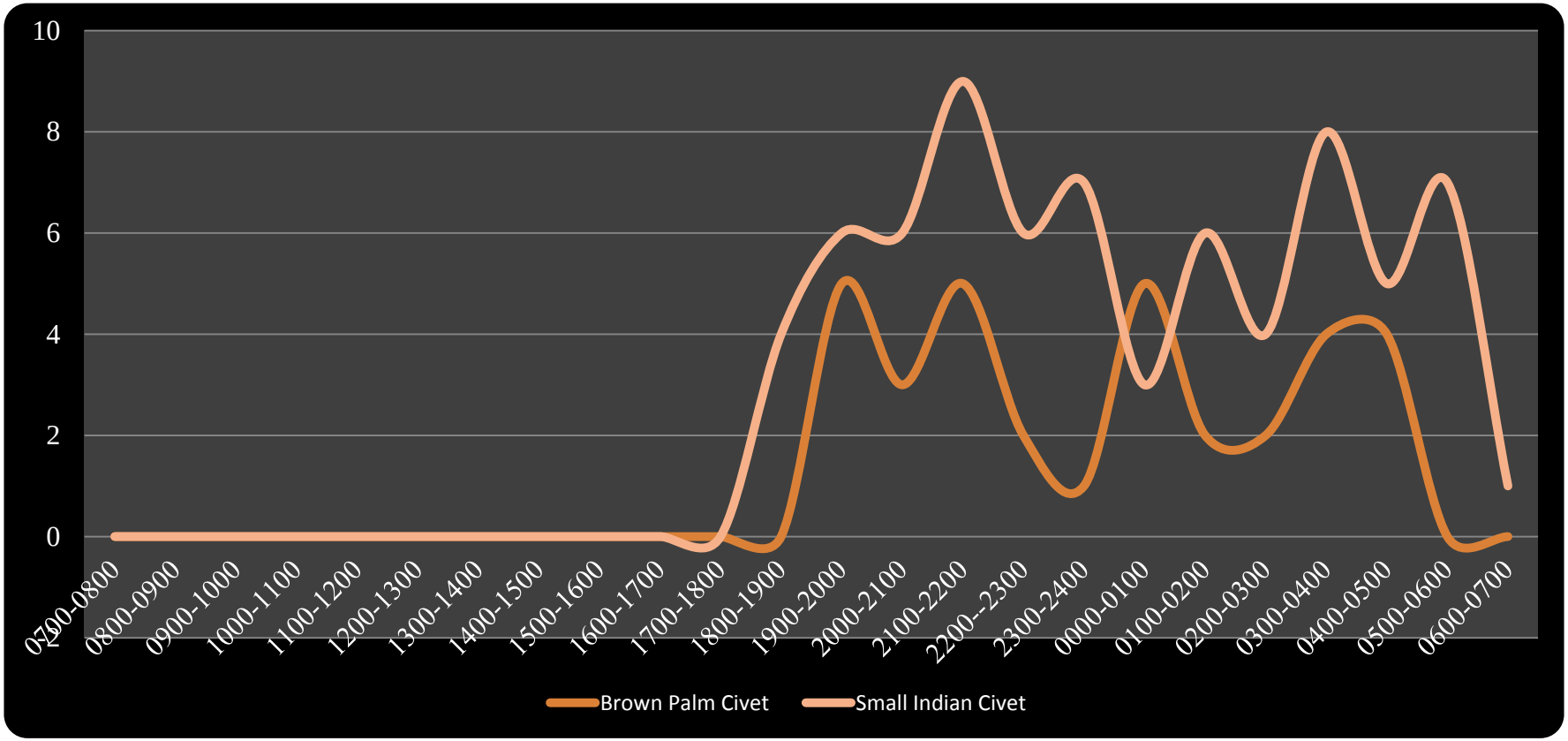


Figure 6. Active period of Brown Palm Civet and Small Indian Civet of civets in Silent Valley National Park

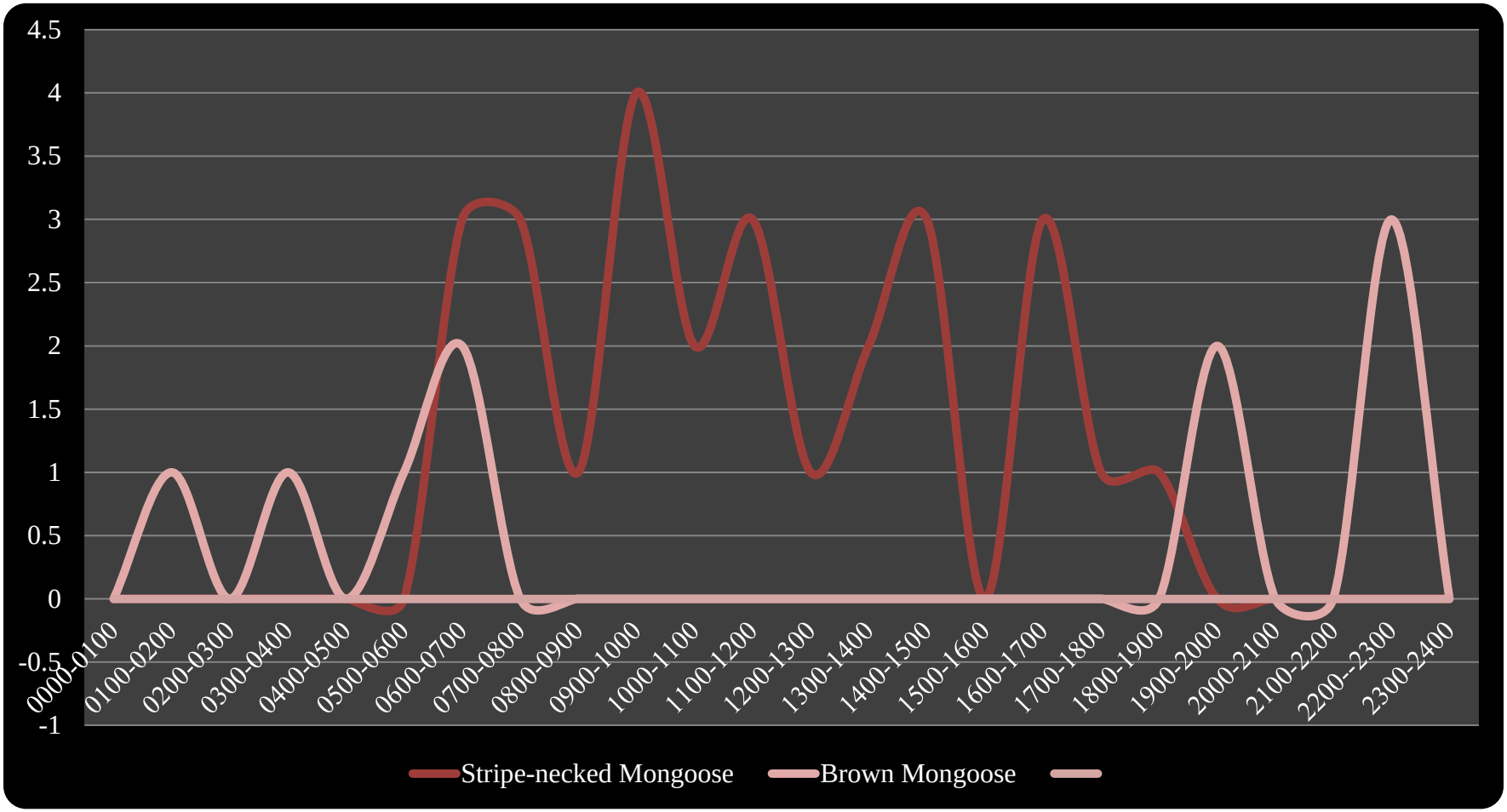


Figure 7. Active period of Stripe-necked Mongoose and Brown in Silent Valley National Park

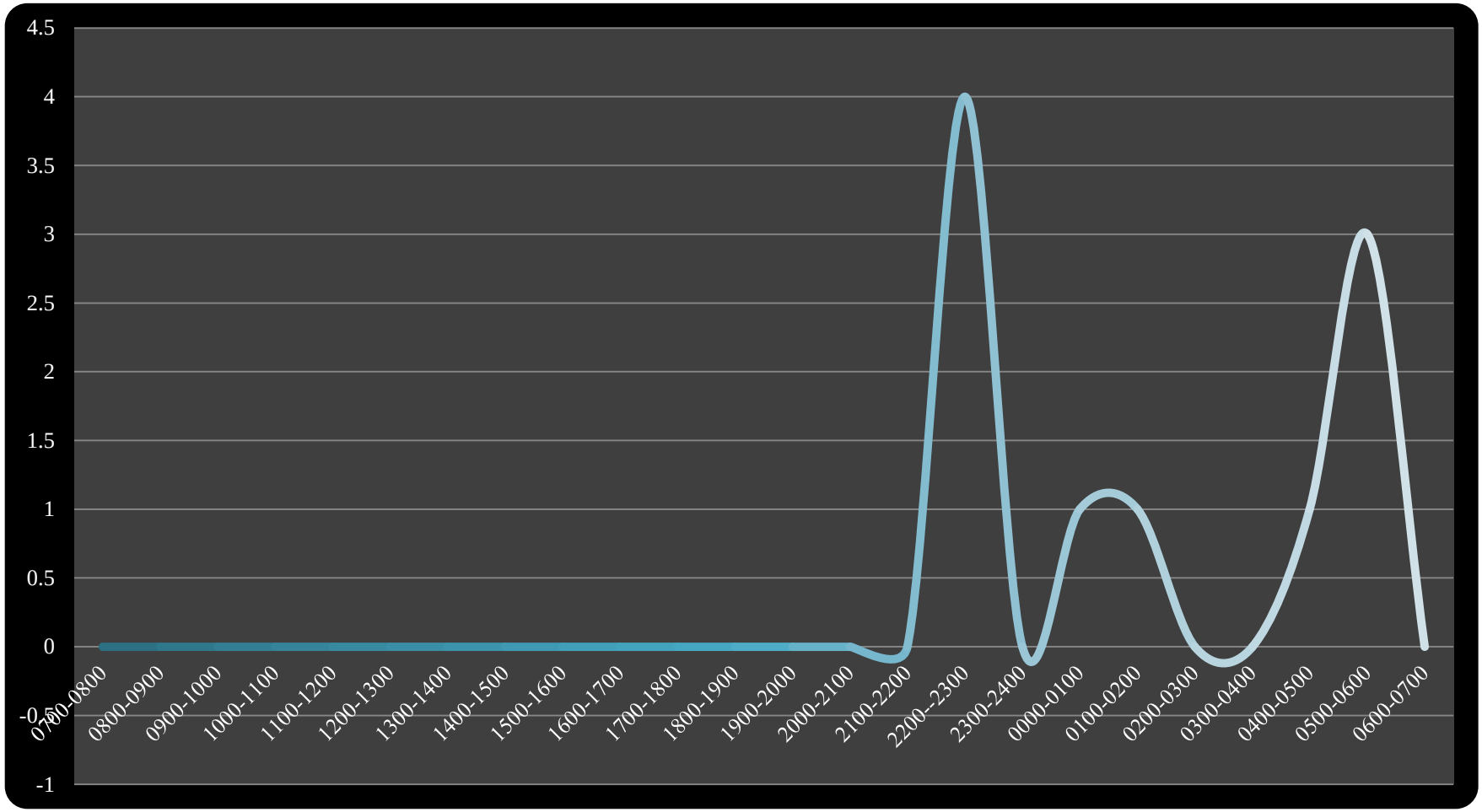


Figure 8. Active period of Leopard Cat in Silent Valley national Park

Mongoose. The Stripe-necked Mongoose have diurnal activity pattern where Brown Mongoose have a nocturnal activity pattern, Stripe-necked Mongoose have a peak activity during 0900-1000hrs. The peak activity of Brown Mongoose ranges from 2200-2300hrs.

Figure 8 illustrate the activity pattern of Leopard Cat in SVNP. The species showed a nocturnal activity pattern with a activity peaks during 2200-2300hrs and 0500-0600hrs.

4.2.4. Logistic Regression for the Prediction of Presence or Absence of Species Using Habitat Parameters

Logistic regression measures the relationship between a categorical dependent variable and one or more independent variables, which are usually (but not necessarily) continuous, by using probability scores as the predicted values of the dependent variable. Here it is used to check whether the prediction of presence or absence of the species using habitat parameters is possible. Twenty micro-habitat parameters were used in this regression analysis. The result of logistic regression analysis done for each species is given below in detail.

4.2.4.1. Logistic regression for the prediction of presence or absence of Brown Mongoose

Logistic regression analysis was done for predicting the presence of Brown Mongoose species based on different habitat parameters. The goodness of fit statistics of the fitted model is given in Table 10.

Table 10. Goodness of fit statistics (Brown Mongoose)

Statistic	**Full**
Observations	100
Sum of weights	100
DF	79
-2 Log(Likelihood)	-4.50
R^2(McFadden)	1.08
R^2(Cox and Snell)	0.42
R^2(Nagelkerke)	1.07
AIC	37.49
SBC	92.20
Iterations	11

The Likelihood ratio test was used for testing the significance of the regression coefficients in the fitted model and is given in Table 10.

Table 11. Effect of habitat parameters on the occurrence of Brown Mongoose

Source	**Coefficients**	**Chi-square (LR)**	**p-value**
Canopy Height (m)	-0.03	41.19	< 0.0001
Canopy cover (%)	0.01	41.60	< 0.0001
Litter depth(cm)	0.33	41.72	< 0.0001
shrub density(trees/area)	-0.01	41.11	< 0.0001
Tree density	-0.13	43.19	< 0.0001
Climber density	-0.07	41.81	< 0.0001
Buttress density	0.50	44.45	< 0.0001
Canes	0.14	39.15	< 0.0001
distance to largest tree (m)	-0.05	41.91	< 0.0001
Width of the Waterbody	-0.10	42.48	< 0.0001
GBH (cm)	0.00	41.03	< 0.0001
Slope (degrees)	-0.02	41.29	< 0.0001

Hole	1.81	41.72	< 0.0001
Waterbody	0.64	41.09	< 0.0001
Rock	-1.17	43.16	< 0.0001
Fruiting Tree	0.00	41.54	< 0.0001
Swamp	0.02	41.16	< 0.0001
Roots	-0.33	41.46	< 0.0001
Roads	0.00	43.67	< 0.0001
Log	0.70	42.05	< 0.0001

From the above table it could be seen that all the p-values are significant ($p<0.001$). That means all the habitat parametres have significant influence on the presence of Brown Mongoose in Silent Valley NP.

The regression coefficient is the estimated increase in the logged odds of the outcome per unit increase in the value of the independent variable. In Figure 9. variables that are positive indicate that increase in these variables leads to higher presence. Variables that are negative indicate that decrease in these variables leads to higher presence of the species, Brown Mongoose. If the height of the blue bar is more, then these variables are more important.The graph of regression coeifficients indicated that the habitat parametrs like buttress density, litter depth, canopy cover, presence of waterbody and presence of tree hole are highly contributing to the prediction model.

Equation for the prediction of the probability of the presence of Brown Mongoose species from the above analysis is given below.

Brown Mongoose (Present/Absent) = 1 / (1 + exp(-(-0.97-3.20E-02*Canopy Height (m)+1.11E-02*Canopy cover (%)+0.33*Litter depth(cm)-1.28E-03*shrub density(trees/area)-0.13*Tree density-6.94E-02*Climber density+0.49*Buttress density+0.14*Canes-4.80E-02*distance to largest tree (m)-0.10*Width of the Waterbody-2.05E-03*GBH (cm)-2.28E-02*Slope (degrees)+1.80*Hole-1+0.64*Waterbody-1-1.17*Rock-1-0.53*Fruiting Tree-0+0.02*Swamp-1-0.33*Roots-1+1.15*Roads-0+0.69*Log-1)))

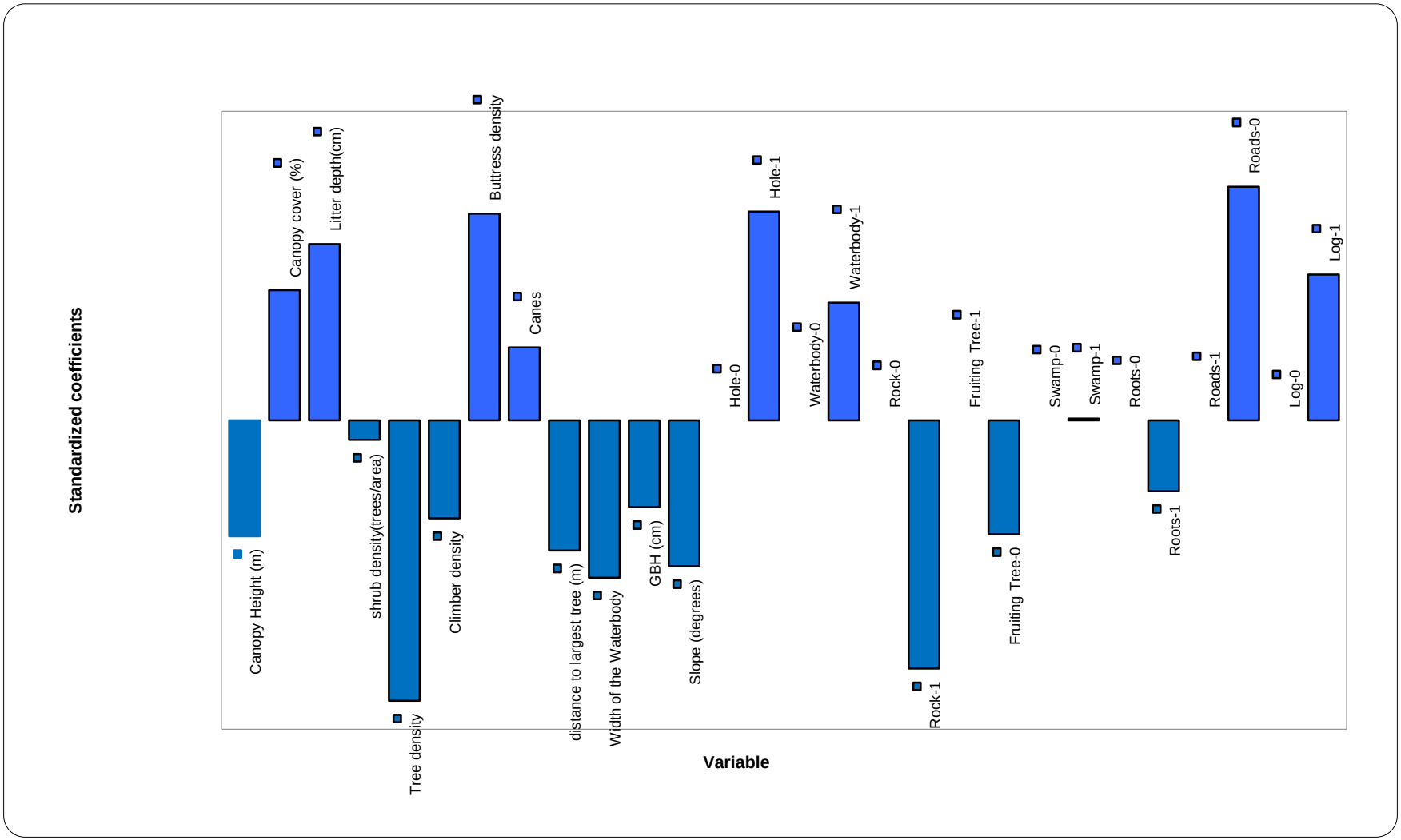


Figure 9. Influence of habitat parameters on the occurrence of Brown Mongoose

The classification table is a method to evaluate the predictive accuracy of the logistic regression model. In this table, the observed values for the dependent outcome and the predicted values (at a user defined cut-off value) are cross-classified.

Classification table of observed and predicted response of the fitted logistic regression model for predicting the presence of Brown Mongoose species in terms different habitat parameters is given as Table 12.

Table 12 .Evaluation of logistic regression model for Brown Mongoose

Observed	Predicted		
	Absence	Presence	Percentage correct
Absence	93	0	100.0
Presence	3	4	57.14
Overall percentage	96	4	97.00

The percentage of correct predictions is 97 per cent. The higher the overall percentage of correct predictions, the better is the model.

4.2.4.2. Logistic Regression for the Prediction of Presence or Absence of Stripe-necked Mongoose

Logistic regression analysis was done for predicting the presence of Stripe-necked Mongoose species based on different habitat parameters. The goodness of fit statistics of the fitted model is given in Table 13.

Table 13. Goodness of fit statistics (Stripe-necked Mongoose)

Statistic	Full
Observations	100
Sum of weights	100
DF	81
-2 Log(Likelihood)	0.000
R^2(McFadden)	1.00
R^2(Cox and Snell)	0.57
R^2(Nagelkerke)	1.00
AIC	38.00
SBC	87.49
Iterations	16

The Likelihood ratio test was used for testing the significance of the regression coefficients in the fitted model and is given in Table14.

Table 14. Effect of habitat parameters on the occurrence of Stripe-necked Mongoose

Source	**Coefficients**	**Chi-square (LR)**	**p- value**
Canopy Height (m)	4.01	44.30	< 0.0001
Canopy cover (%)	-0.05	0.00048	0.982
Litter depth(cm)	-4.40	45.85	< 0.0001
Shrub density(trees/area)	-0.38	42.42	< 0.0001
Tree density	-1.89	47.69	< 0.0001
Climber density	-4.35	37.50	< 0.0001
Buttress density	0.00	41.43	< 0.0001
Canes	0.00	41.53	< 0.0001
distance to largest tree	7.27	40.42	< 0.0001

Width of the Waterbody	-0.40	39.12	< 0.0001
GBH (cm)	-0.16	38.24	< 0.0001
Slope (degrees)	0.42	41.05	< 0.0001
Hole	-13.05	42.29	< 0.0001
Waterbody	21.33	43.62	< 0.0001
Rock	0.27	41.08	< 0.0001
Fruiting Tree	0.00	44.16	< 0.0001
Swamp	-18.97	40.54	< 0.0001
Roots	-23.62	41.17	< 0.0001
Roads	0.00	40.54	< 0.0001
Log	6.61	41.17	< 0.0001

From the Table 13 it could be seen that all the p-values are significant ($p<0.001$) except for canopy cover. That means all the parameters other than canopy cover have significant influence on the presence of Stripe-necked Mongoose.

The regression coefficient is the estimated increase in the logged odds of the outcome per unit increase in the value of the independent variable. In Figure 10 variables that are positive indicate that increase in these variables leads to higher presence. Variables that are negative indicate that decrease in these variables leads to higher presence of the species Stripe-necked Mongoose. The graph of regression coefficients indicated that the habitat parameters like canopy height, litter depth, climber density, and distance to largest to tree are highly contributing to the prediction model.

Equation for the prediction of the probability of the presence of Stripe-necked Mongoose from the above analysis is given below.

Stripe-necked Mongoose (Present/Absent) = 1 / (1 + exp(-(-25.02+4.01*Canopy Height (m)-4.96E-02*Canopy cover (%)-4.40*Litter depth(cm)-0.38*shrub density(trees/area)-1.89*Tree density-4.35*Climber density+7.26*distance to largest tree (m)-0.40*Width of the Waterbody-

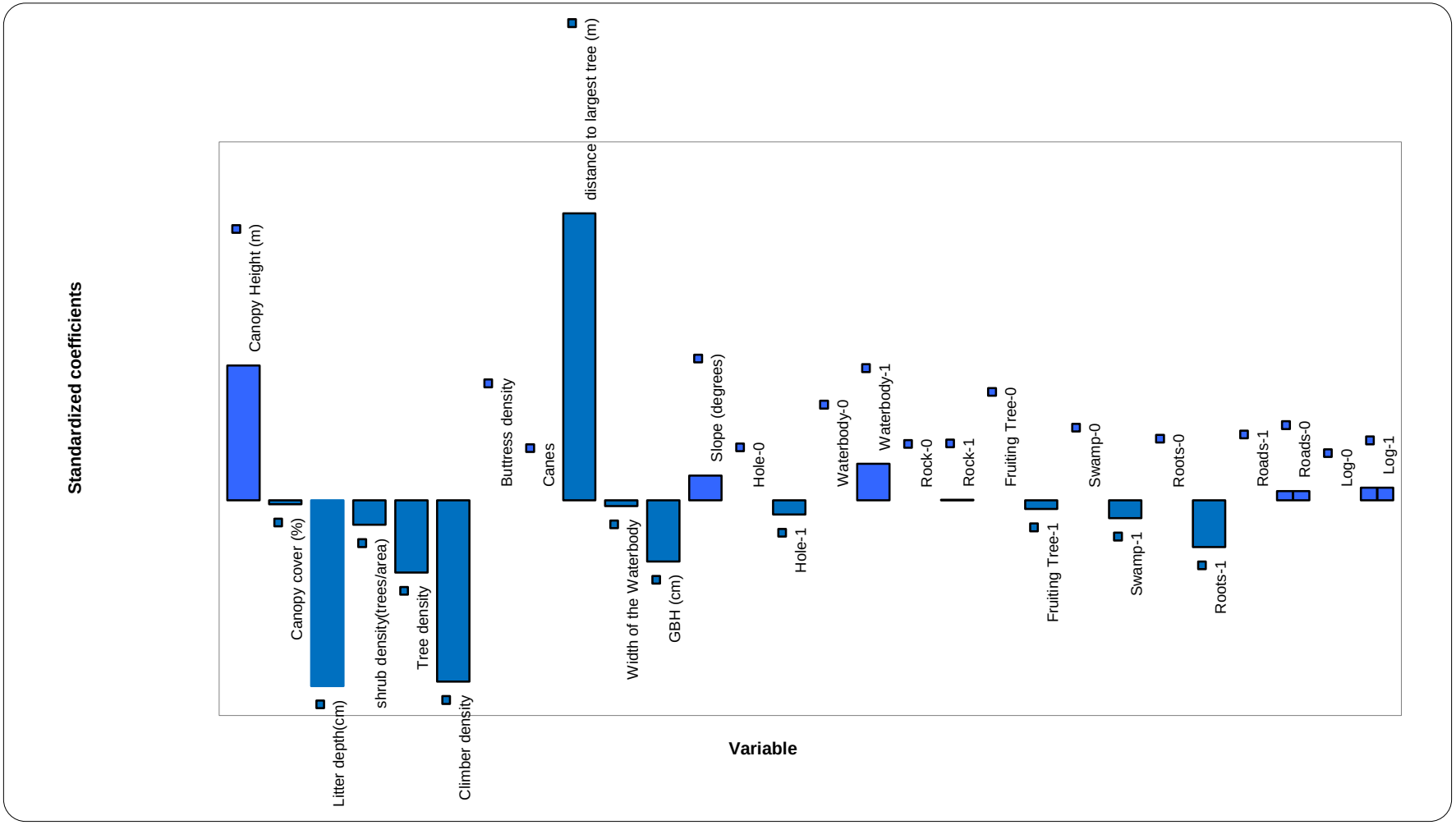


Figure 10. Influence of habitat parameters on the occurrence of Stripe-necked Mongoose

0.15*GBH (cm)+0.42*Slope (degrees)-13.05*Hole-1+21.33*Waterbody-1+0.27*Rock-1-4.35*Fruiting Tree-1-18.96*Swamp-1-23.61*Roots-1+4.96*Roads-0+6.61*Log-1)))

Classification table of observed and predicted response of the fitted logistic regression model for predicting the presence of Stripe-necked Mongoose species in terms different habitat parameters is given as Table 14

Table 15. Evaluation of logistic regression model for Stripe-necked Mongoose

Observed	Predicted		
	Absent	Presence	% correct
Absence	85	0	100.00%
Presence	0	15	100.00%
Total	85	15	100.00%

The percentage of correct predictions is 100 per cent. The higher the overall percentage of correct predictions, the better is the model.

4.2.4.3. Logistic Regression for the Prediction of Presence or Absence of Brown Palm Civet

Logistic regression analysis was done for predicting the presence of Brown Palm Civet based on different habitat parameters. The goodness of fit statistics of the fitted model is given in table.

Table 16. Goodness of fit statistics (Brown Palm Civet)

Statistic	Full
Observations	100
Sum of weights	100.000
DF	79

-2 Log(Likelihood)	86.219
R^2(McFadden)	0.182
R^2(Cox and Snell)	0.174
R^2(Nagelkerke)	0.268
AIC	128.219
SBC	182.927
Iterations	6

The Likelihood ratio test was used for testing the significance of the regression coefficients in the fitted model and is given in Table 17

Table 17. Effect of habitat parameters on the occurrence of Brown Palm Civet

Source	Coefficients	Chi-square (LR)	p- value
Canopy Height	0.06	1.394	0.238
Canopy cover	-0.04	0.075	0.784
Litter depth	0.44	3.460	0.063
Shrub density	-0.02	3.146	0.076
Tree density	0.05	0.342	0.559
Climber density	0.03	0.062	0.804
Buttress density	-0.01	0.000	0.985
Cane density	-0.02	0.005	0.941
Distance to largest tree	-0.09	2.406	0.121
Width of the Waterbody	-0.21	1.026	0.311
GBH	-0.01	0.830	0.362
Slope	0.04	3.146	0.076
Hole	-0.64	0.318	0.573
Waterbody	0.68	0.350	0.554
Rock	-0.24	0.127	0.721

Fruiting Tree	0.01	1.046	0.306
Swamp	1.27	0.820	0.365
Roots	1.24	2.032	0.154
Roads	0.00	0.580	0.446
Log	-0.58	0.485	0.486

From the above Table 117 it could be seen that the p-values are not significant ($p<0.001$) for all the parameters studied. That means all these habitat parametres have no significant influence on the presence of Brown Palm Civet.

The regression coefficient is the estimated increase in the logged odds of the outcome per unit increase in the value of the independent variable. In Figure 11 variables that are positive indicate that increase in these variables leads to higher presence. Variables that are negative indicate that decrease in these variables leads to higher presence of the species Brown Palm Civet. If the height of the blue bar is more, then these variables are more important.The graph of regression coeifficients indicated that the habitat parametrs like canopy height, litter depth , Shrub density, distanceto largest tree, width of waterbody, slope, and presence of roots are highly contributing to the prediction model.

Equation for the prediction of the probability of the presence of Brown Palm Civet from the above analysis is given below.

Brown Palm Civet (Present/Absent) = 1 / (1 + exp(-(-3.83+0.06*Canopy Height (m)-4.08E-03*Canopy cover (%)+0.44*Litter depth(cm)-2.05E-02*shrub density(trees/area)+4.64E-02*Tree density+2.50E-02*Climber density-6.07E-03*Buttress density-2.04E-02*Canes-8.55E-02*distance to largest tree (m)-0.21*Width of the Waterbody-3.45E-03*GBH (cm)+3.78E-02*Slope (degrees)-0.64*Hole-1+0.68*Waterbody-1-0.24*Rock-1+0.77*Fruiting Tree-1+1.26*Swamp-1+1.23*Roots-1+0.55*Roads-0-0.58*Log-1)))

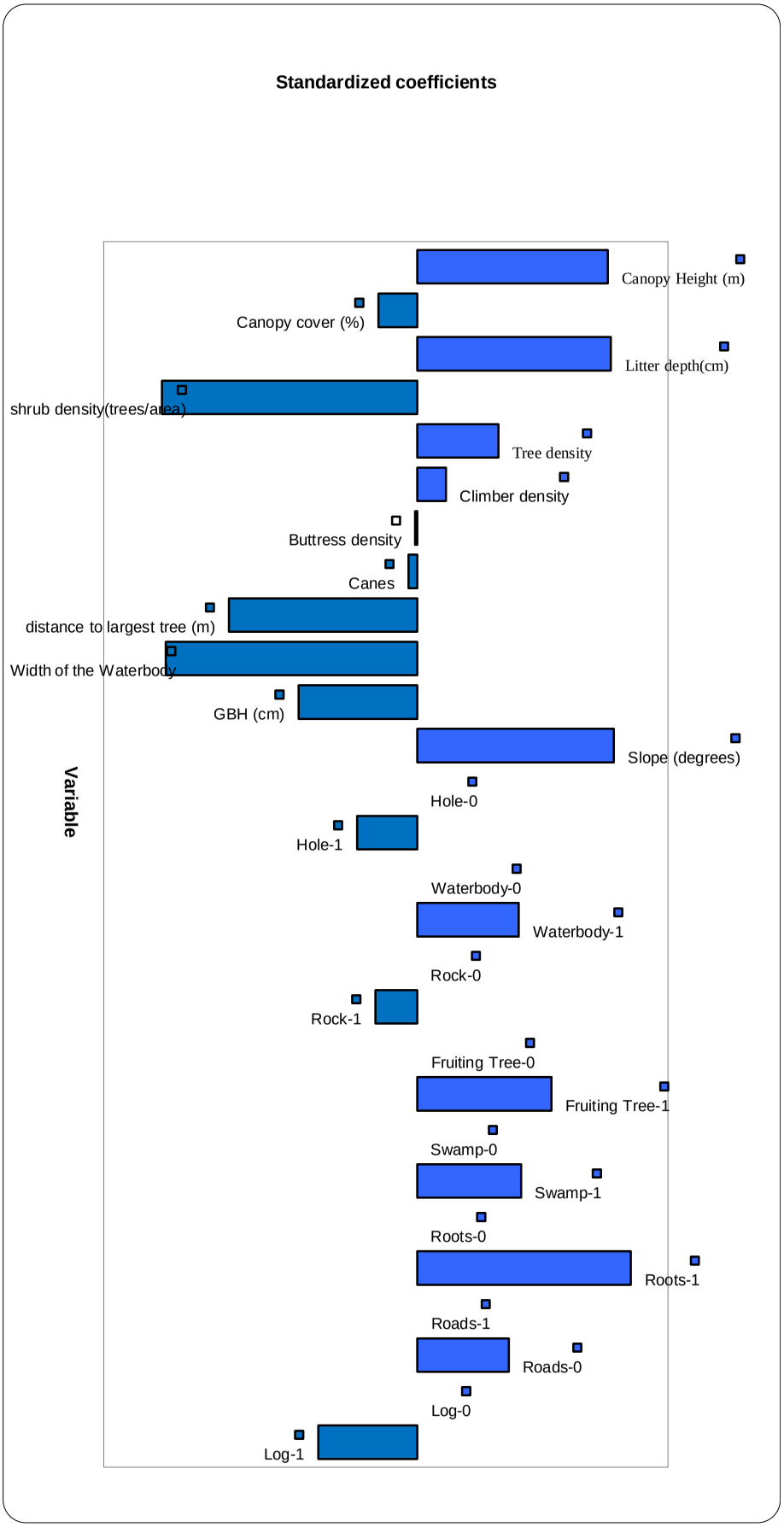


Figure 11. Influence of habitat parameters on the occurrence of Brown palm Civet

Classification table of observed and predicted response of the fitted logistic regression model for predicting the presence of Brown Palm Civet in terms different habitat parameters is given as Table 18.

Table 18. Evaluation of logistic regression model for Brown Palm Civet

Observed	Predicted		
	Absence	Presence	Percentage correct
Absence	75	3	96.15%
Presence	17	5	22.73%
Total	92	8	80.00%

The percentage of correct predictions is 80 per cent. The higher the overall percentage of correct predictions, the better is the model.

4.2.4.4. Logistic Regression for the Prediction of Presence or Absence of Small Indian Civet

Logistic regression analysis was done for predicting the presence of Small Indian Civet based on different habitat parameters. The goodness of fit statistics of the fitted model is given in Table 19.

Table 19. Goodness of fit statistics (Small Indian Civet)

Statistic	Full
Observations	100
Sum of weights	100.000
DF	79
-2 Log(Likelihood)	82.048
R^2(McFadden)	0.284
R^2(Cox and Snell)	0.278
R^2(Nagelkerke)	0.407

AIC	124.048
SBC	178.756
Iterations	6

The Likelihood ratio test was used for testing the significance of the regression coefficients in the fitted model and is given in Table 20.

Table 20. Effect of habitat parameters on the occurrence of Small Indian Civet

Source	Coefficients	Chi-square (LR)	p- value
Canopy Height (m)	0.09	2.964	0.085
Canopy cover (%)	-0.01	0.000	0.994
Litter depth(cm)	-0.37	1.712	0.191
shrub density(trees/area)	-0.01	0.002	0.964
Tree density	0.06	0.416	0.519
Climber density	-0.18	1.312	0.252
Buttress density	-1.03	3.292	0.070
Cane density	-1.08	9.260	0.002
distance to largest tree (m)	0.03	0.102	0.749
Width of the Waterbody	-0.02	0.009	0.924
GBH (cm)	-0.01	0.635	0.426
Slope (degrees)	0.02	1.048	0.306
Hole	2.12	2.633	0.105
Waterbody	-1.00	0.510	0.475
Rock	0.91	1.446	0.229
Fruiting Tree	0.01	5.950	0.015
Swamp	4.70	10.316	0.001
Roots	1.10	1.653	0.199
Roads	0.01	1.675	0.196
Log	-1.11	1.732	0.188

From the above Table 20 it could be seen that the p-values are significant ($p<0.001$) only for three parameters cane density, fruiting tree, and swamp. That means these three habitat parametres have significant influence on the presence of Small Indian Civet.

The regression coefficient is the estimated increase in the logged odds of the outcome per unit increase in the value of the independent variable. In Figure 12 variables that are positive indicate that increase in these variables leads to higher presence. Variables that are negative indicate that decrease in these variables leads to higher presence of the species Small Indian Civet. If the height of the blue bar is more, then these variables are more important.The graph of regression coeifficients indicated that the habitat parametrs like canopy height, buttress density, canes, Presence of fruiting trees, and presence of swamp are highly contributing to the prediction model.

Equation for the prediction of the probability of the presence of Small Indian Civet from the above analysis is given below.

Small Indian Civet (Present/Absent) = 1 / (1 + exp(-(-1.57+9.20E-02*Canopy Height (m)-9.41E-05*Canopy cover (%)-0.37*Litter depth(cm)-4.37E-04*shrub density(trees/area)+5.64E-02*Tree density-0.17*Climber density-1.03*Buttress density-1.08*Canes+0.02*distance to largest tree (m)-2.08E-02*Width of the Waterbody-2.87E-03*GBH (cm)+2.20E-02*Slope (degrees)+2.11*Hole-1-1.00*Waterbody-1+0.91*Rock-1-1.79*Fruiting Tree-1+4.69*Swamp-1+1.09*Roots-1-1.03*Roads-0-1.11*Log-1)))

Classification table of observed and predicted response of the fitted logistic regression model for predicting the presence of Small Indian Civet in terms different habitat parameters is given as Table 21.

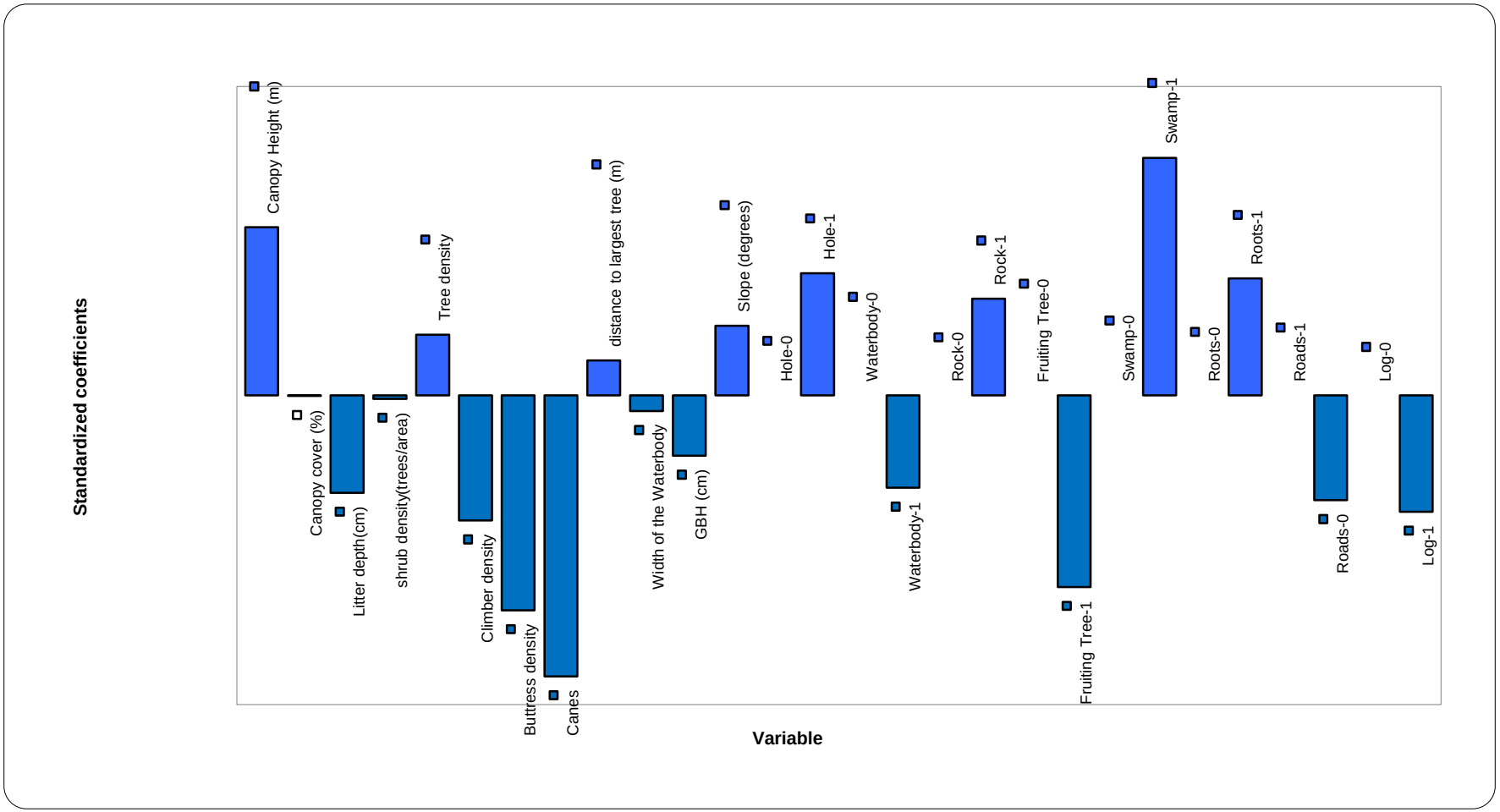


Figure 12. Influence of habitat parameters on the occurrence of Small Indian Civet

Table 21. Evaluation of logistic regression model for Small Indian Civet

Observed	Predicted		
	Absence	Presence	Percentage correct
Absence	66	8	89.19%
Presence	13	13	50.00%
Total	79	21	79.00%

The percentage of correct predictions is 79 per cent. The higher the overall percentage of correct predictions, the better is the model.

4.2.4.5. Logistic regression for the prediction of presence or absence of Leopard Cat

Logistic regression analysis was done for predicting the presence of Leopard Cat based on different habitat parameters. The goodness of fit statistics of the fitted model is given in Table 22.

Table 22. Goodness of fit statistics Leopard Cat

Statistic	Full
Observations	100
Sum of weights	100.00
DF	79
-2 Log(Likelihood)	0.000
R^2(McFadden)	1.000
R^2(Cox and Snell)	0.454
R^2(Nagelkerke)	1.000
AIC	42.000
SBC	96.709
Iterations	19

The Likelihood ratio test was used for testing the significance of the regression coefficients in the fitted model and is given in Table 23.

Table 23. Effect of habitat parameters on the occurrence of Leopard cat

Source	Coefficients	Chi-square (LR)	p- value
Canopy Height (m)	0.99	0.640	0.424
Canopy cover (%)	0.15	0.004	0.949
Litter depth(cm)	3.36	0.900	0.343
shrub density(trees/area)	0.34	31.712	< 0.0001
Tree density	-2.10	38.366	< 0.0001
Climber density	4.08	20.021	< 0.0001
Buttress density	-31.41	100.263	< 0.0001
Canes	37.12	96.576	< 0.0001
distance to largest tree (m)	-4.44	76.309	< 0.0001
Width of the Waterbody	-2.69	70.701	< 0.0001
GBH (cm)	-0.10	9.732	0.002
Slope (degrees)	0.43	0.005	0.944
Hole	61.35	72.088	< 0.0001
Waterbody	-169.19	678.191	< 0.0001
Rock	21.23	0.241	0.623
Fruiting Tree	0.01	27.566	< 0.0001
Swamp	210.28	217.697	< 0.0001
Roots	-60.07	299.505	< 0.0001
Roads	0.01	29.442	< 0.0001
Log	-26.64	12.998	0.000

From the above Table 23 it could be seen that the p-values are significant ($p<0.001$) except for five parameters canopy height, canopy cover, litter depth, slope and the presence of rock. That means these five habitat parametres do not have any significant influence on the presence of Leopard Cat.

The regression coefficient is the estimated increase in the logged odds of the outcome per unit increase in the value of the independent variable. In Figure 13. variables that are positive indicate that increase in these variables leads to higher presence. Variables that are negative indicate that decrease in these variables leads to higher presence of the species Leopard Cat. If the height of the blue bar is more, then these variables are more important.The graph of regression coeifficients indicated that the habitat parametrs like canopy height, buttress density, canes, Presence of fruiting trees, and presence of swamp are highly contributing to the prediction model.

Equation for the prediction of the probability of the presence of Leopard Cat from the above analysis is given below.

Species (Present/Absent) = 1 / (1 + exp(-(-14.58+0.98*Canopy Height (m)+0.15*Canopy cover (%)+3.35*Litter depth(cm)+0.34*shrub density(trees/area)-2.09*Tree density+4.08*Climber density-31.41*Buttress density+37.11*Canes-4.44*distance to largest tree (m)-2.69*Width of the Waterbody-0.10*GBH (cm)+0.43*Slope (degrees)+61.35*Hole-1-169.18*Waterbody-1+21.22*Rock-1-33.32*Fruiting Tree-1+210.28*Swamp-1-60.06*Roots-1-28.19*Roads-0-26.63*Log-1)))

Classification table of observed and predicted response of the fitted logistic regression model for predicting the presence of Leopard Cat in terms different habitat parameters is given as Table 24.

Table 24. Effect of habitat parameters on the occurrence of Leopard Cat

Observed	Predicted		
	Absence	Presence	Percentage correct
Absence	91	0	100.00%
Presence	0	9	100.00%
Total	91	9	100.00%

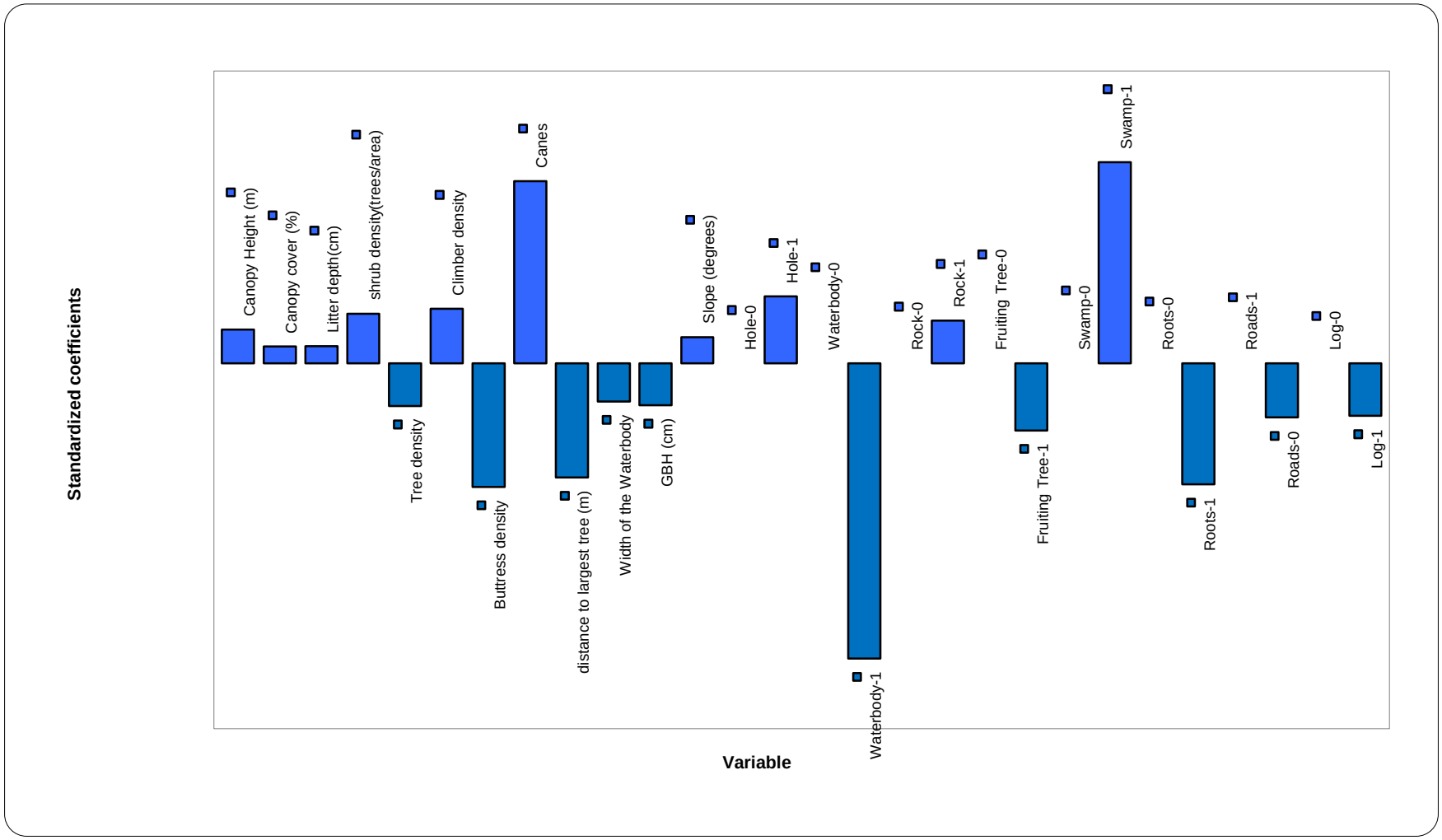


Figure 13. Influence of habitat parameters on the occurrence of Leopard Cat

The percentage of correct predictions is 100 per cent. The higher the overall percentage of correct predictions, the better is the model.

4.2.5. The 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 25 below shows the pair wise Fisher's distances (blue cells) and associated P values (red cells). There is no significant difference in the clusters indicating that the species show no significant niche partitioning (Figure 14).

Table 25. Fisher's distance matrix

	Brown Mongoose	**Brown Palm Civet**	**Leopard Cat**	**Small Indian Civet**	**Stripe-necked Mongoose**
Brown Mongoose		0.721	0.777	1.457	0.956
Brown Palm Civet	0.787		0.389	0.908	1.616
Leopard Cat	0.728	0.989		0.767	1.116
Small Indian Civet	0.136	0.579	0.739		1.757
Stripe-necked Mongoose	0.525	0.082	0.361	0.051	

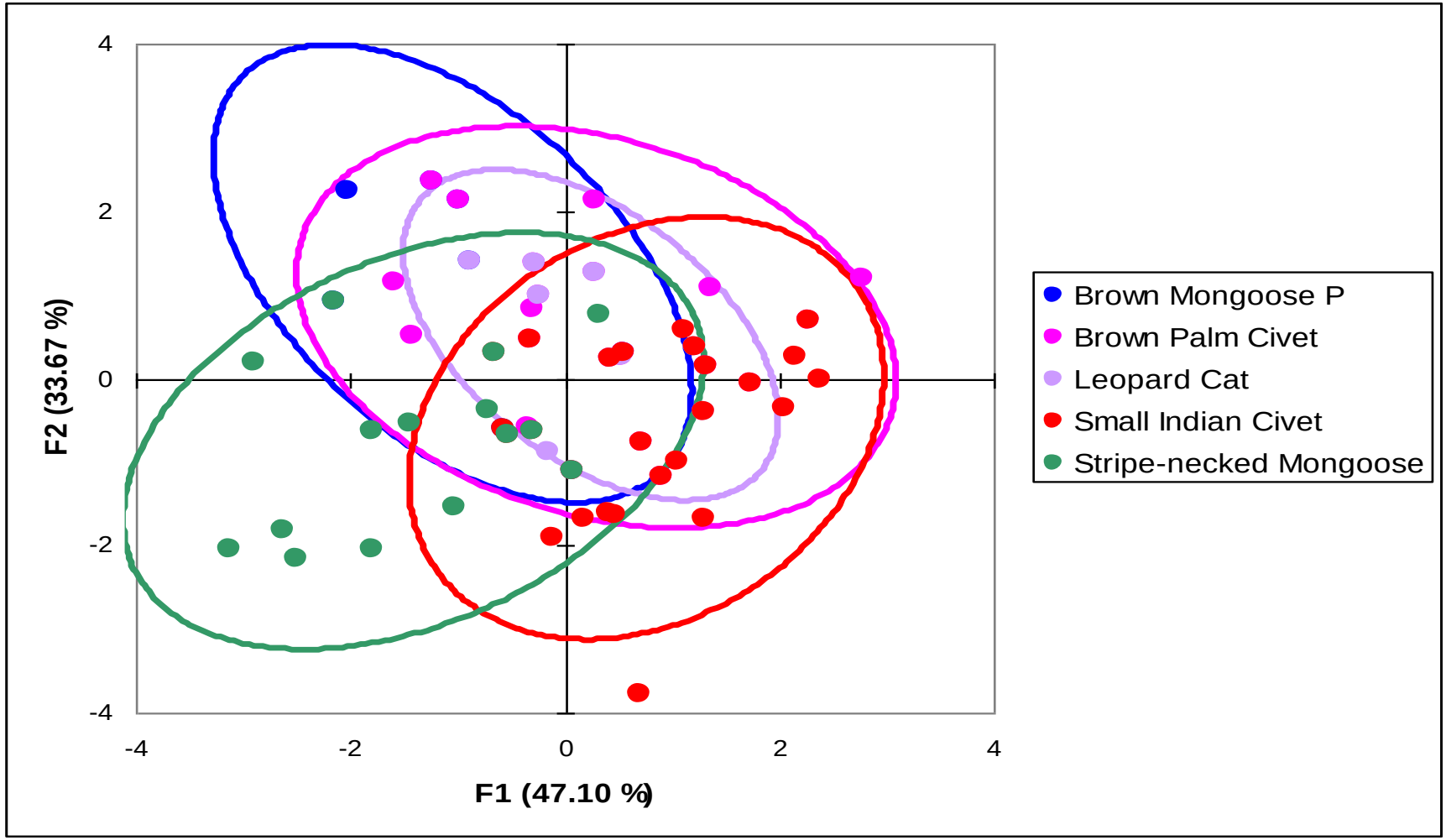


Figure 14. Niche overlapping of small carnivores in Silent Valley National Park

Plate 5. Indirect evidences of small carnivores

4.3. INDIRECT EVIDENCES ON SMALL CARNIVORES OF SILENT VALLEY NATIONAL PARK

The day transects were done on the existing trails, forest roads and streams, searching for indirect evidences of small carnivores in Silent Valley NP. A total of 45km was walked through the various trails in search of the indirect evidences. Twenty six indirect evidences including 23 scats and two tracks pertaining to small carnivores were identified from the National Park. Apart from the scats and sparints, the track of one small cat also confirmed. The otter trails were collected from the stream beds. Pugmarks of other carnivores were also located from the Silent Valley NP which included Tiger *Panthera tigris,* Pathera Leopard *Panthera pardus* and Wild Dog *Cuon alpinus*.

Among the 26 indirect evidences, 19 were of civets (73.08%), five of otters (19.23%) and two of small cats (7.69%). Scat abundance (scats/kilometer) was calculated as a measure to represent the abundance of small carnivores in Silent valley NP. It was found that the total scat abundance is only 0.51.

4.4. SMALL CARNIVORES OF SILENT VALLEY NATIONAL PARK BASED ON DIRECCT SIGHTINGS

There were only three direct sightings of small carnivores during the study. They were the two sightings of Stripe-necked Mongoose *Herpestes vitticollis*, and one sighting of the Brown Palm Civet *Paradoxurus jerdoni*, all from Sairandri in Silent Valley.

4.5. HABITAT USE INDEX (HUI) OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK

Habitat Use Index (HUI) of small carnivore species during two seasons in Silent Valley NP was estimated from the indirect evidences collected during the study period. The HUI of small carnivores is given in Table 25, Figure 15. All the small carnivore groups except small cats showed a variation in the HUI during the Non-rainy season. All other species have a higher HUI during Non-rainy season.

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

Small Carnivore Group	**Rainy Season**	**Non-rainy Season**
Civet	4.35	78.26
Otter	4.35	8.70
Small Cat	4.35	0.00

4.6. DISTRIBUTION OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK

The distribution of small carnivores in SVNP is illustrated in Figure 16-20. Figure 16 shows the distribution of Small Indian Civet. The species was

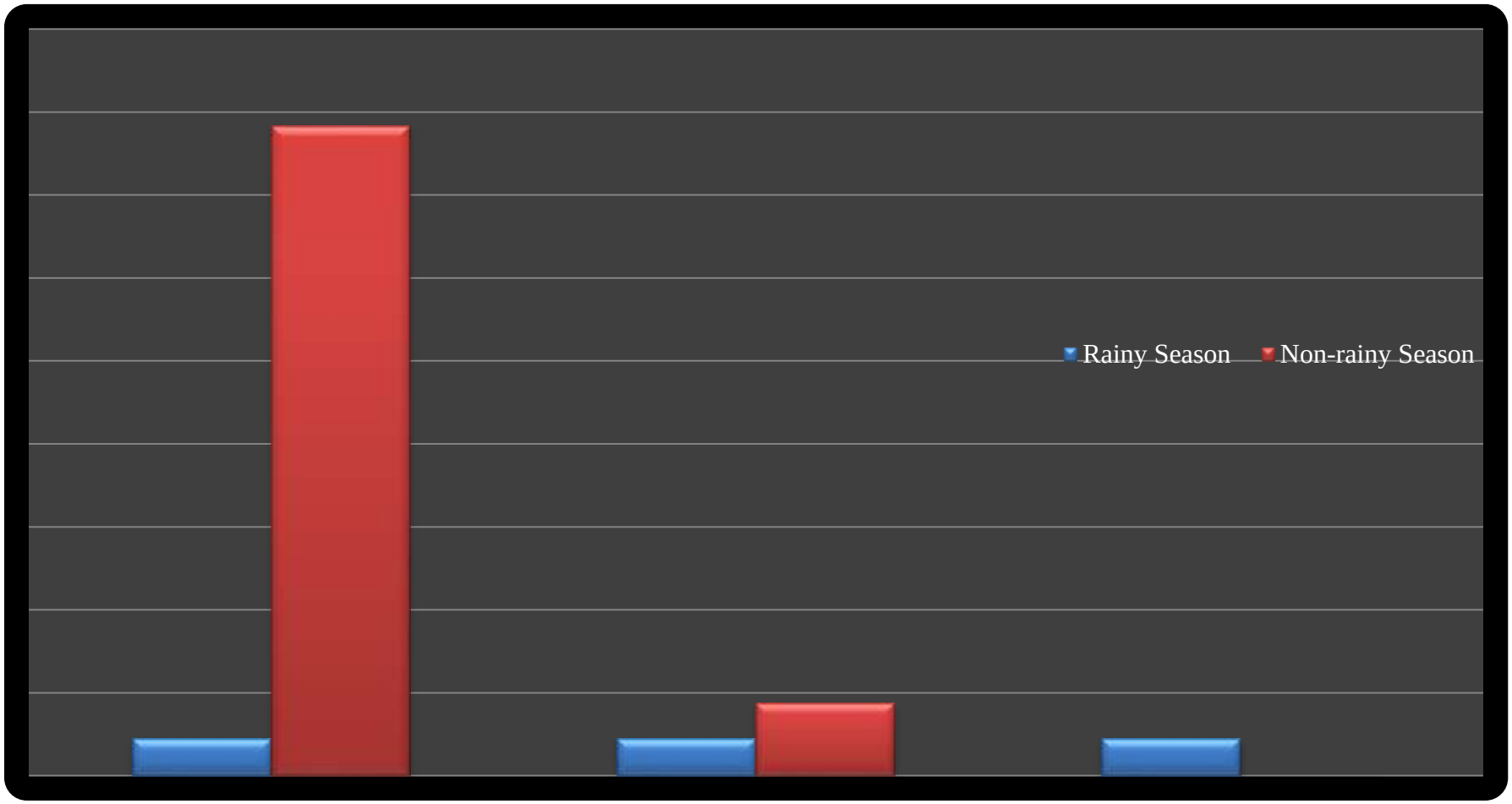


Figure 15. Habitat Use Index during rainy and non-rainy seasons in Silent Valley National Park

recorded from all the three study locations. Figure 17 illustrates the distribution of Brown palm Civet from SVNP. It also recorded from all the study sites. Figure 18 and Figure 19 show the distribution of Stripe-necked Mongoose and Brown Mongoose respectively. Both of these species reported from all the three study locations during the study. Figure 20 illustrates the distribution of species Leopard cat which is recorded from all the three study locations, Asian Small-clawed Otter is recorded from two locations Neelikkal and Sairandhri and Nilgiri Marten is only recorded from Sairandhri.

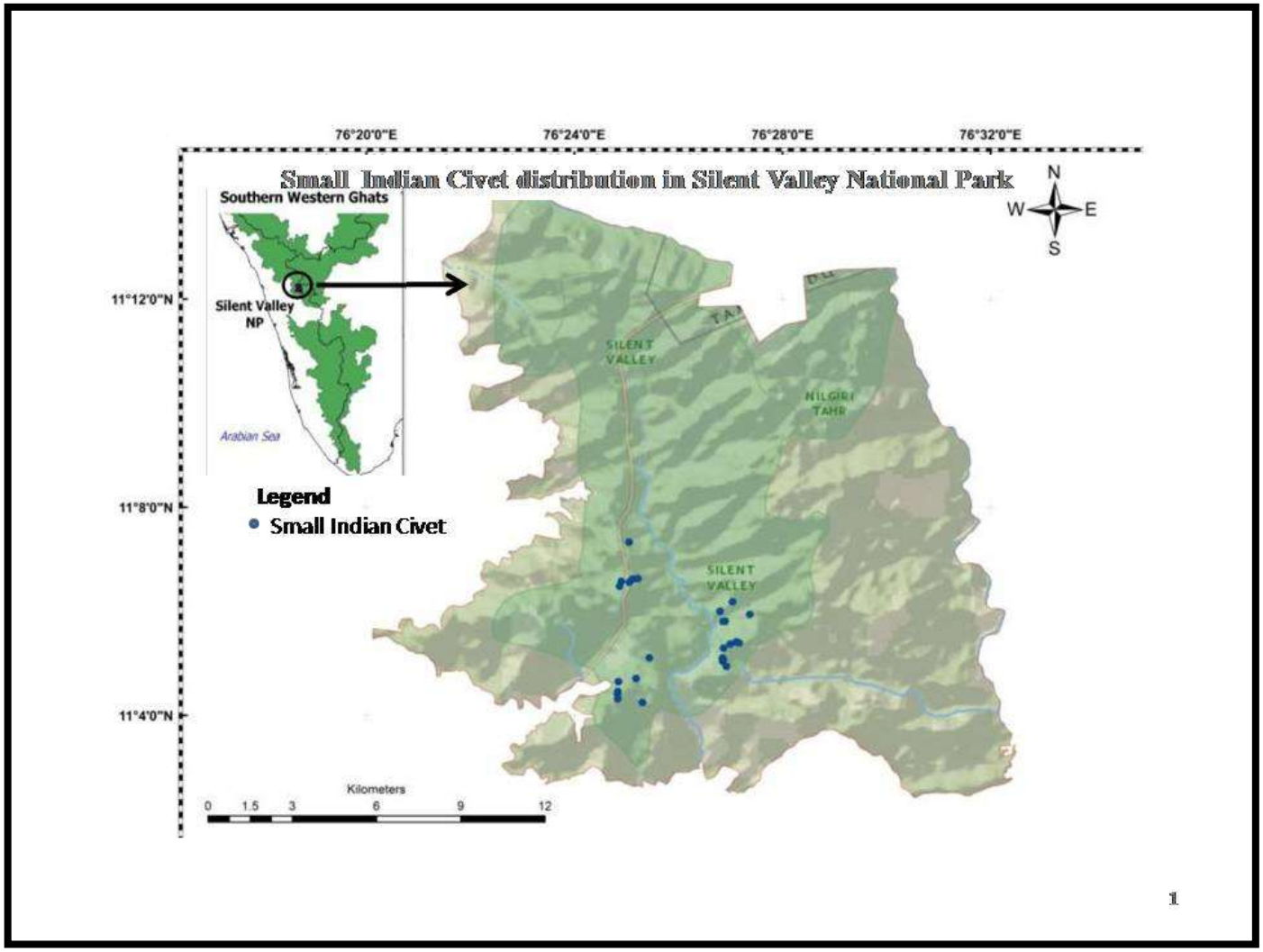


Figure 16. Distribution map of Small Indian Civet in Silent Valley National Park

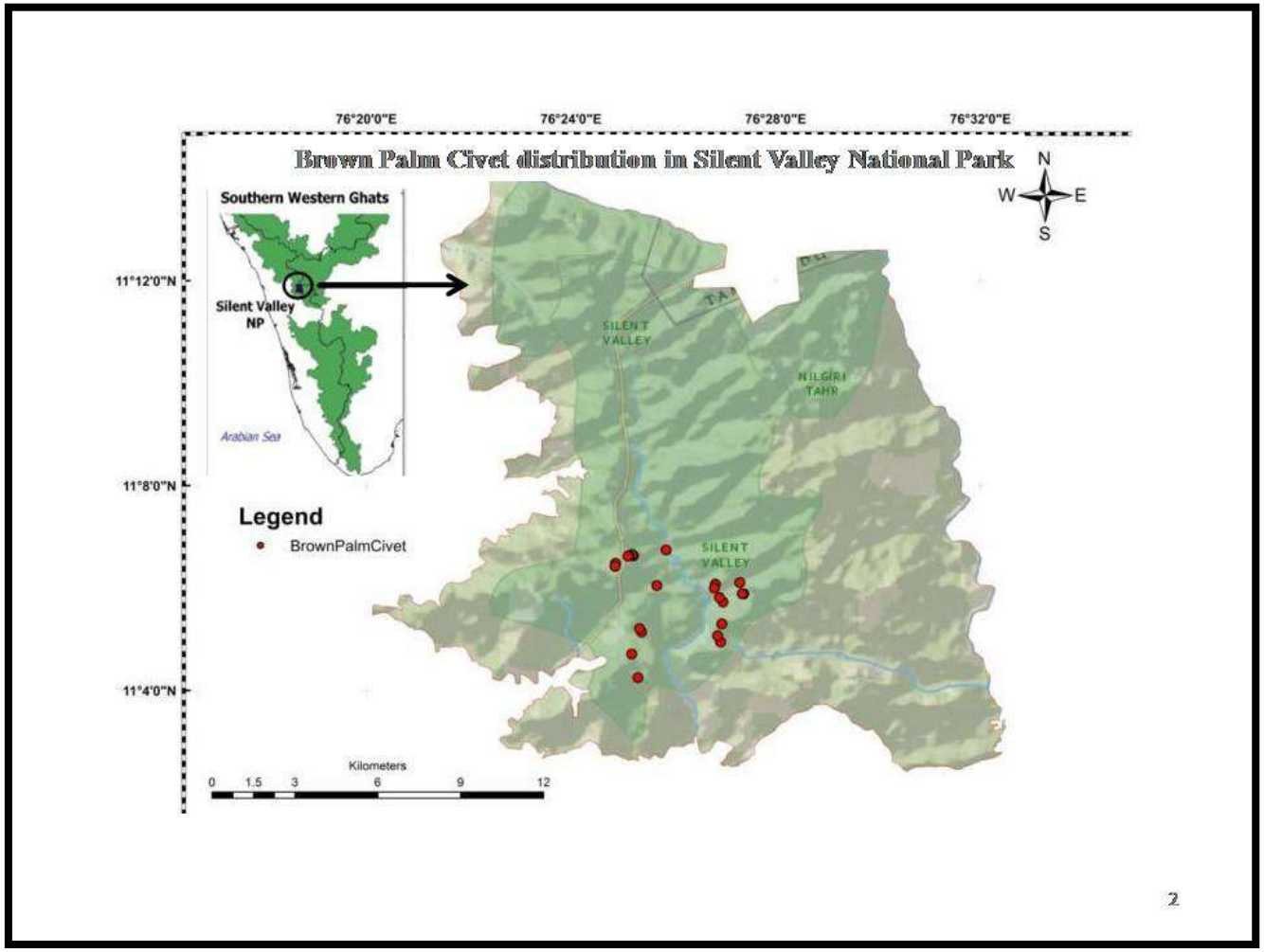


Figure 17. Distribution map of Brown Palm Civet in Silent Valley National Park

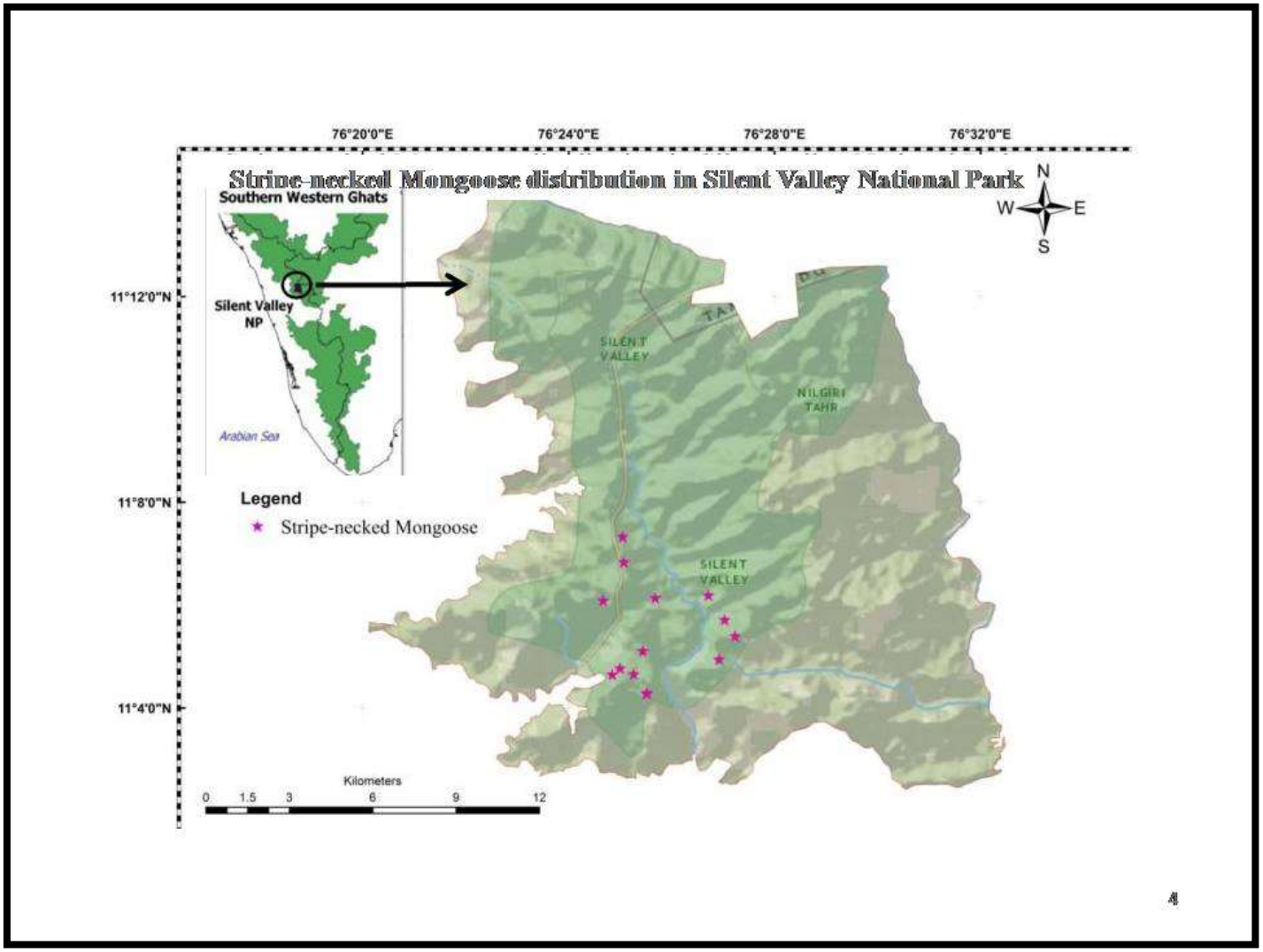


Figure 18. Distribution map of Stripe-necked Mongoose in Silent Valley National Park

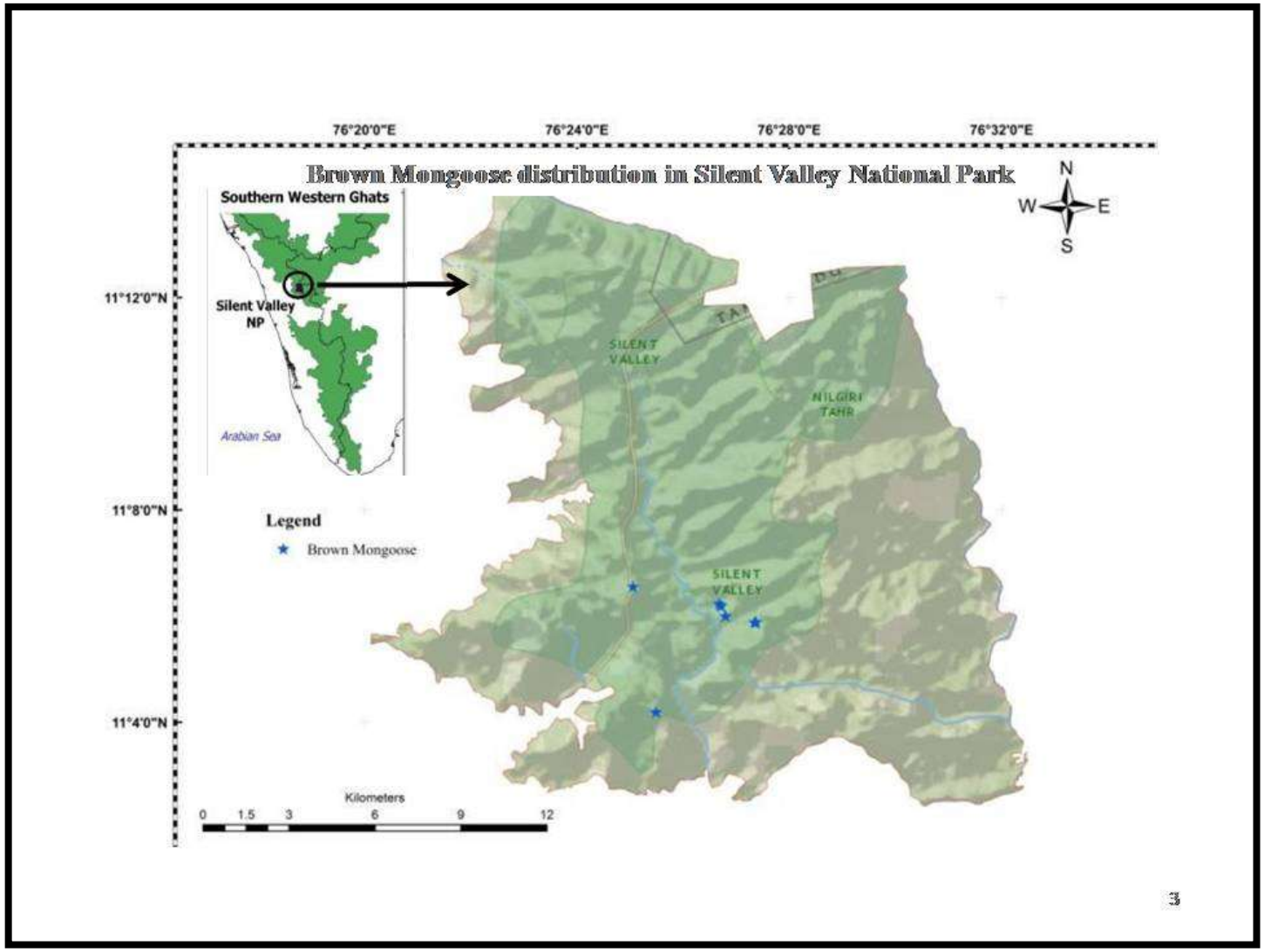


Figure 19. Distribution map of Brown Mongoose in Silent Valley National Park

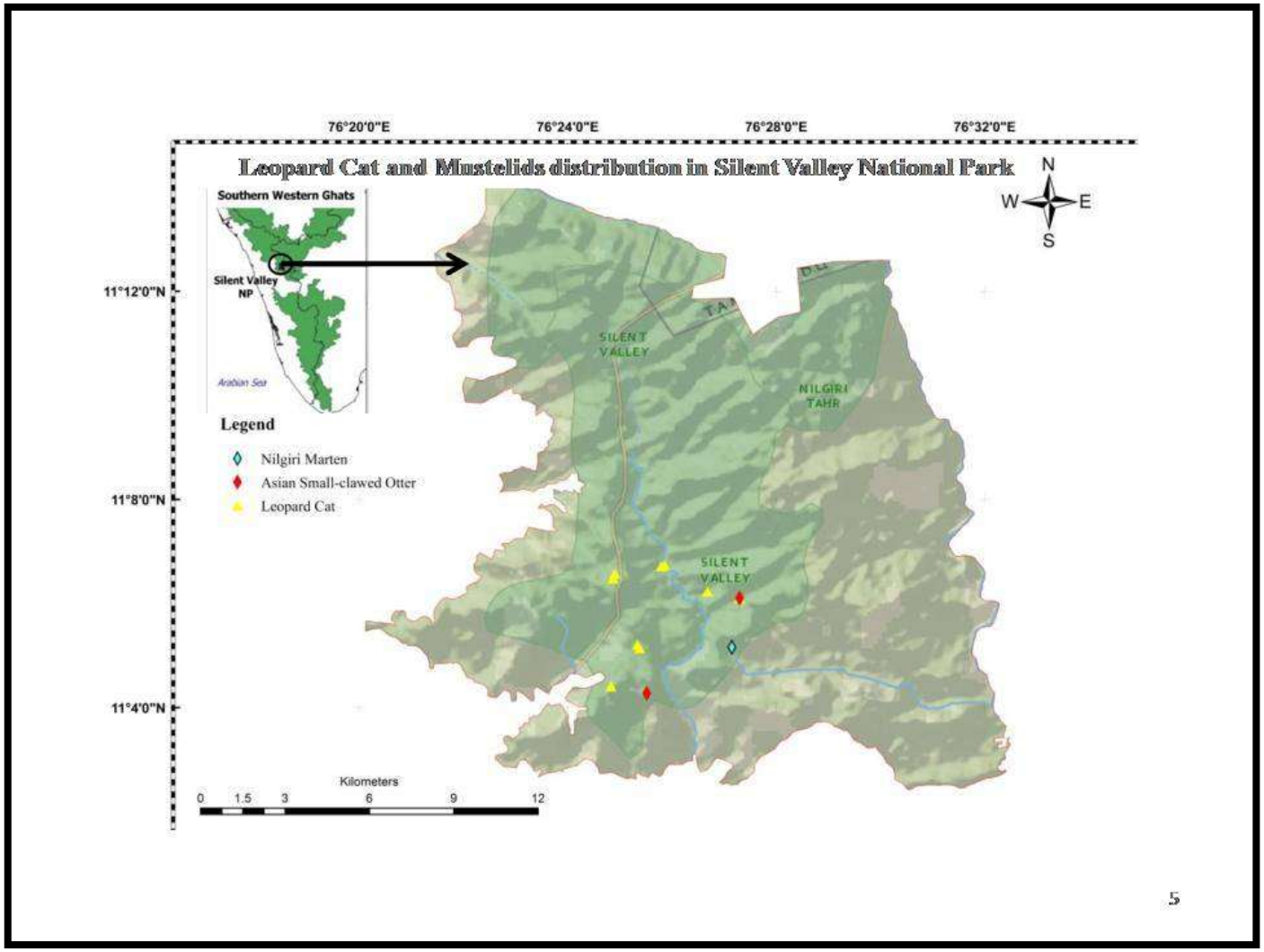


Figure 20. Distribution map of Leopard Cat and Mustelids in Silent Valley National Park

Discussion

DISCUSSION

5.1. DIVERSITY OF SMALL CARNIVORES OF SILENT VALLEY NATIONAL PARK

The seven species of small carnivores identified from Silent Valley National Park include two species of viverrids viz. *Viverricula indica* and *Paradoxurus jerdoni*, two species of mongoose namely *Herpestes vitticollis and Herpestes fuscus,* two species mustelids such as one otter *Aonyx cinereus* and the Nilgiri Marten *Martes gwatkinsii.* and one species of small cat *Prionailurus bengalensis.*

The absence of more widespread and common species indicates the undisturbed habitats of SVNP. From earlier studies it has found that the disturbed habitats are susceptible to invasions by more widespread and common species at the cost of restricted endemic species. This also alter the composition of the community (Oehler & Litavais, 1996)

4.6.3. Family Viverridae

5.1.1.1. Small Indian Civet *Viverricula indica*

The Small Indian Civet is buff to grey colored with small brown or dark spots on the flanks. The black and white ringed tail has 6-10 dark bands. This civet lacks a spinal crest and has a cream throat with two dark bands across it. Its ears are small, rounded and set close to each other on top of the head, more like a cat's. Legs of Small Indian Civet are dark and long. It is not very arboreal and prefers thick grass and scrub. It dens in burrows or under rocks. This species occurs in almost all kinds of habitats, including the arid zones of western India. They are omnivorous in diet and are known to feed largely on insects. Secretions from their perineal glands are used to mark territories. Despite being good

climbers, they have been observed to forage largely on the ground. The tail is almost two third the length of head and body and is conspicuously marked with 9-10 concentric black rings. The weight varies from 2-4 kg (Prater, 1971; Wilson and Mittermeier, 2009; Menon, 2014). The head and body measure 450 to 630 mm while tail length varies from 369 and 413 mm. Secretions from their perineal glands are used to mark territories. Small Indian civets are commercially exploited for the "civetone" or scent, extracted at regular intervals from the perineal gland that is used in perfume industries and in Indian medicine for its purported aphrodisiac properties. The species is also hunted for it meat which got a great demand in the market (Pocock, 1939). Four subspecies of Small Indian Civet have been identified from India; *V. indica indica from So*uthern Peninsular India, *V. indica deserti from Ce*ntral India, *V. indica wellsi from No*rth-west India, and *V. indica baptistae from up*per Bengal and Northeast India (Wilson and Mittermeier, 2009).

During the present study, 72 camera trapped images were obtained. All the images were of solitary animals. The species were reported from the tropical wet evergreen forest type. Small Indian Civets have been reported to be the most common small carnivore in the drier forests of the southern Western Ghats and rare in the tropical wet evergreen forests of the region (Mudappa, 2002).

5.1.1.2. Brown Palm Civet Paradoxurus jerdoni

It is an endemic carnivore restricted to the rainforest tracts of the Western Ghats (Rajamani *et al*. 2002). The species is a highly arboreal and frugivorous and also plays an active role in seed dispersal of many rainforest tree and liana species. The Brown Palm Civet is more or less similar to the Common Palm Civet in size. The general body color is brown with deep brown or blackish face and shoulder speckled with Buffy-grey, which merge with the grayish flanks. All the limbs are darker, similar to face and shoulder. Unlike Common Palm Civet it lacks distinct marking on the body. The length of the tail is almost the size of head

and body with the distal end lighter brown to dirty white. Weight ranges from 2.4 - 4.0kg, head and body length 480 - 590mm and tail length from 400 - 535mm (Pocock 1939, Corbet & Hill 1992, Mudappa 1998; and Wilson and Mittermeier, 2009). Pocock (1939) has recognized two subspecies of Brown Palm Civet such as *P. jerdoni jerdoni* which is distributed south of the Palghat gap, (in Palnis, Nilgiris and Travancore), and the second sub species *P. jerdoni caniscus* north of the Palghat gap (from Coorg).

During the present study, 33 camera trapped images were obtained and one individual was sighted in the night in front of the forest out post. Mudappa (1998) stated that the species is common in higher altitude and reported from an altitude range of 500-1,300m.

5.1.2 Family Herpestidae

5.1.2.1. Stripe-necked Mongoose Herpestes vitticollis

It is the largest of the Asiatic mongoose. It is endemic to the Western Ghats in India and Sri Lanka. The species has a distinct black stripe with a white border on the sides of the neck. The Stripe-necked Mongoose occurs in well-wooded habitats, particularly in the dry and moist deciduous forests. It is known to prefer streams and rivers and is believed to feed extensively on crabs. There are reports of it hunting small mammals such as mouse deer in Sri Lanka (Prater, 1971). General colour varies from grizzled dark brown and yellowish-grey to tawny-red. Three to four inches of the tip of the tail is black. Head and body length is between 430 to 530mm tail 304.5 to 325mm and weight ranges from 1.36 to 2.73kg (Pocock, 1939; Phillips 1984; Corbet & Hill, 1992). The species is typically a forest dwelling species. It is found near to water sources. This indicates that probably it preys upon frogs, fishes and crabs (Wilson and Mittermeier, 2009). Though it is diurnal in habit it is more active during crepuscular period. The litter size is probably two to three. Two subspecies of Stripe-necked

Mongoose are known from India. The typical form *H. vitticollis vitticollis* from Western Ghats, Coorg and Kerala is characterised by the dominance of chestnut red on its coat and the second *H. vitticollis inornatus* from north Kanara has no red tinge on the upper side of the body (Pocock, 1939 and Wilson and Mittermeier, 2009).

During the present study, 27 camera trapped images were obtained and there were two separate sightings of the species one during night in front of the forest outpost and one during day time.

The Stripe-necked Mongoose is distributed from Bombay to Dharwar to Cape Comorin (Jerdon, 1874; Blanford, 1888-1891). In Kerala the known distribution include Periyar Tiger Reserve (Ramachandran, 1985), Eravikulam national Park (Madhusudan, 1995), Anaikatty reserve foreset (Rompaey and Jayakumar, 2003) and Parambikulam Wildlife Sanctuary (Pillay, 2009). Stripe-necked Mongoose was known only from the Western Ghats of southern India and Sri Lanka. Recent records contain both direct sightings and camera trap images of the animal come from the north-central Western Ghats in the states of Maharashtra and Goa (Punjabi *et al*., 2014).

5.1.2.3. Brown Mongoose Herpestes fuscus

The Brown Mongoose is found in the forests of the south Indian hill ranges at 900-1850m (Prater, 1971; Corbet and Hill, 1992; Mudappa, 1998). Outside India it occurs in Sri Lanka (Phillips, 1984; Wilson and Mittermeier, 2009). On an average the brown mongoose is slightly larger than the grey mongoose and more uniformly dark brown above and below. It is heavily built with a relatively shorter tail which is only about two-thirds the length of the head and body. The dark brown pelage is often more or less speckled with yellow or tawny colour. The contour hair are less harsh and the upper half or third of the soles of the hind feet are covered with hair throughout the year. The length of the head and body is around 500 mm, tail 300 mm and weight about 2.7kg (Prater, 1971; Phillips, 1984).

Five subspecies of Brown Mongoose have been reported. Out of this only one subspecies *H. fuscus fuscus* is known from Western Ghats, India and the other four subspecies such as *H. fuscus flavidense*, *H. fuscus rubidior*, *H. fuscus maccarthiae* and *H. fuscus siccatus* are known from Sri Lanka (Pocock, 1941, Wilson and Mittermeier, 2009).

During the present study, 10 camera trapped images were obtained. Among that a pair was camera trapped on 6th December 2015.

In South India Brown Mongoose is found from 700 to 1,300m from Virajpet in south Coorg and Ooty in the Nilgiri hills, Tiger Shola in the Palni hills, High Wavy Mountains in Madurai, KMTR in Agasthyamalai hills, Valparai plateau in the Anamalai hills, and Peeramedu in Kerala (Pocock, 1939, Prater; 1971; Corbet & Hill, 1992; Mudappa, 1998, 2001, and Sreehari *et al.*, 2013). Thus the present sighting is the first confirmed record of this species from SVNP and the fourth sighting from Kerala.

5.1.3 Family Mustelidae

5.1.3.1. Nilgiri Marten Martes gwatkinsii

The Nilgiri Marten is endemic to Western Ghats. The Nilgiri Marten is almost similar to Yellow-throated Marten *Martes flavigula* of Himalayas in size. Blackish body with yellowish orange neck, typical weasel like leg, stout tail, pointed head and a flat skull with a concave depression on the forehead are the unique identifying characters of Nilgiri Marten (Pocock, 1941; Prater, 1971). The head to body length varies from 550 to 650 mm, tail length 400-450 mm and weight is around 2.1kg (Pocock, 1941). Very little information about the distribution, occurrence, abundance and ecology makes the Nilgiri Marten as one of the least known species of martens in the world (Wirth and Van Rompaey, 1991) and is currently listed in the IUCN Red List as Vulnerable (Choudhury *et al*., 2012). It is believed to be diurnal and arboreal, like other marten species it possibly descends to the ground for hunting. Nilgiri Martens have been observed

to hunt small vertebrates like Mouse Deer and varanus. There is a report of them feeding on the nectar of *Ceiba pentandra* (Hutton, 1944). There is a report of it preying on crows in the high ranges of Kerala (Gouldsbury, 1949) and Malabar Giant Squirrel in the high wavy mountains of Kerala (Hutton, 1944) and on insects (Pocock, 1941).

During the present study a pair Nilgiri Marten was camera trapped on 7th October 2015 near to a ficus tree where these animals are believed to be living.

The Nilgiri Marten has been reported from the following areas in the Western Ghats such as Sholayar (Vijayan, 1979), Brahmagiris (Schreiber *et al*., 1989), Eravikulam National Park (Madhusudan, 1995), Mukkurthi National Park (Yoganand & Kumar 1995, 1999), Peppara Wildlife Sanctuary and Silent Valley National Park (Christopher & Jayson 1996), Upper Bhavani (Gokula & Ramachandran 1996), KMTR (Mudappa, 2001), Periyar Tiger Reserve (Kurup and Joseph, 2001) and Parambikulam Tiger Reserve (Sreehari and Nameer, 2012). It was also sighted in Silent Valley National Park, Attappadi Reserve Forest, Muthikkulam South Reserve Forest, and Nilambur South Reserve Forest by Balakrishnan (2005). The Nilgiri Marten sightings from the Western Ghats have been compiled by Krishna and Karnad (2010). The additional Nilgiri Marten sighting locations reported by them include, Anamalai Tiger Reserve, Nelliampathy Reserve Forest, Grass Hills National Park, Pambadum shola National Park, Talakaveri Wildlife Sanctuary and Sandynallah in Nilgiris.

5.1.3.2. Asian Small-clawed Otter Aonyx cinereus

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

contour hair often paler, but rarely white, giving a grey tint. The ventral side is generally paler brown than the upper, often showing the grey cast (Pocock 1941).

Among the three subspecies in the world two subspecies were reported from India. One is the *A. cinereus concolor* which is seen in northeast India, Nepal, Bhutan, Bangladesh and Myanmar, extending to Sumatra and the second is the *A. cinereus nirnai* that is seen in the hill ranges of southern India (Pocock,1941 and Wilson and Mittermeier, 2009).

There were two camera trap captures of Asian Small-clawed Otter from the SVNP. In addition, otter spraints and tracks were found on the banks of the Kunthy River. There were only three published study on the otters in Western Ghats, viz. Meena (2002), Anoop and Hussain (2004 and 2005) and Perinchery *et al.* (2011).

5.1.4 Family Felidae

5.1.4.1. Leopard Cat Prionailurus bengalensis

The species is one of the most adaptable wild cats, similar to leopard. Its colour and marking give it the aspect of a miniature leopard. The prevailing colour of the body is yellow to brownish below and silvery grey on the tip of coat hairs. The body and limbs are marked by black spots. Both colour and pattern are very variable in this species. Often there are 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. It is an extremely versatile cat, which is arboreal and preys up on small birds and animals. It is nocturnal in habit and seldom seen. It takes rest in hollows in trees. Total body length comes up to 60 cm and weights from 3 to 7 kg (Prater, 1971; Wilson and Mittermeier, 2009; and Menon, 2014).

Ten camera trap images of Leopard cat were obtained during the study. The altitudinal range was 900- 1150m from MSL.

5.2. SPECIES RICHNESS AND ABUNDANCE OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK USING THE CAMERA TRAP STUDIES

At Silent Valley NP, seven species of small carnivores have been captured in the camera trapped from 1450 trap days. Mudappa *et al*. (2007), who studied the small carnivores in Kalakad-Mundanthurai Tiger Reserve with a camera trap effort of 295, recorded three species, while her studies at Anamalai hills with 95 camera trap nights also recorded three species. Rao *et al*. (2007), after 1084 camera trap efforts recorded only four species of small carnivores. Datta *et al.* (2008), reported that after a camera trap effort of 1537 in Namdapha NP they got six species, while at Pakke WLS, after a camera trap effort of 231, they recorded four species. Kalle *et al.* (2013), 7380 camera trap nights recorded nine species from Mudumalai Tiger Reserve. Sreehari (2012) recorded eight species from 1349 trap nights. In Eravikulam NP, Nikhil (2015) recorded eight species from 855 camera trap days. Thus our study results corroborates with the general camera trap capture success in different part of the country and the Western Ghats.

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

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 number of occurrence where very high compared to other similar studies in South

Asia and from Western Ghats. The overall capture success rate is 10.89% (158 of 1450 trap days) and it recorded seven species of small carnivores from Silent Valley NP. The success rate of Parambikulam Tiger Reserve and Eravikulam National Park was 4.1% (Sreehari, 2012) and 2.1% (Nikhil, 2015) respectively. In Kalakkad Mundanthurai Tiger Reserve (Mudappa, 1998) was 41% recording three small carnivore species. The camera trap success rate is fairly high and this could be due to the peculiar habitat of the study area and reduced human interventions in the National Park. Small carnivore success rate was high in non-rainy season (71.7%) than the rainy season (37.2).

5.3. SPECIES RICHNESS AND ABUNDANCE OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK USING INDIRECT EVIDENCES

Using the scat abundance study, it was observed that the civets (82.61%) were the most abundant small carnivore in Silent Valley NP followed by otters (13.04%). The small cats (4.35%) were the least abundant family. There was a notable variation in the scat abundance between the two seasons studied. The overall scat abundance was more for the non rainy season (78.26%). This may be due to the low detectability of scats during rainy seasons. In rainy season most of the scats were difficult to locate and identify because heavy rains washes away the scats.

This estimation, however, has couple of limitations such as; the scat abundance need not be proportional to animal abundance. Yoganand and Kumar (1999), has opined that the defecation behaviors of the individuals of different families are mostly unknown and the defecation rate may vary among different groups of species. Thus one cannot estimate the abundance of small carnivore using the indirect evidences; it can at the best be used for recording the presence-absence of a small carnivore and to supplement the camera trap data.

5.4. SPECIES RICHNESS AND DIVERSITY OF THE SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK

The various diversity indices and species richness parameters such as number of taxa (S), number of individuals (n), Dominances, Shannon-Weiner index (H), Simpson's index (1-D), Berger Parker index and Margalef index (M) were calculated for the two seasons such as rainy season (September to December) and non-rainy season (January to April). The species diversity during the two seasons of SVNP was compared using student t-test and it was found to be significant at 0.05 levels. Rainy season showed greater species diversity and species richness when compared to non-rainy season.

5.5. THE TIME ACTIVITY PATTERN OF CAMERA TRAPPED SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK

The use of time and distributes of activities by an animal within the diel cycle is an important niche dimension. This helps the animals to reduce interspecific competition and predation risk. This minimizes the temporal overlap between similar species and thus increase niche segregation (Gerber *et al.,* 2012).

By analyzing activity pattern of small carnivores in SVNP during this study it was found that the sympatric species of viverridae, the Brown Palm Civet and Small Indian Civet have a nocturnal activity pattern as the earlier studies suggested (Wilson and Mittermeier, 2009).The radio collard animal was active over the 50% of the time between 1630hrs and 0430hrs with a peak activity between 1930hrs to 0130hrs. The radio collaring studies of the Small Indian Civet in Myanmar showed a peak activity from 1930hrs to 2200hrs and from 0030hrs to 0300hrs. The radio collaring studies done on the species Brown Palm Civet also found that the individual of the species were active between the dusk and dawn. In the present study also the activity pattern of these species followed similar trends.

The activity pattern of two herpestids showed a significant difference in their active periods during the present study. as discussed in other studies (Wilson

and Mittermeier, 2009). The active peak of Stripe-necked Mongoose was from 0900hrs to 1000hrsand that of Brown Mongoose was from 2200hrs to 2300hrs. The activity patterns of these two Mongooses corroborate with the older studies.

The radio collard individuals in Malaysia were nocturnal. But in Thailand the radio collard individuals showed an activity pattern which was arrhythmic which lead to the conclusion that the species forage extensively on both nocturnal and diurnal preys (Wilson and Mittermeier, 2009). In the present study, the Leopard Cat has activity during 2100hrs and 0700hrs with a peak activity from 2200hrs to 2300hrs and from 0500hrs to 0600hrs. The activity pattern of Leopard Cat during the present study follows the same trend.

5.6. 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 species did not show any significant difference in the clusters indicating that the species show no significant niche partitioning in SVNP. If this trend is true then it is alarming from conservation point of view, because this means that 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 sympatric small carnivores of SVNP 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).

5.7. HABITAT USE INDEX (HUI) OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK

Habitat Use Index (HUI) of small carnivore species during two seasons in Silent Valley NP was estimated from the indirect evidences collected during the

study period. There was no variation in the habitats between different sampling blocks. But a variation in HUI was observed between the two season of SVNP. All the small carnivore groups except small cats showed a variation in the HUI during the Non-rainy season. All other species have a higher HUI during Non-rainy season.

5.8. CONSERVATION STATUS OF SMALL CARNIVORES OF SILENT VALLEY NATIONAL PARK

Out of the seven species of small carnivores recorded from SVNP *Martes gwatkinsii* and *Paradoxurus jerdoni* are endemic to Western Ghats. While the *Herpestes vitticollis* and *Herpestes fuscus* are restricted to the Western Ghats and Sri Lanka. Two species of small carnivores from SVNP, *Martes gwatkinsii* and *Aonyx cinereus* have been categorized as Vulnerable as per the IUCN (Mudappa *et al.,* 2015; and Wright *et al.,* 2015).

The present study on the small carnivores in SVNP observed no potential threats to the small carnivores of the NP. The National Park has very stringent protection strategies.

Summary

SUMMARY

Most of the Protected Areas of the country in general and Kerala in particular do not have a comprehensive inventory of the small carnivores. Even basic information such as the distributional range of these species is not known (Nameer, 2000). No studies have been done on the small carnivores of Silent Valley National Park (henceforth SVNP), except for the studies on the sighting records of Nilgiri Marten (Christopher and Jayson, 1996) and habitat characterization of Nilgiri Marten (Balakrishnan, 2005). But a firsthand knowledge about the mammalian fauna, especially the small carnivores of SVNP is not available and hence the present study. The objectives of the study were to understand diversity, status, distribution and habitat preference of the small carnivores of SVNP. The methods employed to study the small carnivores were, camera trap survey and day transect survey for the direct and indirect evidences. A total of 1450 camera trap days consisting of 34,800hrs of trapping and 45 kilometers of transect walk were done. The salient findings are summarized below.

- A total of seven species of small carnivores in four families were recorded from the SVNP during the present study. This comprise of two species each of herpestids, viverrids, mustelids, and one species from felidae. All of these species were camera trapped from the Silent Valley National Park
- The civets reported from SVNP are Small Indian Civet *Viverricula indica* and Brown Palm Civet *Paradoxurus jerdoni*. Thus out of the three species of civets in Western Ghats two have been recorded from the NP
- The mongooses reported from SVNP are Stripe-necked Mongoose *Herpestes vitticollis*, and Brown Mongoose *Herpestes fuscus.* Thus 50% of mongoose species from Kerala have been reported from SVNP
- The mustelids reported from SVNP are Asian Small Clawed Otter *Aonyx cinereus* and Nilgiri Marten *Martes gwatkinsii.* Thus out of the four species of mustelids known from the Western Ghats two have been reported from SVNP
- The only lesser cat reported from SVNP is Leopard Cat *Prionailurus bengalensis.* Thus one out of the three lesser cats known from Western Ghats has reported from SVNP
- The most common species recorded was Small Indian Civet *Viverricula indica* (45.57%) followed by Brown Palm Civet *Paradoxurus jerdoni* (20.89%), Stripe-necked Mongoose

Herpestes vitticollis (17.09%), Brown Mongoose *Herpestes fuscus*(6.33%), Leopard Cat *Prionailurus bengalensis* (6.33%) and Asian Small Clawed Otter *Aonyx cinereus* (3.16%) . The Nilgiri Marten *Martes gwatkinsii* was captured only once (5.5%) in the camera traps during the study period

- The camera traps also documented the presence of 14 other mammals such as Tiger *Panthera tigris,* Leopard *Panthera pardus,* Wild Dog *Cuon alpines*, Sambar Deer *Rusa unicolor*, Barking Deer *Muntiacus muntjak*, Indian Chevrotain *Moschiola indica*, Gaur *Bos gaurus*, Wild Boar *Sus scrofa,* Indian Crested Porcupine *Hystrix indica,* Lion-tailed Macaque *Macaca silenus*, Nilgiri Langur *Semnopithecus johnii*, Jungle Striped Squirrel *Funambulus tristriatus* and an unidentified rodent species from the Silent Valley National Park. During the camera trap survey photograph of a Black Panther was also obtained. These species have accounted for the 73.26% of the camera trap pictures in the National Park
- The overall small carnivore success rate has been generally high at SVNP (10.90%) when compared to other locations in Western Ghats. Out of two seasons studied small carnivore capture success rate was maximum during the non-rainy season (71.7%)
- Out of the 158 camera trap images obtained during the study period 105 (66.46%) were of viverrids. Small Indian Civet was the commonest small carnivore in Silent Valley NP accounting for 45.57% of the camera trap images, followed by Brown Palm Civet (20.89%) and Stripe-necked Mongoose (17.09%)
- The analysis of activity pattern of small carnivores of SVNP showed a significant difference in activity distribution of sympatric species. The Stripe-necked Mongoose have diurnal activity pattern where Brown Mongoose have a nocturnal activity pattern. Even though two species of viverrids, Small Indian Civet and Brown palm civet are nocturnal they have varying peak activity periods
- Logistic regression analysis was done for predicting the presence of Brown Mongoose species based on different habitat parameters and found that all the habitat parametres have significant influence on the presence of Brown Mongoose in Silent Valley NP
- Logistic regression analysis was done for predicting the presence of Stripe-necked Mongoose species based on different habitat parameters and discovered that all the

parameters other than canopy cover have significant influence on the presence of Stripe-necked Mongoose

- Logistic regression analysis was done for predicting the presence of Brown Palm Civet based on different habitat parameters and found that three parameters litter depth, shrub density and slope have significant influence on the presence of Brown Palm Civet
- Logistic regression analysis was done for predicting the presence of Small Indian Civet based on different habitat parameters and found that only three parameters cane density, fruiting tree, and swamp have significant influence on the presence of Small Indian Civet
- Logistic regression analysis was done for predicting the presence of Leopard Cat based on different habitat parameters and found that five parameters canopy height, canopy cover, litter depth, slope and the presence of rock do not have any significant influence on the presence of Leopard Cat
- 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 significant overlapping in SVNP
- There was no variation in habitat preference between the sampling blocks of SVNP. But, a variation in Habitat Use Index (HUI) of small carnivore species during two seasons in SVNP was observed. All the small carnivore groups except small cats have a higher HUI during Non-rainy season

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STATUS, DISTRIBUTION AND HABITAT PREFERENCES OF SMALL CARNIVORES IN SILENT VALLEY NATIONAL PARK, KERALA

by

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(2014-17-101)

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN FORESTRY

Faculty of Forestry

Kerala Agricultural University

DEPARTMENT OF WILDLIFE SCIENCES

COLLEGE OF FORESTRY

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2016

ABSTRACT

Status, distribution and habitat preference of small carnivores in Silent Valley National Park (SVNP) was studied during September 2015 to April 2016, using camera trap survey and day transects survey for the direct and indirect evidence. Seven species of small carnivores were recorded during the study. They are Small Indian Civet *Viverricula indica*, Brown Palm Civet *Paradoxurus jerdoni*, Stripe-necked Mongoose *Herpestes vitticollis*, Brown Mongoose *Herpestes fuscus*, Leopard Cat *Prionailurus bengalensis*, and Asian Small-clawed Otter *Aonyx cinereus*, and Nilgiri Marten *Martes gwatkinsii*. 12 mammal species other than small carnivores were reported along with 7 species of birds and one species of reptile during this present study. Small Indian Civet is the most abundant small carnivore in SVNP followed by Brown Palm Civet, and Stripe-necked Mongoose. From the diversity indices, it is found that species diversity was high during rainy season compared to non-rainy season.

The analysis of activity pattern of small carnivores of SVNP showed a significant difference in activity distribution of sympatric species. The Stripe-necked Mongoose has diurnal activity pattern where Brown Mongoose has a nocturnal activity pattern. Two species of viverrids, Small Indian Civet and Brown Palm Civet showed a nocturnal activity, but they have varying peak activity periods. Leopard Cat had a nocturnal activity pattern.

Logistic regression analysis was done for predicting the presence of small carnivore species based on 20 habitat parameters. The predictive accuracy of the regression model for occurrence of Stripe-necked Mongoose and Leopard Cat were 100%, which of Brown Mongoose, Brown Palm Civet and Small Indian Civet was 97%, 80%, and 79% respectively. Differential preferences of the species for the studied habitat variables were examined using discriminant analysis. It is interesting to note that the small carnivores of Silent Valley shows niche overlapping.

Appendices

Appendix I: Camera trap data on small carnivores in Silent Valley National Park from September 2015 to April 2016

Sl. No.	Place	Date	Latitude	Longitude	Altitude (m)	Habitat
Brown Mongoose						
1	Sairandhri	03-10-15	11.09809	76.45628	1050	Evergreen
2	Sairandhri	03-10-15	11.09813	76.45578	1040	Evergreen
3	Sairandhri	03-10-15	11.09813	76.45578	1040	Evergreen
4	Sairandhri	04-10-15	11.09813	76.45578	1040	Evergreen
5	Neelikkal	28-11-15	11.069917	76.42483	992	Evergreen
6	Neelikkal	06-12-15	11.069917	76.42483	992	Evergreen
7	Poochippara	26-02-16	11.109278	76.41764	1163	Evergreen
8	Sairandhri	07-04-16	11.100028	76.44669	998	Evergreen
9	Sairandhri	19-04-16	11.103194	76.44528	922	Evergreen
10	Sairandhri	09-04-16	11.103833	76.44475	929	Evergreen
Stripe-necked Mongoose						
11	Sairandhri	30-09-15	11.08242	76.44871	1045	Evergreen
12	Sairandhri	05-10-15	11.09523	76.45055	973	Evergreen
13	Neelikkal	25-11-15	11.077694	76.42114	973	Evergreen
14	Neelikkal	09-12-15	11.079556	76.41664	1010	Evergreen
15	Neelikkal	05-12-15	11.0775	76.41411	1077	Grassland
16	Neelikkal	01-12-15	11.122167	76.41753	1047	Evergreen
17	Neelikkal	27-11-15	11.085139	76.42406	987	Evergreen
18	Neelikkal	11-12-15	11.071306	76.42528	1003	Evergreen
19	Neelikkal	03-12-15	11.071583	76.42528	1009	Evergreen
20	Neelikkal	01-12-15	11.071306	76.42531	1006	Evergreen
21	Poochippara	25-02-16	11.102361	76.42808	972	Evergreen
22	Poochippara	28-02-16	11.102361	76.42808	972	Evergreen
23	Poochippara	28-02-16	11.102361	76.42808	972	Evergreen
24	Poochippara	29-02-16	11.113917	76.41789	1154	Evergreen
25	Sairandhri	11-04-16	11.101472	76.41119	952	Evergreen
26	Sairandhri	06-04-16	11.103194	76.44528	922	Evergreen
27	Sairandhri	06-04-16	11.103194	76.44528	922	Evergreen
28	Sairandhri	07-04-16	11.103194	76.44528	922	Evergreen
29	Sairandhri	07-04-16	11.103194	76.44528	922	Evergreen
30	Sairandhri	07-04-16	11.103194	76.44528	922	Evergreen
31	Sairandhri	08-04-16	11.103194	76.44528	922	Evergreen
32	Sairandhri	09-04-16	11.103194	76.44528	922	Evergreen
33	Sairandhri	12-04-16	11.103194	76.44528	922	Evergreen

34	Sairandhri	15-04-16	11.103194	76.44528	922	Evergreen
35	Sairandhri	16-04-16	11.103194	76.44528	922	Evergreen
36	Sairandhri	16-04-16	11.103194	76.44528	922	Evergreen
37	Sairandhri	19-04-16	11.089972	76.45394	1267	Evergreen
Brown Palm Civet						
38	Sairandhri	01-10-15	11.08242	76.44871	1045	Evergreen
39	Sairandhri	01-10-15	11.08443	76.44773	1066	Evergreen
40	Sairandhri	07-10-15	11.0954	76.44952	981	Evergreen
41	Sairandhri	06-10-15	11.09809	76.45628	1050	Evergreen
42	Sairandhri	03-10-15	11.09813	76.45578	1040	Evergreen
43	Neelikkal	29-11-15	11.078528	76.41978	988	Evergreen
44	Neelikkal	01-12-15	11.070833	76.42181	1021	Evergreen
45	Neelikkal	05-12-15	11.085667	76.423	990	Evergreen
46	Neelikkal	03-12-15	11.086778	76.42231	980	Evergreen
47	Poochippara	27-02-16	11.100778	76.42797	973	Evergreen
48	Poochippara	27-02-16	11.1105	76.42033	1090	Evergreen
49	Poochippara	29-02-16	11.112333	76.43097	918	Evergreen
50	Poochippara	27-02-16	11.110889	76.41989	1109	Evergreen
51	Poochippara	01-03-16	11.1105	76.41886	1140	Evergreen
52	Poochippara	27-02-16	11.108028	76.4145	1141	Evergreen
53	Poochippara	28-02-16	11.108028	76.4145	1141	Evergreen
54	Poochippara	29-02-16	11.108028	76.4145	1141	Evergreen
55	Poochippara	01-03-16	11.108028	76.4145	1141	Evergreen
56	Poochippara	01-03-16	11.108028	76.4145	1141	Evergreen
57	Poochippara	02-03-16	11.108028	76.4145	1141	Evergreen
58	Poochippara	02-03-16	11.108028	76.4145	1141	Evergreen
59	Poochippara	01-03-16	11.107056	76.41433	1134	Evergreen
60	Poochippara	01-03-16	11.110333	76.41853	1136	Evergreen
61	Sairandhri	06-04-16	11.101722	76.45497	1011	Evergreen
62	Sairandhri	13-04-16	11.101722	76.45497	1011	Evergreen
63	Sairandhri	14-04-16	11.101722	76.45497	1011	Evergreen
64	Sairandhri	17-04-16	11.101722	76.45497	1011	Evergreen
65	Sairandhri	11-04-16	11.101278	76.447	1012	Evergreen
66	Sairandhri	17-04-16	11.101278	76.447	1012	Evergreen
67	Sairandhri	11-04-16	11.100028	76.44669	998	Evergreen
68	Sairandhri	13-04-16	11.096833	76.44833	904	Evergreen
69	Sairandhri	13-04-16	11.088306	76.44911	1057	Evergreen
70	Sairandhri	13-04-16	11.088306	76.44911	1057	Evergreen
Small Indian Civet						

71	Sairandhri	04-10-15	11.08242	76.44871	1045	Evergreen
72	Sairandhri	02-10-15	11.08402	76.44753	1068	Evergreen
73	Sairandhri	04-10-15	11.08402	76.44753	1068	Evergreen
74	Sairandhri	04-10-15	11.08499	76.44749	1057	Evergreen
75	Sairandhri	02-10-15	11.08443	76.44773	1066	Evergreen
76	Neelikkal	30-11-15	11.078528	76.41978	988	Evergreen
77	Neelikkal	30-11-15	11.0775	76.41411	1077	Grassland
78	Neelikkal	28-11-15	11.074361	76.41392	1108	Grassland
79	Neelikkal	29-11-15	11.074361	76.41392	1108	Grassland
80	Neelikkal	03-12-15	11.074361	76.41392	1108	Grassland
81	Neelikkal	04-12-15	11.074361	76.41392	1108	Grassland
82	Neelikkal	29-11-15	11.073528	76.41383	1092	Evergreen
83	Neelikkal	04-12-15	11.073528	76.41383	1092	Evergreen
84	Neelikkal	23-11-15	11.072056	76.41389	1113	Grassland
85	Neelikkal	29-11-15	11.072056	76.41389	1113	Grassland
86	Neelikkal	30-11-15	11.072056	76.41389	1113	Grassland
87	Neelikkal	30-11-15	11.072056	76.41389	1113	Grassland
88	Neelikkal	09-12-15	11.072056	76.41389	1113	Grassland
89	Neelikkal	11-12-15	11.072056	76.41389	1113	Grassland
90	Neelikkal	01-12-15	11.122167	76.41753	1047	Evergreen
91	Neelikkal	13-12-15	11.122167	76.41753	1047	Evergreen
92	Neelikkal	27-11-15	11.070833	76.42181	1021	Evergreen
93	Neelikkal	13-12-15	11.085139	76.42406	987	Evergreen
94	Poochippara	24-02-16	11.1105	76.42033	1090	Evergreen
95	Poochippara	27-02-16	11.109278	76.41764	1163	Evergreen
96	Poochippara	27-02-16	11.109639	76.41508	1147	Evergreen
97	Poochippara	28-02-16	11.109639	76.41508	1147	Evergreen
98	Poochippara	29-02-16	11.109639	76.41508	1147	Evergreen
99	Poochippara	02-03-16	11.109639	76.41508	1147	Evergreen
100	Poochippara	25-02-16	11.108028	76.4145	1141	Evergreen
101	Poochippara	27-02-16	11.108028	76.4145	1141	Evergreen
102	Poochippara	27-02-16	11.108028	76.4145	1141	Evergreen
103	Poochippara	28-02-16	11.108028	76.4145	1141	Evergreen
104	Poochippara	28-02-16	11.108028	76.4145	1141	Evergreen
105	Poochippara	29-02-16	11.108028	76.4145	1141	Evergreen
106	Poochippara	28-02-16	11.110333	76.41853	1136	Evergreen
107	Sairandhri	07-04-16	11.099028	76.45625	1024	Evergreen
108	Sairandhri	07-04-16	11.103111	76.45072	1022	Evergreen
109	Sairandhri	07-04-16	11.103111	76.45072	1022	Evergreen

110	Sairandhri	11-04-16	11.103111	76.45072	1022	Evergreen
111	Sairandhri	12-04-16	11.103111	76.45072	1022	Evergreen
112	Sairandhri	11-04-16	11.100028	76.44669	998	Evergreen
113	Sairandhri	11-04-16	11.096833	76.44833	904	Evergreen
114	Sairandhri	09-04-16	11.096778	76.44764	906	Evergreen
115	Sairandhri	07-04-16	11.088222	76.44781	1033	Evergreen
116	Sairandhri	11-04-16	11.088222	76.44781	1033	Evergreen
117	Sairandhri	14-04-16	11.088222	76.44781	1033	Evergreen
118	Sairandhri	14-04-16	11.088222	76.44781	1033	Evergreen
119	Sairandhri	09-04-16	11.089556	76.44994	1157	Evergreen
120	Sairandhri	16-04-16	11.089556	76.44994	1157	Evergreen
121	Sairandhri	08-04-16	11.090222	76.45189	1205	Evergreen
122	Sairandhri	09-04-16	11.090222	76.45189	1205	Evergreen
123	Sairandhri	11-04-16	11.090222	76.45189	1205	Evergreen
124	Sairandhri	11-04-16	11.090222	76.45189	1205	Evergreen
125	Sairandhri	12-04-16	11.090222	76.45189	1205	Evergreen
126	Sairandhri	13-04-16	11.090222	76.45189	1205	Evergreen
127	Sairandhri	17-04-16	11.090222	76.45189	1205	Evergreen
128	Sairandhri	07-04-16	11.089889	76.45281	1239	Evergreen
129	Sairandhri	08-04-16	11.089889	76.45281	1239	Evergreen
130	Sairandhri	08-04-16	11.089889	76.45281	1239	Evergreen
131	Sairandhri	09-04-16	11.089889	76.45281	1239	Evergreen
132	Sairandhri	09-04-16	11.089889	76.45281	1239	Evergreen
133	Sairandhri	09-04-16	11.089889	76.45281	1239	Evergreen
134	Sairandhri	10-04-16	11.089889	76.45281	1239	Evergreen
135	Sairandhri	11-04-16	11.089889	76.45281	1239	Evergreen
136	Sairandhri	11-04-16	11.089889	76.45281	1239	Evergreen
137	Sairandhri	11-04-16	11.089889	76.45281	1239	Evergreen
138	Sairandhri	12-04-16	11.089889	76.45281	1239	Evergreen
139	Sairandhri	12-04-16	11.089889	76.45281	1239	Evergreen
140	Sairandhri	12-04-16	11.089889	76.45281	1239	Evergreen
141	Sairandhri	13-04-16	11.089889	76.45281	1239	Evergreen
142	Sairandhri	14-04-16	11.089889	76.45281	1239	Evergreen
Leopard Cat						
143	Neelikkal	27-11-15	11.073528	76.41383	1092	Evergreen
144	Neelikkal	11-12-15	11.085667	76.423	990	Evergreen
145	Neelikkal	07-12-15	11.086778	76.42231	980	Evergreen
146	Poochippara	01-03-16	11.112	76.42994	944	Grassland
147	Poochippara	01-03-16	11.112333	76.43097	918	Evergreen

148	Poochippara	02-03-16	11.109639	76.41508	1147	Evergreen
149	Poochippara	29-02-16	11.108028	76.4145	1141	Evergreen
150	Poochippara	02-03-16	11.108028	76.4145	1141	Evergreen
151	Sairandhri	07-04-16	11.101722	76.45497	1011	Evergreen
152	Sairandhri	08-04-16	11.103833	76.44475	929	Evergreen
Asian Small-clawed Otter						
153	Neelikkal	25-11-15	11.071306	76.42531	1006	Evergreen
154	Neelikkal	11-12-15	11.071306	76.42531	1006	Evergreen
155	Sairandhri	09-04-16	11.101722	76.45497	1011	Evergreen
156	Sairandhri	12-04-16	11.101722	76.45497	1011	Evergreen
157	Sairandhri	12-04-16	11.101722	76.45497	1011	Evergreen
Nilgiri Marten						
158	Sairandhri	07-10-15	11.088222	76.44781	1033	Evergreen

Appendix II: Indirect evidence data on small carnivores in Silent Valley National Park from September 2015 to April 2016

Sl. No.	Species	LatitudeN	Longitude E	Altitude (m)	Habitat
1	Civet	11.104730	76.419400	979	Evergreen
2	Civet	11.103190	76.419640	997	Evergreen
3	Civet	11.102610	76.419720	970	Evergreen
4	Civet	11.101660	76.419750	967	Evergreen
5	Civet	11.100840	76.428600	967	Evergreen
6	Civet	11.082420	76.448710	1045	Evergreen
7	Civet	11.084430	76.447730	1066	Evergreen
8	Civet	11.078528	76.419778	988	Evergreen
9	Civet	11.074361	76.413917	1108	Grasslands
10	Civet	11.073528	76.413833	1092	Grasslands
11	Civet	11.072056	76.413889	1113	Evergreen
12	Civet	11.109639	76.415083	1147	Evergreen
13	Civet	11.109639	76.415083	1147	Evergreen
14	Civet	11.108028	76.414500	1141	Evergreen
15	Civet	11.101722	76.454972	1011	Evergreen
16	Civet	11.101278	76.447000	1012	Evergreen
17	Civet	11.088306	76.449111	1057	Evergreen
18	Civet	11.099028	76.456250	1024	Evergreen
19	Civet	11.103111	76.450722	1022	Evergreen
20	Otter	11.096690	76.446000	927	Evergreen
21	Otter	11.112910	76.431720	916	Evergreen
22	Otter	11.112910	76.431720	916	Evergreen
23	Otter	11.098430	76.432870	967	Evergreen
24	Otter	11.098430	76.432870	967	Evergreen
25	Small Cat	11.092306	76.446861	1013	Evergreen
26	Small Cat	11.07353	76.413833	1092	Evergreen