ASSESSING THE STATUS AND DISTRIBUTION OF LARGE MAMMALS IN HIGHWAVY AND ITS ENVIRONS, SOUTHERN WESTERN GHATS

Technical Report

G. Srinivas , S. Babu, Honnavalli N. Kumara , Sanjay Molur

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Assessing the status and distribution of large mammals in Highwavy and its environs, southern Western Ghats

Technical Report
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Srinivas, Babu, Kumara and Molur

The Western Ghats, a chain of mountains running parallel to the West Coast from river Tapti in Gujarat to Kanyakumari the southernmost tip of the India, cover five percent of the country and holds 30% of India's biodiversity (Rodgers and Panwar, 1988). It is one of the biodiversity hotspots of the World (Myers et al. 2000). About one-third of its area is still covered by natural vegetation, including about 20,000 sq. km of rain forests (Collins, 1990). This hill range (1600 km) starting from 8 º20'N has only one major discontinuity, the Palghat Gap. Annual rainfall of the Western Ghats may vary from 2350 to 7450 mm along the north-south gradient and the rainfall is largely from the southwest monsoon (June - August). Unique geographic position and distinct physiographic, edaphic and climatic gradients make the Western Ghats suitable for a wide array of habitats that support unique sets of plant and animal species (Biju, 2001). Several forest operations such as Coffee, Tea and Cardamom have been started during the 19th century resulting in clearing of Semi Evergreen and Evergreen forests (Fischer, 1921).

Baseline data like occurrence, abundance and population dynamics are the key for the conservation and planning of the management for any forests. However, such information is not available for most the Indian forests except few protected areas with charismatic species like tiger, elephant or lion. Same is true with many forested areas including few small protected areas of the Western Ghats. Highwavy environs is one such area include one protected area i.e. Megamalai (Highwavy) Wildlife Sanctuary which lack baseline information where systematic attempt has not been made till date to document the many taxonomic groups including mammals.

The Highwavy Mountains

Theni Forest Division including Highwavy mountain is considered here as Highwavy environs and it is geographically located between 90 30'to 100 30' N and 770 to 780 30' E in the political boundary of Theni District of Tamil Nadu State (Fig 1.1). The area is surrounded by Srivilliputhur Grizzled Squirrel Wildlife Sanctuary in the south, Palni hills in the northeast and Periyar Tiger Reserve in the southwest. The total area of this division is 863.85 sq. km and a small portion (269.11sq.km) of the division has been declared as Megamalai Wildlife Sanctuary and the

remaining large extent of forest areas are still under the reserved forest category. The altitude of the division ranges from 300 to 2016 m. The Theni Forests receive rainfall from both Southwest (June - August) and Northeast (September - November) monsoons, the later contributes more than 60% of the annual total. The region harbors variety of vegetation types; Montane shola and Grassland, Open Rock with Grass, Wet Evergreen, Moist deciduous, Riverine and Dry deciduous forest and Plantations such as Tea, coffee and Cardamom. This mountain range forms an important catchment area for the rivers Vaigai and Suruliar that feed the dry eastern plains of the south Tamil Nadu. However, the upper Vaigai catchment area is facing high level anthropogenic pressure and lack of protection.

The Highwavy mountains are also known as the Megamalai Hills, (In Tamil: *Megha* = cloud, *Malai* = hill). The Highwavy mountains are also known as Patchakumachi, (In Tamil: *Patcha* = green, *Kumachi* = jungle). The name "Highwavy Mountains" was applied by the earlier explorers who just noted the appearance from the Cumbam Valley. The elevated plateau constitutes a spur from the Cardamom Hills oriented southeast-northeast. Megamalai Hill constitutes the western edge of the Varusanad Hills along the deep Cumbam Valley. The present study area (Highwavy environs) has undulating terrain and most of the area is steep.

The present study was planned based on our earlier study in lower taxa (amphibians and reptiles) and a short-term survey on primate in the area. An exploration made at six decades ago by Angus. F. Hutton (1949) also raised several interesting questions on mammals in the region. Further, the region also expected to act as crucial corridor between Anamalai hills and Periyar-Agatiyamalai. Thus, the present study was taken up with the financial support of CEPF-ATREE small grants and Rufford Small Grants, through Wildlife Information Liaison Development (WILD) Society and Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore.

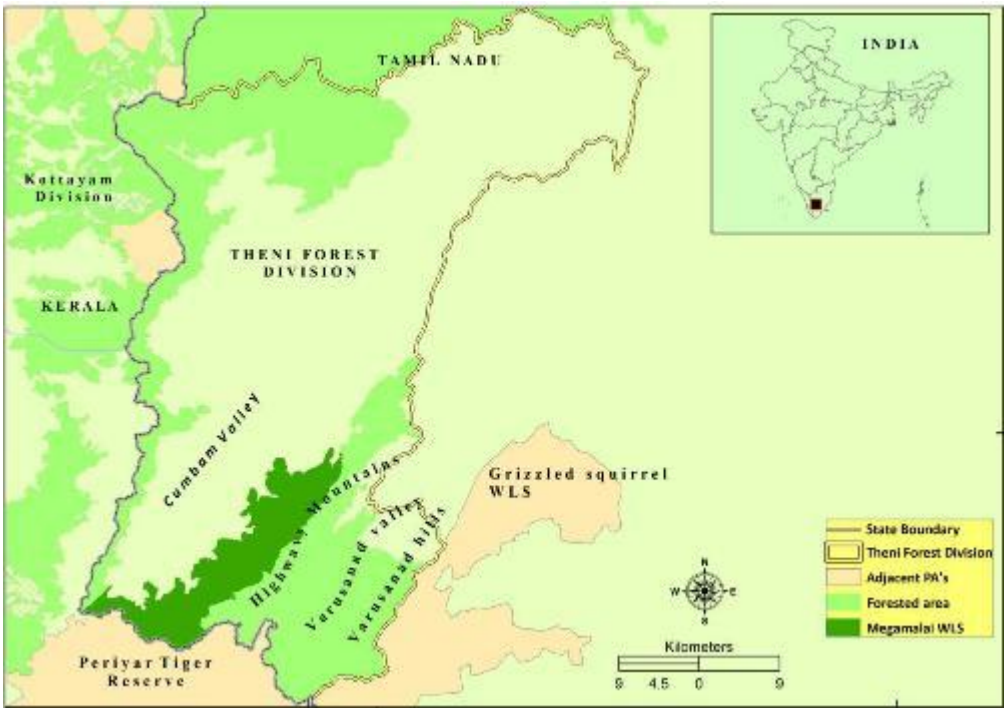

Figure 1.1 Map showing Theni Forest Division and Highwavy environs

Objectives

- To prepare an inventory of large mammals in the Highwavy environs
- To systematically assess the status and distribution of large mammals in the Highwavy environs.
- To identify nature and extend of threats to the conservation of large mammals in the Highwavy environs
- To identify high mammal rich zones in the mountain range through occupancy estimation.
- To identify biological corridor and developing conservation action plan for conservation.
- To transfer the knowledge of large mammals for better management of the Highwavy environs to the managers and stakeholders.

Methods

Based on the above objectives the study was carried out from June 2011 to December 2012. Three methods were adapted to address the proposed objectives. Among them, grid walk method was followed as a major one. Four sq. km grids were overlaid on the base map of the study area to identify the individual sampling units. All the full girds were selected and incomplete grids were rejected. Within each selected grid, search trail with 0.5 km segment as spatial replicates, thus five replicates (2.5 km) per grid were established. The detection history of direct and indirect sightings like scats, pugmarks, pellets, dens, feeding evidences were recorded for each 100 m segment. At every 100 m interval, habitat covariates were recorded in segment thereby five habitat covariate points in each segment and a total of 25 points per grid. Threats including live anthropogenic pressure and weed cover were recorded qualitatively.

Despite the search trails in the selected grids, camera traps were deployed to know the occurrence of the nocturnal and elusive mammals in the grids. And also for nocturnal mammals (arboreal mammals), spotlighting survey/night surveys were carried out in all the accessible grids. Incidental data on all the sightings of mammals were maintained (species name, number of individuals, GPS locations and habitat related parameters). All the sight records of all the species from all the methods were used to prepare the inventory.

The Report

The present study was attempted to document the inventory of large mammals, estimate the relative abundance and occupancy. Grids were considered as a minimum unit to understand the distribution pattern and abundance. Chapter I has addressed the need of present study, frame work for the project. Chapter II consolidated list of mammals in the Highwavy environs was prepared based on primary and secondary data and information about the rare and first records obtained from the present study. Chapter III provides the relative abundance of mammals as encounter rate for large mammals and their abundance in various elevational categories, forest types and disturbance levels. Chapter IV illustrates the area occupied by different species of mammals by means of occupancy estimation in the Highwavy environs and Chapter V highlights the threats, conservation issues and mitigation measures to be considered for the management of Highwavy environs.

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Chapter II

Mammals of Highwavy environs

Introduction

Information such as presence or absence of any species co-relates to the habitat in which it lives. However, baseline information is the basic requisite for any management action. It is basic requisite for any management action. Since there are different taxa which constitute the biodiversity of the area, effective documentation requires a basic knowledge of habits of animals, its habitats and behaviour.

In many of the protected area such information is lacking or dating back to several decades one such area is Highwavy (Megamalai). In spite of being an important wildlife corridor, updated data on mammals of the landscape is lacking. While reviewing the available literature on mammals of the landscape, it was found that mammal survey in the hill range was started in the beginning of 19th century by Prater. He explored and collected mammals from the Cumbam Valley and the northern slopes of Highwavy Mountains, and these specimens were preserved in Bombay Natural History Society (BNHS) Museum collections. Subsequently, Wroughton (1917) wrote the descriptions for collection made by Prater, from which he identified 24 species mainly rodents and bats. After a lapse of three decades, Hutton (1949) collected and described the habit, habitat and distribution of 56 mammal species including few range restricted and threatened species. More than two decades later (1972), when working on the specimens of megachiropterans at BNHS, Thonglongya had noticed that the specimen labelled *Cynopterus sphinx,* collected at the Highwavy Mountains, was wrongly identified. He identified it as a new genus *Latidens* and named the species as *salimalii*, after India's eminent ornithologist Salim Ali. *Latidens salimalii* (Thonglongya 1972) is endemic to south India. Subsequent survey by BNHS and Harrison Zoological Museum rediscovered *L. salimalii* at the Highwavy Tea and Coffee Estates (Kardana Coffee Estate) and suggested that it is located from two areas in southern Western Ghats (Muni 1993, Menon, 2009). In addition, few short surveys were also attempted to address the roost site characteristics of the bat (Singaravelan & Marimuthu 2003 a, b). Kumara et al. (2011) highlighted that the landscape hold one of the largest populations of globally threatened lion-tailed macaque *Macaca silenus* with larger group size. Bhupathy et al. (2012) has highlighted the conservation significance of the landscape using select vertebrates. Although the landscape has been well explored in terms of mammals over

the decades (1917 – 2012) through a series of short-term studies at different time period (1917-2012), the updated list of mammals and their current status (qualitative) in the landscape is meagre. In this context, we update the mammals of the Highwavy based on primary (June 2011 – December 2012) and secondary information.

Methods

We have carried out a study on status and distribution of large mammals in the landscape between June 2011 and December 2012. The entire landscape was gridded on the base map and each grid was sampled for the presence -absence of the mammals by walking on pre-determined paths. During this all the sighted animals were recorded, droppings on trail was recorded with species identity, and also animals presence was recorded based on tracks and signs (We also conducted night surveys using flashing the light or using a motor vehicle with light by driving slowly recording animals found on either side of the forest (sampling effort 85 km) for recording species. Further, we also reviewed the literature to prepare a comprehensive list for mammals for the landscape (e.g. Wroughton 1917; Hutton 1949; Thonglongya 1974; Muni 1993; Singaravelan & Marimuthu 2003 a, b). The status of each mammal species observed by Hutton was compared with the current population status (consolidated from the study) to understand the influence of six decades of disturbance on distribution of large mammals (41 Species). IUCN status, endemism and schedule category in Indian Wildlife Protection Act (1972) were compiled to highlight the conservation significance of the landscape in terms of mammals.

Results

A total of 133 grids (4 sq.km size) were sampled for tracks and signs of mammals, and 85 km road that intersect forests were surveyed for nocturnal mammals. Sixty three species of mammals belongs to 24 families were recorded from the landscape (Table 1). The family muridae (rats and mouse) was recorded with maximum number of species (Fig. 2.1) followed by sciuridae (squirrels) and felidae (cats). Among the 63 species, 24 are globally threatened (including one Critically Endangered; seven Endangered; 11 Vulnerable and five Near-Threatened species), 10 are endemic to Western Ghats and three to India (Fig. 2.2). Number of species recorded as common (C) and very common (VC) were lower than the Hutton's observation however uncommon (UC) and rare (RR) were higher than the earlier observation (Fig. 2.3). Five species *viz.*, rusty-spotted cat, Malabar

spiny tree mouse, Indian grey mongoose, grizzled giant squirrel and common palm civet were added newly to the existing list of mammals in Highwavy. Further, three species of bats *viz.*, Sálim Ali fruit bat *Latidens salimalii*, lesser dog-faced fruit bat *Cynopterus brachyotis* and rufous horseshoe bat *Rhinolophus rouxii* were not recorded by Hutton but recorded by Singaravelan & Marimuthu (2003 a, b). Some of the sight records of earlier notes arises doubts of its accuracy, in particular the sightings of Malabar civet and fishing cat. Detailed species information, for each new site record, obtained from the present study is presented here.

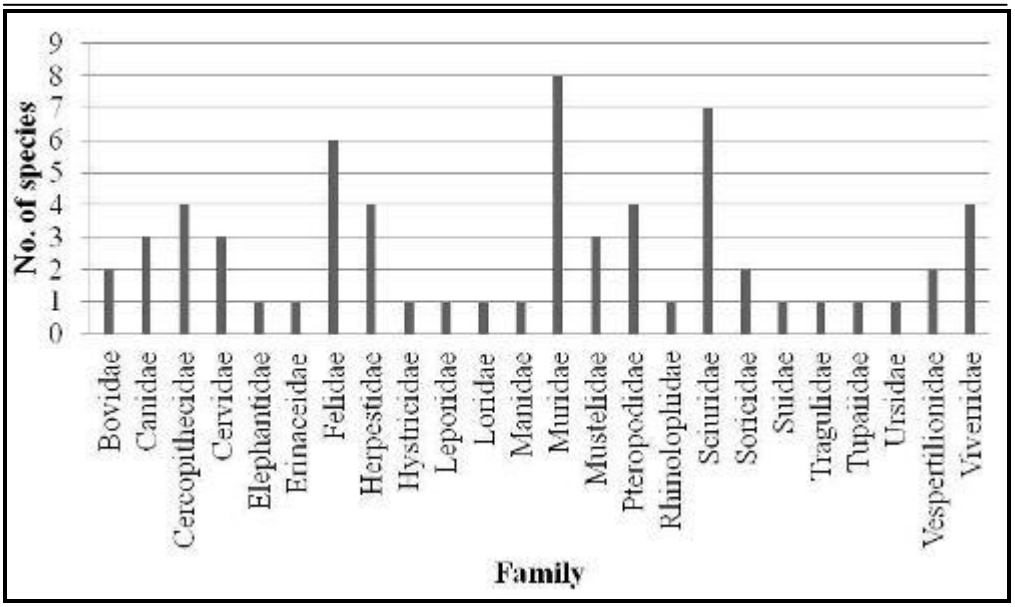

Figure 2.1 Family wise species richness of mammals in Highwavy environs

Rusty-spotted cat *Prionailurus rubiginosus*

Four observations of rusty-spotted cats were obtained during the present study. This included two direct sightings (June 2012; Vannathiparai of Gudalur Range) and two indirect sightings (July 2012, a dead one was found at Manjanoothu of Varusanad Valley and a road kill near Rajapalayam town). The species presumably prefers low elevation, leeward side and next to human settlements in the Highwavy.

Malabar spiny tree mouse *Platacanthomys lasiurus*

Single individual was located at No. 29 coffee Estate, which is located in the south-eastern slopes of Highwavy Mountains, at 20:00 hours on 21st December 2011 during the night surveys in coffee Estate areas. It was observed on a shrub at 1.5 m height from the ground.

Grizzled giant squirrel *Ratufa macroura*

In five different occasions, seven individuals were observed along the tributaries and main river of Vaigai (Image 3). The western most location of the species in the Varusanad Valley is Arasaradi, where the rain-shadow starts. The distribution of the species was confirmed down towards the Gandhigramam and in other parts of Varusanad Valley in particular hill ranges that extend towards the eastern side requires intensive survey. Although highly scattered in distribution, around 20 nests of the species was located over the riparian forests in low elevations (>400 m).

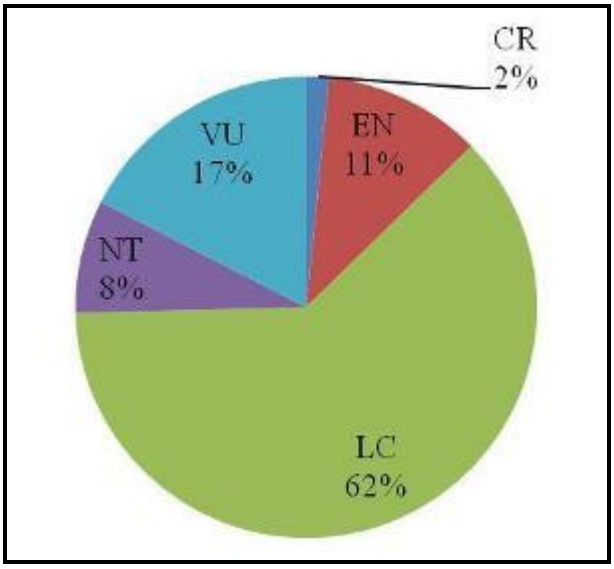

Figure 2.2 Threat status of mammals recorded in Highwavy environs

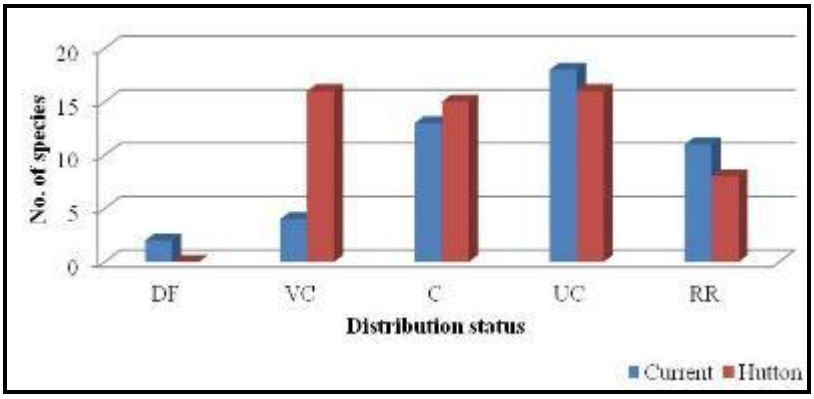

Figure 2.3. Comparing the abundance status of mammals in two different time periods in Highwavy environs

Indian grey mongoose *Herpestes edwardsii*

It was frequently seen in the dry zones of Varusanad Valley and the eastern portions of Highwavy. Mostly single individual was seen but occasionally they were observed in pairs.

Common palm civet *Paradoxurus hermaphroditus*

Although it is commonly seen along the foothills next to coconut plantations, Hutton (1949) had not reported the species during his survey. During the night survey in January 2012 at Highwavy Tea Estate, single individual was sighted. However, later it was found that the species was frequently been sighted in plains than in mountains, further the species has been considered as pest in the coconut plantation in the downhill.

Arboreal mammals

We recorded eight arboreal mammals including five primates, two giant squirrels and one flying squirrel. The distribution of lion-tailed macaque (*Macaca silenus*) and Nilgiri langur (*Trachypithecus johnii*) was restricted to the high rainfall areas on western side *viz.,* Vellimalai, No. 29 Estate, Karana Estate, Ammakajam and Jyothi Estates, whereas bonnet Macaque (*Macaca radiata*) was recorded from all the elevation gradients while tufted grey langur (*Semnopithecus priam*) was recorded only from the drier forests, mostly at the down hills. Grey slender loris (*Loris lydekkerianus*) was sighted frequently in the low elevation dry forests. Among giant squirrels, Indian giant squirrel (*Ratufa indica*) was found in all the elevational categories and forest types, whereas small population of Grizzled giant squirrel (seven individuals observed) was observed along the Vaigai River and its tributaries. Indian giant flying squirrel (*Petaurista philippensis*) was recorded during the night surveys in thick canopied forests areas such as Vellimalai and Highwavy Estates.

Table 2.1 List of mammals observed in Highwavy environs, southern Western Ghats, India

Sl.No	Common Name	Scientific Name	Endemic	IUCN Status	Source	Highwavy Status
	Cercopithecidae					
1	Nilgiri Langur	*Trachypithecus johnii*	WG	VU	1,2	UC
2	Tufted Grey Langur	*Semnopithecus priam*	IN	NT	1,2	UC
3	Lion-tailed Macaque	*Macaca silenus*	WG	EN	1,2	RR
4	Bonnet Macaque	*Macaca radiata*	IN	LC	1,2	C
	Loridae					
5	Grey Slender Loris	*Loris lydekkerianus*	LC	1,2	UC	
	Felidae					
6	Tiger	*Panthera tigris*	EN	1,2	RR	
7	Leopard	*Panthera pardus*	NT	1,2	UC	
8	Jungle Cat	*Felis chaus*	LC	1,2	UC	

9	Leopard Cat	*Prionailurus bengalensis*	LC	1,2	RR	
10	Fishing Cat	*Prionailurus viverrinus*	EN	2	?	
11	Rusty-spotted cat	*Prionailurus rubiginosus*	VU	1	RR	
	Canidae					
12	Dhole	*Cuon alpinus*	EN	1,2	UC	
13	Golden Jackal	*Canis aureus*	LC	2	RR	
14	Indian Fox	*Vulpes bengalensis*	LC	1,2	C	
	Viverridae					
15	Small Indian Civet	*Viverricula indica*	LC	1,2	UC	
16	Malabar Civet	*Viverra civettina*	WG	CR	2	?
17	Common Palm Civet	*Paradoxurus hermaphroditus*	LC	1	UC	
18	Brown Palm Civet	*Paradoxurus jerdoni*	WG	LC	1,2	UC
	Herpestidae					
19	Indian Grey Mongoose	*Herpestes edwardsii*	LC	1	UC	
20	Ruddy Mongoose	*Herpestes smithii*	LC	1,2	UC	
21	Indian Brown Mongoose	*Herpestes fuscus*	VU	1,2	UC	
22	Stripe-necked Mongoose	*Herpestes vitticollis*	LC	1,2	C	
	Mustelidae					
23	Smooth-coated Otter	*Lutrogale perspicillata*	VU	1,2	UC	
24	Asian Small-clawed Otter	*Aonyx cinerea*	VU	1,2	UC	
25	Nilgiri Marten	*Martes gwatkinsi*	WG	VU	1,2	RR
	Sciuridae					
26	Indian Giant Squirrel	*Ratufa indica*	IN	LC	1,2	UC
27	Grizzled Giant Squirrel	*Ratufa macroura*	NT	1	RR	
28	Common Palm Squirrel	*Funambulus palmaram*	LC	1,2	VC	
29	Western Ghats Striped Squirrel	*Funambulus tristriatus*	WG	LC	1,2	C
30	Dusky-Striped Squirrel	*Funambulus sublineatus*	VU	1,2	C	
31	Indian Giant Flying Squirrel	*Petaurista philippensis*	LC	1,2	UC	
32	Travancore Flying Squirrel	*Petinomys fuscocapillus*	NT	1,2	NE	
	Cervidae					
33	Sambar	*Rusa unicolor*	VU	1,2	C	
34	Southern Red Muntjac	*Muntiacus muntjak*	LC	1,2	C	
35	Chital	*Axis axis*	LC	1,2	C	
	Tragulidae					
36	Indian Chevrotain	*Moschiola indica*	LC	1,2	C	
	Bovidae					
37	Nilgiri Tahr	*Nilgiritragus hylocrius*	WG	EN	1,2	R
38	Gaur	*Bos gaurus*	VU	1,2	UC	
	Suidae					
39	Wild Boar	*Sus scrofa*	LC	1,2	C	

	Elephantidae					
40	Asian Elephant	*Elephas maximus*	EN	1,2		
	Soricidae					
41	House Shrew	*Suncus murinus*	LC	2	NE	
42	White-toothed Pygmy Shrew	*Suncus etruscus*	LC	2	N	
	Erinaceidae					
43	Madras Hedgehog	*Paraechinus nudiventris*	WG	LC	1,2	C
	Hystricidae					
44	Indian Crested Porcupine	*Hystrix indica*	LC	1,2	VC	
	Manidae					
45	Thick-tailed Pangolin	*Manis crassicaudata*	NT	1,2	RR	
	Ursidae					
46	Sloth Bear	*Melursus ursinus*	VU	1,2	UC	
	Leporidae					
47	Indian Hare	*Lepus nigricollis*	LC	1,2	VC	
	Muridae					
48	Greater Bandicoot Rat	*Bandicota indica*	LC	1,2	VC	
49	House Rat	*Rattus rattus*	LC	2	NE	
50	White-tailed Wood Rat	*Madromys blanfordi*	LC	2	N	
51	Indian Bush Rat	*Golunda ellioti*	LC	2	N	
52	Asiatic Long-tailed Climbing Mouse	*Vandeleuria oleracea*	LC	2	NE	
53	House Mouse	*Mus musculus*	LC	2	N	
54	Little Indian Field Mouse	*Mus booduga*	LC	2	NE	
55	Malabar Spiny Tree Mouse	*Platacanthomys lasiurus*	WG	VU	1	RR
	Tupaiidae					
56	Madras Treeshrew	*Ananthana elliotti*	LC	2	NE	
	Pteropodidae					
57	Indian Flying Fox	*Pteropus giganteus*	LC	1,2,4	C	
58	Lesser Dog-faced Fruit Bat	*Cynopterus brachyotis*	LC	3,4	NE	
59	Greater Shortnosed Fruit Bat	*Cynopterus sphinx*	LC	2	NE	
60	Sálim Ali Fruit Bat	*Latidens salimalii*	WG	EN	1,3,4,5	RR
	Rhinolophidae					
61	Rufous Horse shoe Bat	*Rhinolophus rouxii*	LC	5	NE	
	Vespertilionidae					
62	Painted Woolly Bat	*Kerivoula picta*	LC	2,4	NE	
63	Lesser Asiatic Yellow House Bat	*Scotophilus kuhlii*	LC	2,4	NE	

Endemics: WG= Endemic to Western Ghats; IN=Endemic to India
IUCN Status: CR=Critically Endangered; EN=Endangered; VU=Vulnerable; NT=Near-Threatened; LC=Least Concern
Sources: 1=Present study (2012); 2=Hutton (1949); 3=Muni (1994); 4&5=Singaravelan & Marimuthu (2003 a, b)
Highwavy Status: VC=Very Common; C=Common; UC=Uncommon; RR=Rare; NE=Not Evaluated; ?=Unconfirmed record

Gaur

Sambar

Lion-tailed macaque

Nilgiri langur

Grizzled giant squirrel

Indian giant squirrel

Plate 2.1 Some of the large mammals of Highwavy Mountains

Indian hare

Small Indian civet

Malabar tree dormouse

Slender loris

Plate 2.2 Some of the nocturnal mammals of Highwavy environs

Plate 2.3 A dead specimen of rusty spotted cat

Large herbivores

About12 herds of Asian Elephant (*Elephas maximus*) were located during the survey, and the maximum herd size recorded was 10. Sightings of Asian Elephants were in Megamalai, Highwavy, Manalar Estates, Manjanoothu, Vellimalai, Vannathiparai and Arasaradi. Gaur (*Bos gaurus*) was recorded across the hill range but direct sightings were in the Varusanad Valley *i.e.* eastern slopes of Vellimalai. Among the ungulates, sambar (*Rusa unicolor*) was observed widely across the landscape and indirect evidences were recorded in many grids. Chital (*Axis axis*) was recorded mostly in the dry eastern plains of Varusanad Valley and northern slopes of Highwavy. Southern Red Muntjac (*Muntiacus muntjak*) was recorded across the elevational gradients. Indian Chevrotain (*Moschiola indica*) was recorded to be highly selective in habitat utilization and during our survey most of the sightings were from the riparian forests and in tea plantation. Nilgiri Tahr (*Nilgiritragus hylocrius*) was recorded in Varayattu Parai and south-eastern slopes of Highwavy Mountains.

Carnivores

Although the landscape shares the western side with Periyar Tiger Reserve, direct and indirect evidences of Tigers (*Panthera tigris*) were mostly restricted to western plateau of the landscape. Indirect evidences were recorded in Maavadi, upper Manalar, Vellimalai and along the forest road between upper Manalar and Vellmalai. Indirect evidences of leopard (*Panthera pardus*) and dholes (*Cuon alpines*) were frequently observed across the sampling grids and presumably uncommon species in the landscape. Among other carnivore species, jungle Cat (*Felis chaus*), leopard Cat (*Prionailurus bengalensis*), rusty-spotted cat, small Indian civet (*Viverricula indica*), brown palm civet (*Paradoxurus jerdoni*), and common palm civet (*Paradoxurus hermaphrodites*) were seldom seen during the night surveys. Indian grey (*Herpestes edwardsii*) and striped-necked mongooses (*Herpestes vitticollis*) were uncommon during the study but ruddy (*Herpestes smithii*) and Indian brown mongoose (*Herpestes fuscus*) were observed occasionally. Single individual of Nilgiri marten (*Martes gwatkinsi*) was sighted near the evergreen forests of Upper Manalar.

Discussion

Sixty three species of mammals were reported hitherto from the landscape however it is presumed that it is short of few more species of mammals in particular rats, mouse and bats. The high species richness of mammals in the landscape can be attributed to wide elevation gradients (200 -2000 m), varied rainfall pattern (rainfed and rainshadow) and highly mosaic vegetation. These characteristics of landscape endowed with diverse eco-climatic zones and niches that act as refugee for diverse species of mammals. Further, the landscape is shares corridor with important wildlife areas such as Periyar Tiger Reserve and Srivilliputtur Grizzled Squirrel Wildlife Sanctuary in the western and southern side of the landscape, so it facilitates the mammals to utilize this area.

The scope of present study (2012) is restricted to large mammals hence bats and small rodents (rats, shrews and mouse), as it involves capturing for species identification, were not considered for comparison with Hutton (1949) anecdotal notes. Six decades old data showed the distribution of 57 species of mammals including 41 species of large mammals, of which persistence of 38 large mammals in the landscape was observed and three were not recorded during the study *viz.,* malabar civet, fishing cat and golden jackal. Species level status of Malabar civet in India remains unresolved but land-use practices in low elevation of Varusanad Valley (Cashew plantations) matches with the Elayur (Calicut District, Kerala) from where a dead specimen of the species was collected during 1990's (Ashraf et al. 1993). Moreover, Hutton (1949) categorised the species as common in high elevations but we were told by locals that there was no large sized civet in the landscape. This raises the question on the report of Hutton (1949). Furthermore, recent surveys targeting malabar civet had failed to locate them in previously known distribution localities (Nandini & Mudappa 2010). Distribution of fishing cat in south India is another doubtful record; however, the species is also reported from Periyar Tiger Reserve, the south-western boundary of the landscape. In addition, Menon (2009) also sketched southern Western Ghats as distribution limit of the species. More intensive sampling employing camera traps may address this unconfirmed distribution record. Although we have not seen the golden jackal during our survey, locals and forest department staffs have reported that they seldom see the Jackal in the plains next to foot hills.

Species richness of mammals in the Highwavy mountains is comparable with other Protected Areas/reserved forests in the eastern slopes of southern Western Ghats with a similar landscape features *viz.,* Kalakkad-Mundanthurai Tiger Reserve, Srivilliputtur Grizzled Squirrel Sanctuary, Palni Hills and Anamalai Tiger Reserve. The distribution of mammals in Highwavy is also comparable with few key sites in southern Western Ghats such as Periyar Tiger Reserve and Parambikulam Tiger Reserve.

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Introduction

Large herbivores are however, comparatively difficult to conserve owing to their large home range needs, they are highly susceptible to loss of habitat and hunting pressure due to their body size (Madhusudan & Karanth, 2002). Though the forests of Western Ghats has been recognised as one of global biodiversity hotspots (Myers et al. 2000), it also has high human density (Cincotta et al. 2000). People living in the Ghats have been depending on natural resources obtained from the forests including animal's meat (Chandran et al. 1997). However, shrinking of forest cover and increasing human population in forested landscapes have negatively affected the sustainable harvest of many natural resources. Due to drastic decline in the forest cover and increase in the human population negatively affected the sustainable harvest of many resources from the forest. As a result of extensive use of natural resources, the population size of many species in the Western Ghats declined drastically (Chandran et al. 1997). This also has lead drastic reduction in population size of many animals in the Western Ghats (Kumara & Singh, 2004, Madhusudan & Karanth, 2002), however, where ever the large and contiguous forest patches are left and protected are only harbouring the remaining populations of many taxonomic groups. Unfortunately, from many of the forest patches at outside protected areas do not have even the baseline data like presence and abundance of inhabitants. Thus, such data on all the species is very important to manage the forests and formulate future management strategies (Kumara et al. 2011).

Nilgiri Biosphere Reserve in Northern part of Western Ghats include major protected areas, *viz*. Mudumalai Tiger Reserve, Bandipur Tiger Reserve, Nagarahole Tiger Reserve Biligiri Rangaswamy Temple Tiger Reserve, Sathyamangalam Tiger Reserve and Wayanad Wildlife Sanctuary the entire stretch of forest complex holds relatively high density of large mammals (Kumara et al. 2012). However, though the southern part of Western Ghats includes (Anamalai Tiger Reserve, Srivilliputhur Grizzled Giant Squirrel Sanctuary, Kalakkad-Mundanthurai Tiger Reserve, Kanyakumari Wildlife Sanctuary) having various forests types from dry scrub forests at eastern foot hills of the Western Ghats to montane shola at high altitude, but hold less density, however, the diversity of mammals is more than north of Nilgiri Biosphere. Highwavy environs are also a part of this chain of hills without any recent documentation at least for the last three/four decades. Various commercial plantations like coffee, tea, cardamom plantations, and also monoculture plantations like teak breaking the pristine habitats of Highwavy. Thus, the study was

carried out to document the status of large mammals in these hill systems, which are discussed in the present chapter.

Methods

We used the animal sightings from grid walks (see chapter I for more details) to compute the encounter rate for all the species. The grids were classified based on forest types, elevation gradients and disturbance level. Based on the major vegetation type in the grid, the grids were categorised for evergreen forests, savanna forests, dry deciduous forests and scrub forests. Similarly, grids falling to a range of 200 m asl to 500 m asl as low elevation, 500 m asl to 1000 m asl as mid elevation and ≥ 1000 m asl as high elevation. We broadly classified the disturbance level as high, medium, low and no disturbed areas, by scoring the different disturbance factors like human movement, grazing, firewood collection, lopping, timber extraction, grass collection and hunting evidences. The scoring was done for each grid, and grouped them as low, medium and high. Kruskal-Wallis test was used to test the difference between the encounter rate of animals.

The species which are strictly nocturnal were could not be assessed for their abundance during the grid walk. So spotlight survey was carried out using metal road in the study site. During this exercise a jeep was driven at low speed of about 10-20 km/hr to minimise the disturbance to animals as well as for keen observation. At least three persons were involved in this study during each drive, and the survey was carried out between 19:00 to 24:00 hrs. Survey was carried out in Minnilayam to Lower camp, Minnilayam to 12th Value House, Thenpazhani to Kardana, Kardana to Upper Manalar, Manjanoothu to Vellimalai.

Results

A total of 285.6 km grid walk was made in 133 grids in Highwavy. Among the sampled grids, at least one animal was encountered in 75 grids (56.39%) where in other grids (58 (43.61%) grids did not encounter any animals. The species encountered in each grid varied between 1 and 5. Highest of five species were recorded in two of grids, three species in 14 grids, two species in 18 grids and single species in 41 grids.

A total of 20 mammal species with 599 individuals were encountered during the grid walk. Among the mammals Nilgiri langur was the most encountered species 162 (27%), followed by bonnet macaque 161 (26.9%), tufted grey langur 67 (11.2%), Indian giant squirrel 49 (8.18%), sambar 27

(4.51%), lion-tailed macaque 23 (3.84%), black-napped hare and gaur equally had 22 (3.67%), wild pig 13 (2.17%), elephant 11 (1.84%) and rest of the mammals encountered were <10 individuals (Table 3.1).

Relative abundance of mammals in Highwavy

The relative abundance (mean animals per kilometre) of large mammals excluding primates *viz*. Indian giant squirrel was 0.21±0.81, sambar was 0.13±0.60, gaur was 0.07±0.38, wild pig was 0.04±0.25, elephant was 0.04±0.31, chital was 0.03±0.19 and Southern red muntjac was 0.03±0.20 differed significantly ($\chi 2$=26.504, df=7, P<0.001) (Fig. 3.1). Among primate species the relative abundance of bonnet macaque was 0.61±2.13, Nilgiri langur was 0.56±3.06, tufted grey langur was 0.21±1.13 and lion-tailed macaque was 0.08±0.54 (Fig. 3.2). The relative abundance of primates did not differ significantly ($\chi 2$=11.935, df=3, NS). However, the encounter rate of primate groups viz. Nilgiri langur (0.23±1.0), lion-tailed macaque (0.02±0.14), bonnet macaque (0.14±0.39) and tufted grey langur (0.05±0.22) was significantly differed ($\chi 2$=12.068, df=3, P<0.05) (Fig.3.3).

Table 3.1 Mammals encountered during Grid walk in Highwavy environs

Sl.no	Species	Number of Individuals	Percentage
1	Nilgiri langur	162	27.05
2	Bonnet macaque	161	26.88
3	Tufted Grey langur	67	11
4	Indian giant squirrel	49	8.18
5	Sambar	27	4.51
6	Lion-tailed macaque	23	3.84
7	Indian hare	22	3.67
8	Gaur	22	3.67
9	Wild boar	13	2.17
10	Asian elephant	11	1.84
11	Southern red muntjac	10	
12	Chital	8	1.34
13	Dhole	5	0.83
14	Grizzled giant squirrel	4	0.67
15	Indian grey mongoose	4	0.67
16	Sloth bear	3	0.50
17	Indian chevrotain	3	0.5
18	Jungle cat	2	0.33
19	Ruddy mongoose	2	0.33
20	Asian small-clawed Otter	1	0.17
	Total	599	100.00

Elevational distribution of mammals in Highwavy

Among the large mammals, grizzled giant squirrel was found only in low elevation and the encounter rate was 0.03±0.13. Others were found in at least two to three elevations. Though, the elephant was encountered in all the elevation gradients but the encounter rate was relatively high at mid elevation (0.12±0.52). Chital, southern red muntjac and Indian wild boar were found in mid elevation and low elevation. But, all of them had a higher encounter rate in mid elevation *viz*., chital (0.09 ± 0.06), Indian wild boar (0.09±0.36) and southern red muntjac (0.07±0.31). Sambar, Indian giant squirrel and gaur were found in all the elevations, yet, encounter rate of gaur (0.16±0.62) and wild boar (0.09±0.36) were higher in mid elevation, where the encounter rate of sambar was higher in low elevation (0.22±0.79). Though many species show variation in encounter rate Indian giant squirrel is the only species showed significant difference between elevation gradients ($\chi 2$=.15.145 df=2, p<0.001) (Fig.3.4).

To understand the encounter rate in various forest types, vegetation of the study site was broadly categorized as evergreen, savanna, dry deciduous and scrub forests. The major forests types among these four were considered as the forest types for that grid, and the encounter rate of animals were pooled accordingly and compared. Indian giant squirrel was the only species recorded in all the forest

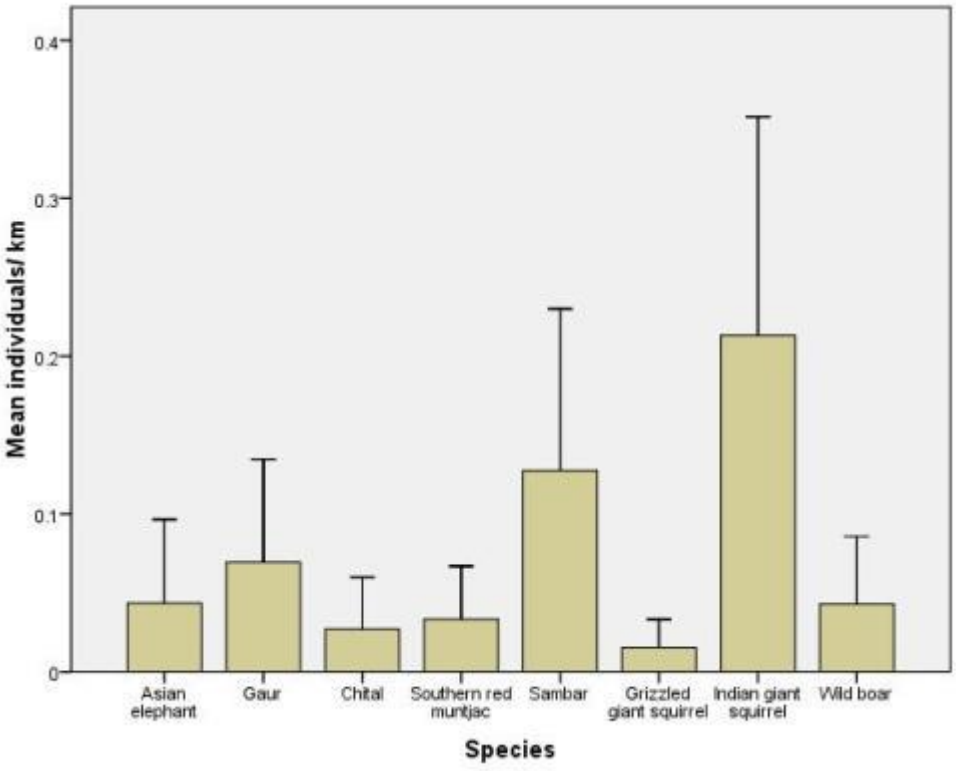


Figure 3.1 Mean encounter rate of mammals in Highwavy environs

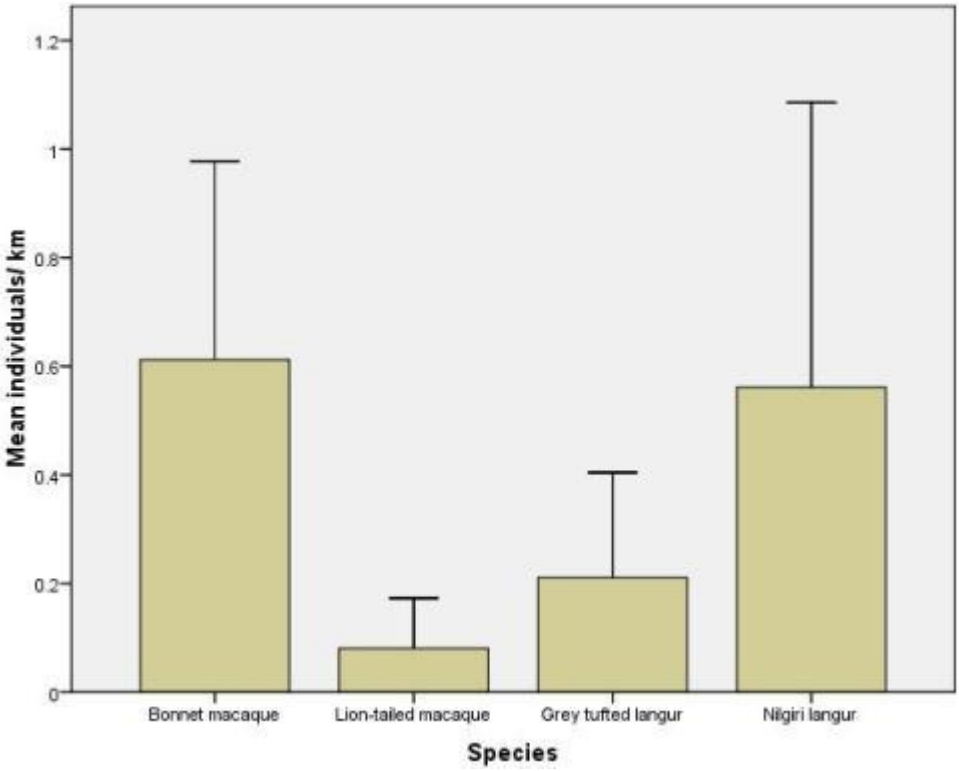


Figure 3.2 Mean encounter rate of primates in Highwavy environs

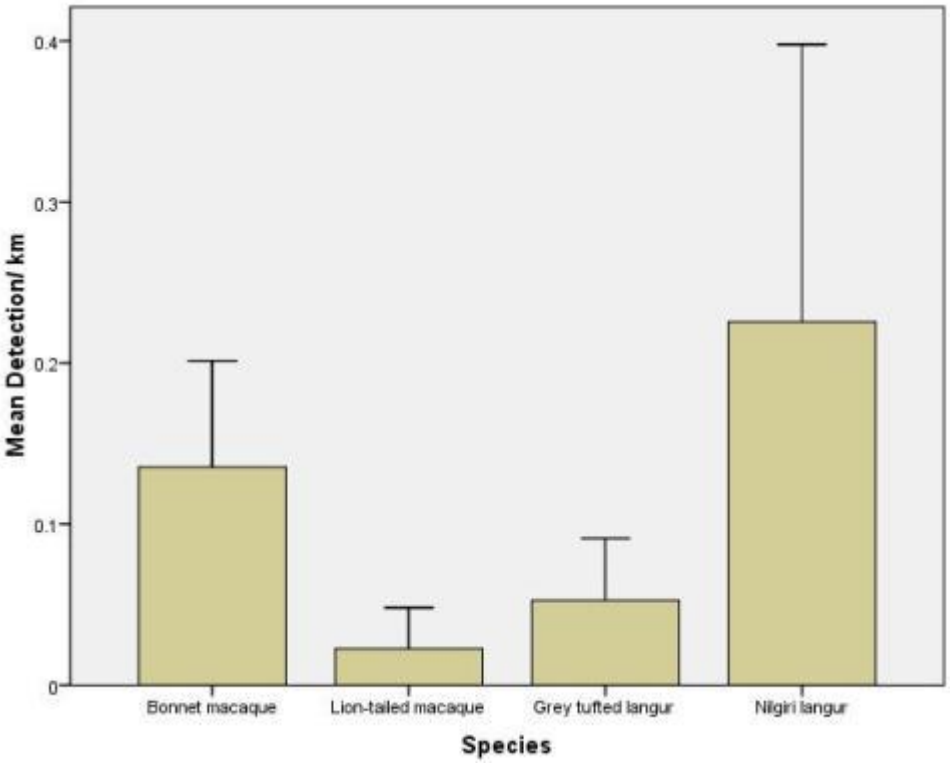


Figure 3.3 Mean detection rate of primates in Highwavy environs

types, where all other species were restricted to few forest types. Chital and grizzled giant squirrel were restricted to dry deciduous and scrub forests and their mean encounter rate was higher (0.09±0.42 and 0.03±0.12) in the scrub forests respectively. Southern red muntjac was found in savanna and dry deciduous and Indian wild boar were found in evergreen and dry deciduous two forest types however, southern red muntjac was encountered high in dry deciduous forests (0.06±0.27) and Indian wild boar was in evergreen forests (0.07±0.29). Elephant, gaur and sambar were encountered in three forest types, however, the mean encounter rate of elephant was more in savanna forests (0.22±0.75), where the gaur was in evergreen forests (0.24±0.78) and sambar was in dry deciduous forests (0.20±0.81). Notably, encounter rate of Indian giant squirrel was increased from scrub (0.12±0.44) to evergreen forests (0.51±1.1) and it was significantly different across forest types ($\chi 2=16.207$ df=3, $P<0.001$). However, the encounter rate of other mammals did not differ across the forest types (Fig. 3.5).

It was expected that the disturbance is another factor which influence the relative abundance of animals. We broadly classified the disturbance level as high, medium, low and no disturbed areas, by scoring the different disturbance factors like human movement, grazing, firewood collection, lopping, timber extraction, grass collection and hunting evidences. The scoring was done for each grid, and grouped them as low, medium and high. The encounter rate of all the animals in the grid was pooled according to the disturbance level and compared. The elephants were encountered only in low disturbed grids (0.09±0.44). Though the chital and grizzled giant squirrel were recorded from the grids with low to high disturbance level, the encounter rate of chital was high (0.04±0.26) in low disturbance areas where, the grizzled giant squirrel was encountered more in high (0.04±0.17) disturbance areas. Though, the gaur was encountered in a medium to undisturbed areas, the encounter rate was high in undisturbed area (0.22±0.73). High encounter rate of Indian wild boar was recorded in medium disturbed area (0.15±0.5) than undisturbed and low disturbed area. The encounter rate of sambar and southern red muntjac did not differed across areas with different disturbance level. However, the higher encounter rate of southern red muntjac was in undisturbed area (0.08±0.37) and sambar was in medium disturbed area (0.36±0.88) (Fig 3.6).

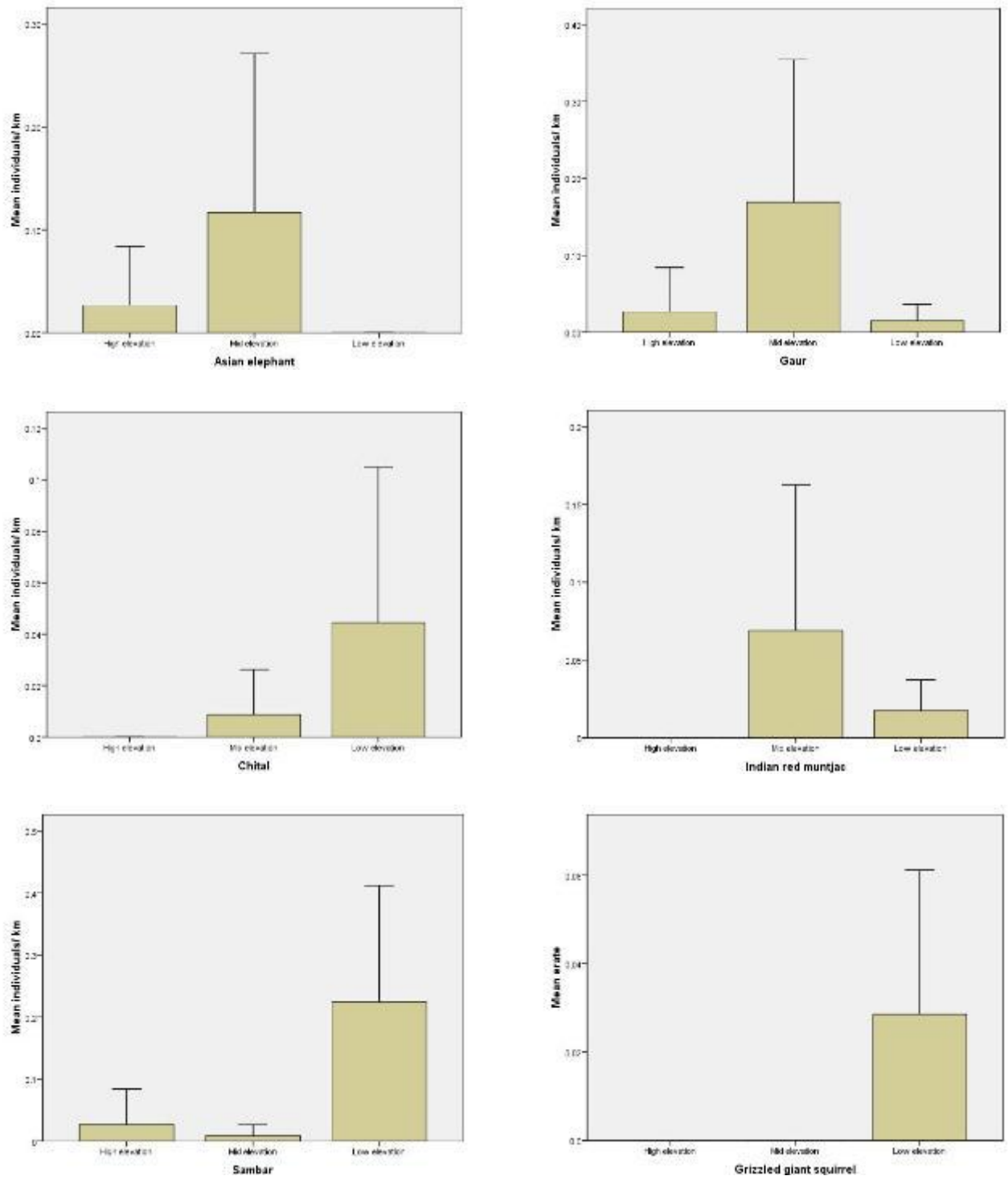


Figure 3.4 Mean encounter rate of mammals in various elevations

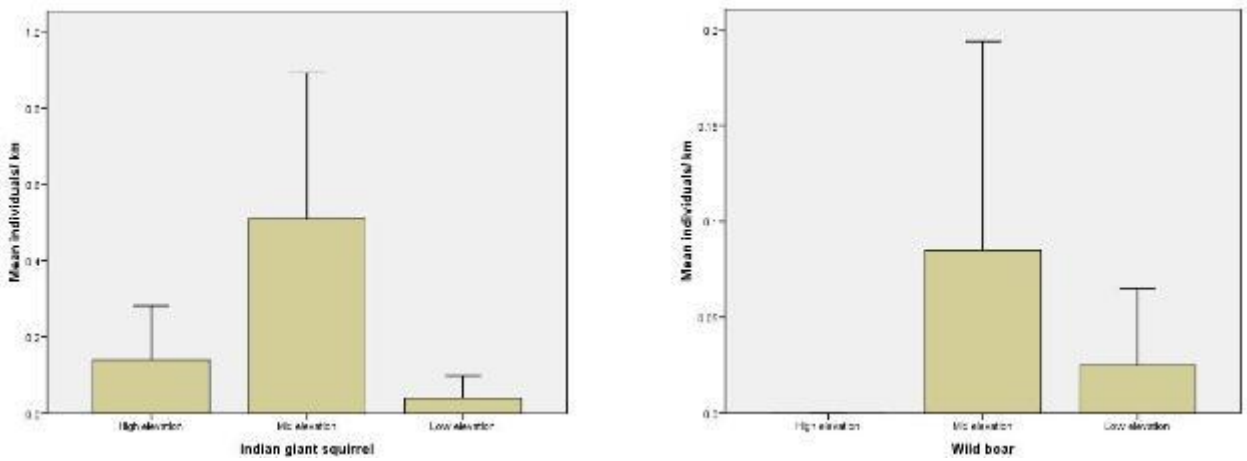
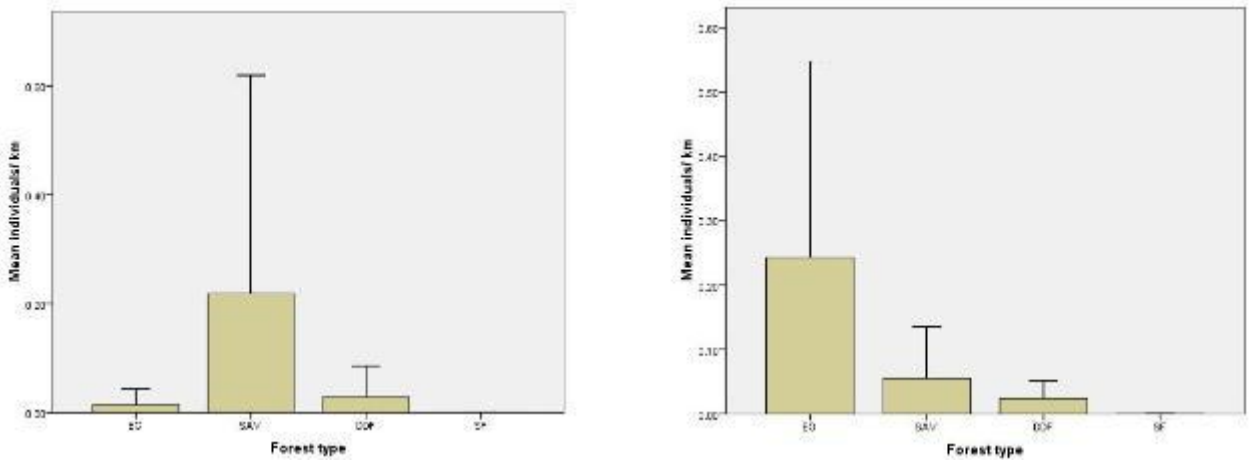
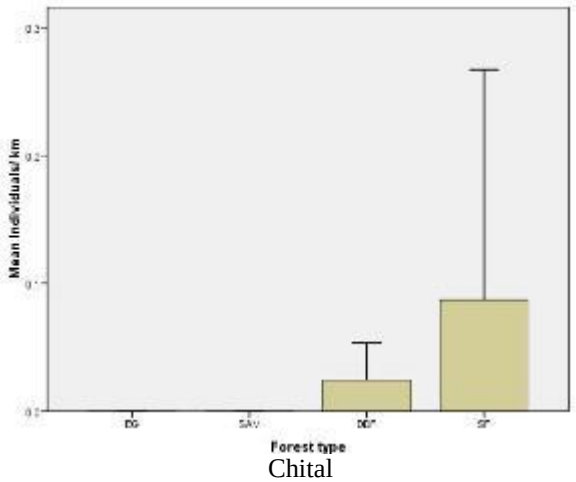


Figure 3.4 Mean encounter rate of mammals in various elevations

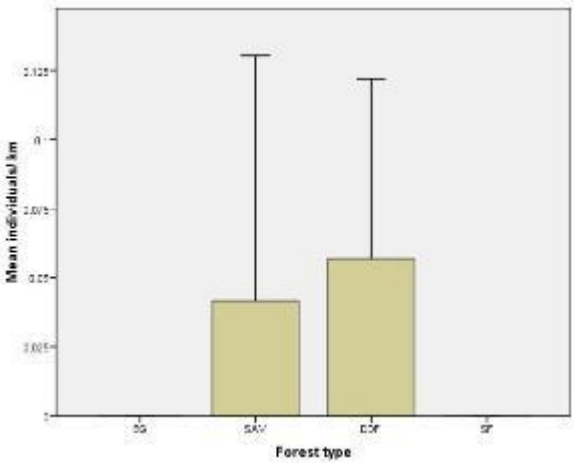


Asian elephant

Gaur

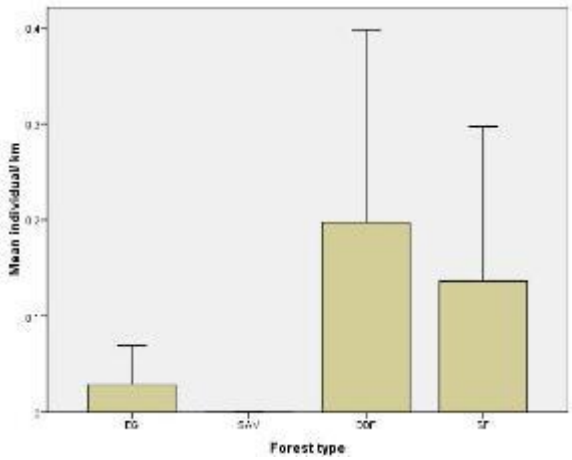


Chital

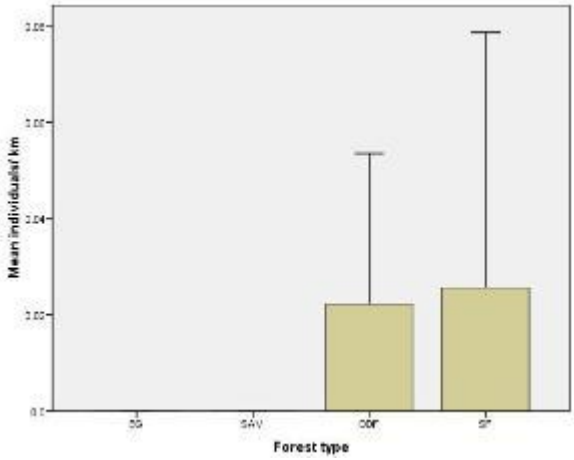


Southern red muntjac

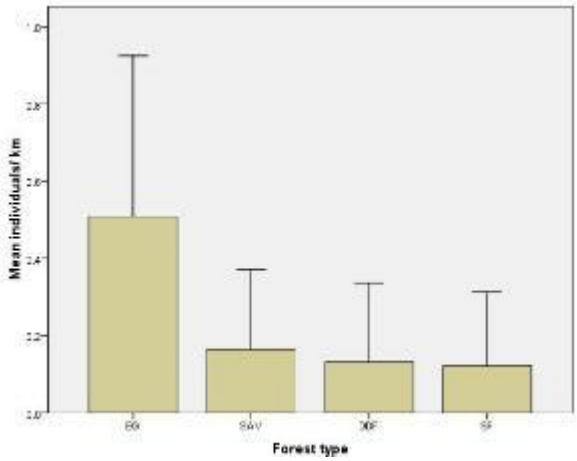
Figure 3.5 Distribution of mammals in Highwavy- forest type



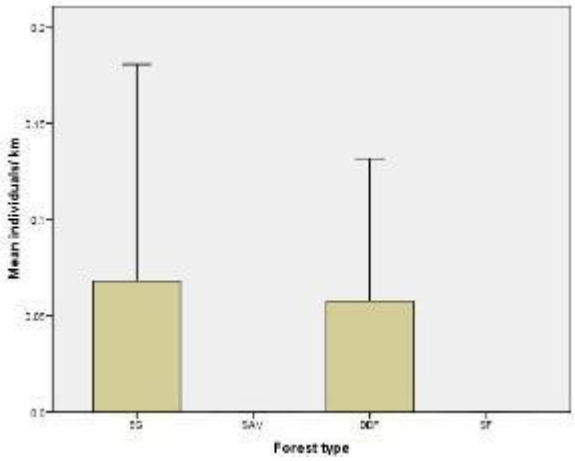
Sambar



Grizzled giant squirrel

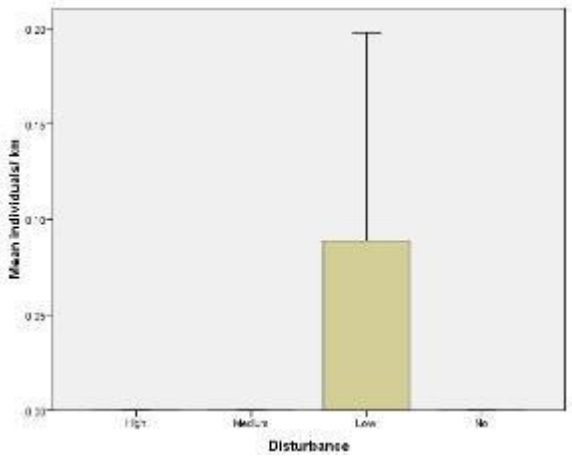


Indian giant squirrel

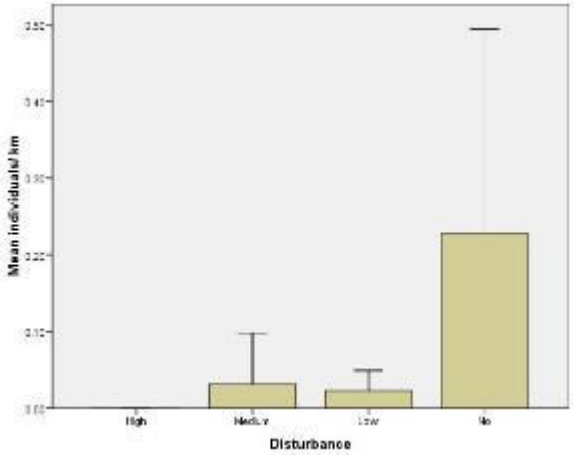


Wild boar

Figure 3.5 Distribution of mammals in Highwavy- forest type

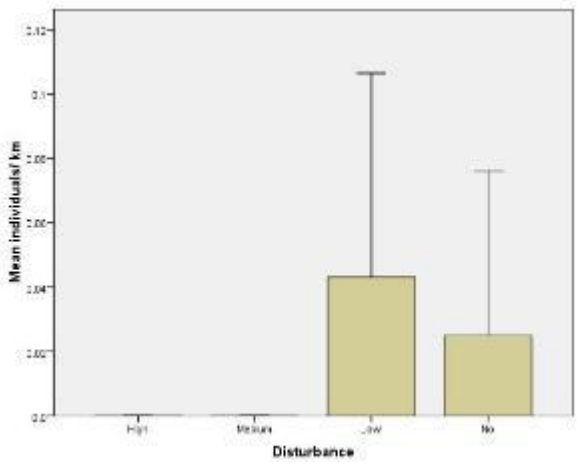


Asian elephant

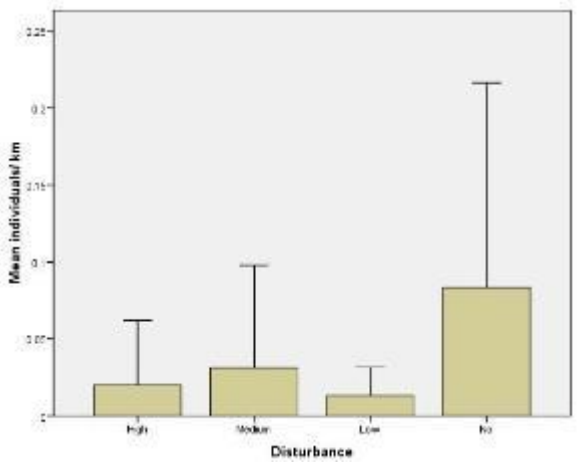


Gaur

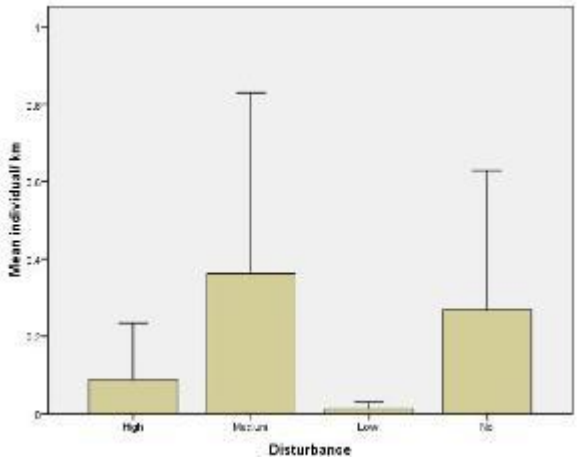
Figure 3.6 Distribution of mammals in Highwavy environs – Disturbance level



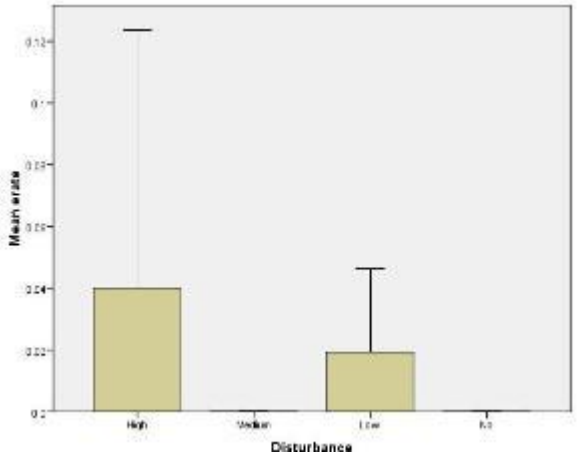
Chital



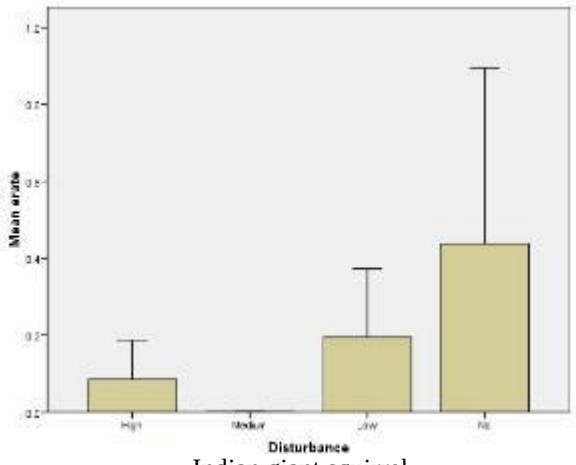
Southern red muntjac



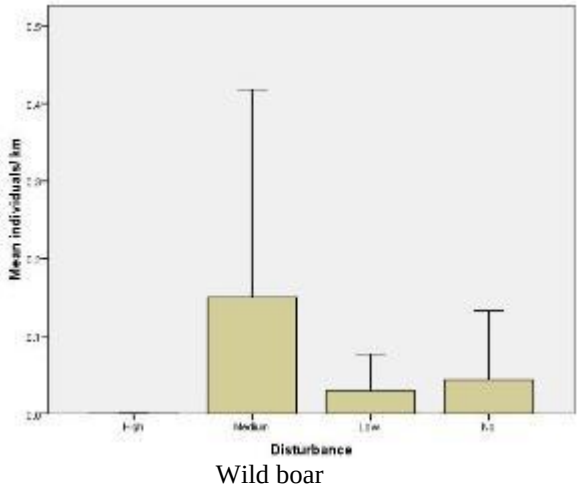
Sambar



Grizzled giant squirrel



Indian giant squirrel



Wild boar

Figure 3.6 Distribution of mammals in Highwavy- forest type

Primates

Among primate species, lion-tailed macaque, Nilgiri langur and tufted grey langur were restricted to one or two elevation gradients where the bonnet macaque was encountered in all the elevation gradients; however the encounter rate differed elevationally for all the species. Although, the lion-tailed macaque and Nilgiri langur was encountered in high and mid elevation, but their encounter rate was high in the high elevation 0.18±0.72 and 0.83±1.51 respectively. Where, the encounter rate of bonnet macaque (0.69±2.52) and tufted grey langur (0.36±1.5) were more in the low elevation. Although, the encounter rate of all the primates vary between the elevation gradients, only Nilgiri langur differ significantly ($\chi 2$=20.232, df=2, P<0.001) (Fig 3.7). Similarly, the encounter rate of lion-tailed macaque in evergreen forests (0.38±1.14), tufted grey langur in dry deciduous (xx) and scrub forests (0.43±1.68) was higher than in other forests types. Although, Nilgiri langur was encountered in evergreen, savanna and dry deciduous forests, but the highest was in evergreen forests (2.62±6.34). Among the primates only Nilgiri langur showed significant difference in the encounter rate in various forest type ($\chi 2$=40.521, df=3, P<0.001) (Fig. 3.8). The encounter rate of lion-tailed macaque (0.16±0.77) and Nilgiri langur (0.83±4.25) was more in the low disturbed area, where, the bonnet macaque was more in highly disturbed area (0.69±2.57) (Fig 3.9).

Carnivores/ predators

Tiger was unseen in Highwavy. Only in few places indirect signs pugmarks, scratch, carrions were found near Vellimalai, Mavadi (Vattathotti) and in between upper Manalar and 29th estates all these places were near or close to Periyar tiger Reserve in Kerala. During the entire study period only once the leopard was sighted between upper Manalar and 29th estate jeepable road. However, in several places indirect signs scat and pugmarks were recorded. We had direct sighting of a pack of dholes and also once the pack was captured by camera traps. Thrice bear was sighted near Vellimalai.

Spotlighting survey/ Nocturnal survey

During the night survey, sambar was the most frequently sighted (n=51, 28.81%), which was followed by slender loris (n=32, 18.08%), gaur (n=16, 9.04%), spotted deer (n=16, 9.04%), black-napped hare (n=15, 8.47%), mouse deer (n=13, 7.34%), barking deer (n=12, 6.78%) rusty-spotted cat (n=8, 4.52%) common palm civet (n=4, 2.26%), brown palm civet (n=3, 1.69%), Indian wild boar (n=3, 1.69%), small Indian civet (n=2,1.13%), pangolin (1, 0.56%) and porcupine (1, 0.56%).

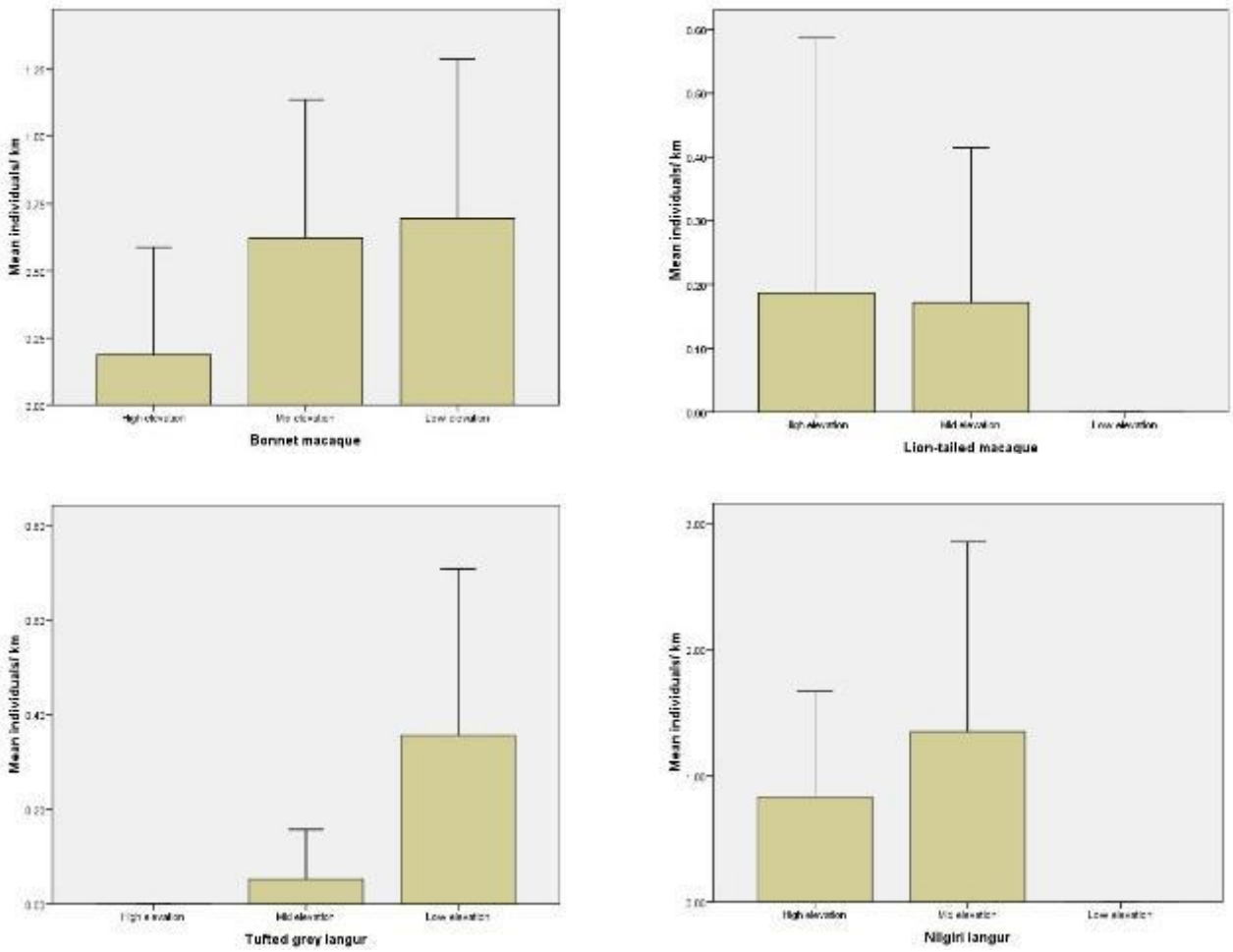
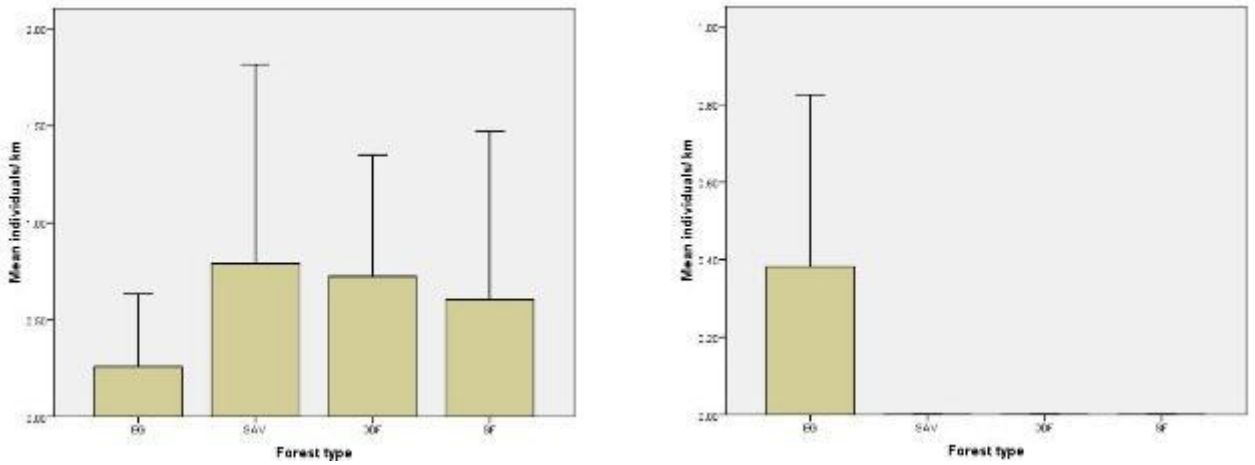
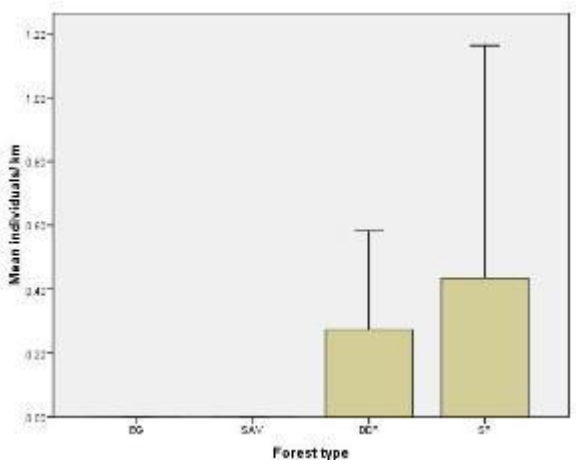


Figure 3.7 Mean encounter rate of Primates in Highwavy in various elevation category

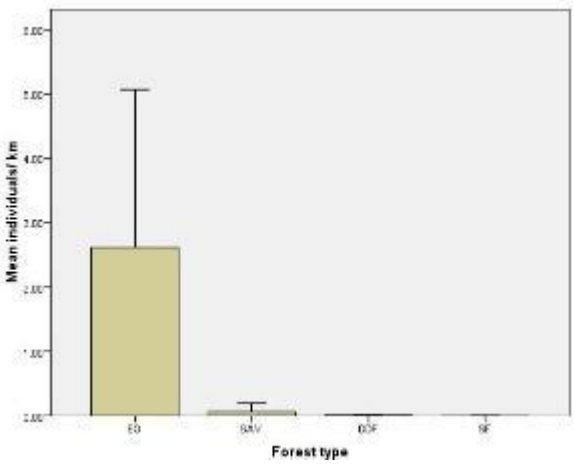


Bonnet macaque

Lion-tailed macaque

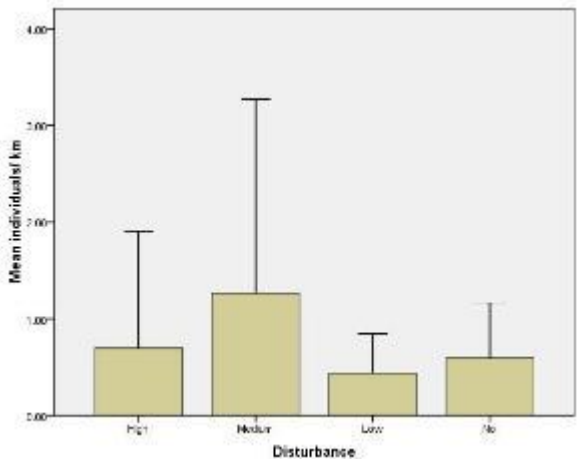


Tufted grey langur

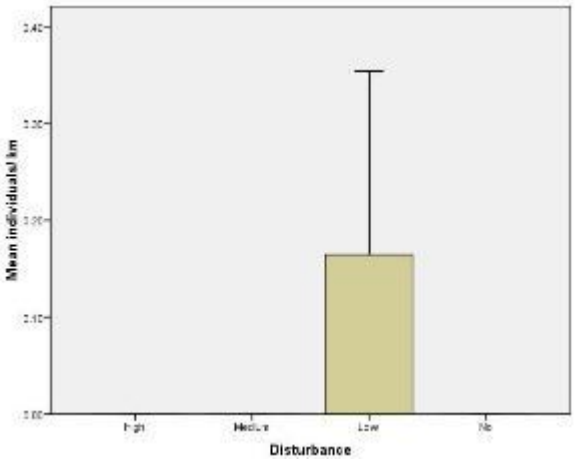


Nilgiri langur

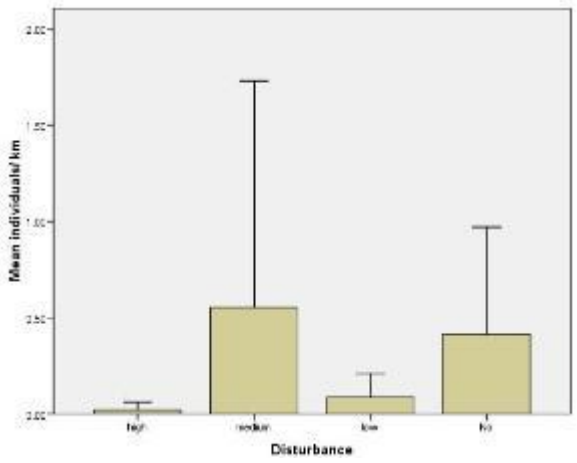
Figure 3.8 Mean encounter rate of Primates in various forest types of Highwavy



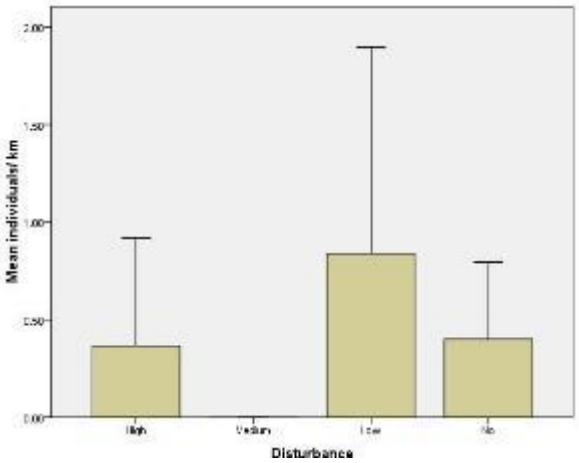
Bonnet



Lion-tailed macaque



Tufted grey langur



Nilgiri langur

Figure 3.9 Mean encounter rate of primates in various disturbance in Highwavy

Discussion

High undulating terrain of Highwavy environs varied from 300 m asl to 1800 m asl, accordingly the forest types also highly varied depending on the rainfall. On eastern slope, the rain shadow areas with less rainfall at foot hill has got a dry scrub forests, on the mid elevation with relatively high rainfall has got the dry deciduous forests with many riparian forests, which gradually transforms in to moist deciduous forests towards further up, at the ridge with high rain fall has got the evergreen forests with many rocky outcrop and shola in between with rolling grass. These high elevation evergreen forests were exploited for many commercial plantations like coffee, tea, cardamom, pepper and clove. This variation in the altitude and such array of forest types resulted in high species richness, however, due to various anthropogenic activities over the period resulted in very low density of larger body size animals at south of Nilgiri Biosphere, which include Highwavy environs, except the large tract of contiguous protected forests like Anamalai, Parambikulam and Periyar Tiger Reserves.

Although, a total of 599 individuals belongs to 20 species was recorded but at the specie level the relative abundance was very poor. Among all the mammals, only two of species Nilgiri langur and Indian giant squirrel statistically showed significant variation in their relative abundance across elevation and forest types. One of the reasons can be preference of these animals for certain elevation and forest types.

Grizzled giant squirrel was record with poor encounter rate, and also highly restricted to riparian forests at low elevation dry deciduous and scrub forests. The species is also known to inhabit riparian forests throughout its distribution range (Joshua & Johnsingh, 1994). Even in the Highwavy environs also the species occupy similar habitat. Where, the Indian giant squirrel was encountered from all the elevation gradients and forest types, which indicate that the species is relatively generalist species than the grizzled giant squirrel.

Sambar and gaur were adapted to graze and browse, where the chital and southern red muntjac are typical grazers. The availability and the distribution of browse and grass in the forest ecosystem determines the habitat preferred by these species. Chital encounter rate was more in dry forests with open wooded forests interspersed with grass, where other species since they adopted for browse and graze, those animals were encountered in various forest types. However, encounter rate of sambar

was higher in dry forests compared to evergreen forests, where the encounter rate of gaur increased from dry forests to evergreen forests. Elephants are known to survive in wide variety of habitat starting from scrub to high elevation (Sukumar & Ramesh, 1995). Although indirect evidences were found in all the elevation category and forest types. Highest encounter rate was in medium elevation and at savanna forests. Since elephants show seasonal movement in these hills, it is difficult to ascertain the proper reason for the variation in their abundance.

Primate's being an arboreal mammal; require good canopy contiguity, however, species like bonnet macaque has adopted to live in scrub forests of plains and human dominated landscapes to high altitude evergreen forests (Kumara et al. 2010). Lion-tailed macaque is confined to medium to high elevation evergreen forests and the encounter rate was very low. The probable reason for the poor encounter rate may be due to restricted distribution, low population and confined to private estates, however, Highwavy environs hold sizable population of ~ 250 animals (Kumara et al. 2011). Nilgiri langur was encountered in medium to high elevations with evergreen, savanna and dry deciduous forests; however the encounter rates decreased from evergreen to dry deciduous. Compare to lion-tailed macaque, the Nilgiri langur is known to inhabit evergreen to moist deciduous forests in its range of distribution, however, within moist deciduous forests they inhabit relatively moist patches like riverine habitat or Valleys. Tufted grey langur replaces Nilgiri langur by distributing in lower to medium hills yet confined to dry deciduous and scrub forests.

Rarity or no sightings of carnivores during the study is not surprising in Highwavy environs, Hutton (1949) also stated that tiger is a visitor to the area and only during dry seasons, but leopards were reported as residents to the hills. However, our sightings of leopard, dholes and bear show their persistence in the hills. Sightings of slender loris (32) and rusty spotted cat (8) show the presence of good populations of these animals in the hills. Sightings of brown palm civets at higher elevation forests show their persistence in the hills.

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Introduction

Around 25% of mammal species are experiencing extirpation and extinction globally (Ceabllos & Ehrlich, 2002). Large mammals are particularly prone to extinction due to their greater body mass and associated life history traits. A recent evaluation highlights that mammals with body mass above 3 kg are more prone to extinction risk (Cardillo et al. 2004). The large body mass makes them more vulnerable/susceptible to wide range of anthropogenic threats (Madhusudan & Mishra 2003). Differential hunting practices, habitat loss, fragmentation and degradation have been affected the distribution and habitat use of large mammal in the tropics (Achard et al. 2002). In this context, it is necessary to assess the status (Schipper et al. 2008) and habitat-species interaction of large mammals live in human dominated landscape.

Distribution and habitat use of mammals is largely driven by a range of factors to suit their biological requirements (Seidensticker 1976, Wrangham & Rubenstein 1986). Current distribution patterns of these threatened mammals are largely unknown and the conservation efforts were hampered by lack of data on species-habitat relationships (Krishna et al. 2008). Occurrence can be modeled as a function of measured habitat covariates, allowing for testing of hypotheses on species–habitat relationships (MacKenzie et al. 2002).

Monitoring programmes are being used increasingly to assess spatial and temporal trends of biological diversity, with an emphasis on evaluating the efficiency of management policies (Yoccoz et al. 2001). However, the accurate population abundance estimation requires considerable amount of effort and resources. The alternate system state variables that are gathered without much effort and time will be useful to monitor status of the species. Occupancy rate can be used as a state variable using presence/absence surveys across several sampling sites (MacKenzie et al. 2002). Occupancy, defined as the proportion of sites occupied by a species, is a state variable commonly used in ecology for the modeling of habitat relationships, metapopulation studies and wildlife monitoring programs. The issue of imperfect detection in the context of occupancy studies has received much attention in recent years (MacKenzie et al. 2002; Guillera-Arroita et al 2010).

In this context, occupancy rate of mammals in Highwavy environs was developed to address habitat –species interaction and to identify species rich zones for prioritizing conservation area.

Methods

Sampling design

Base map of the study area was digitized using Survey of India (SOI) topographic sheets and Government orders for Theni Forest Division and Megamalai Wildlife Sanctuary. The study area window was used for generating 4 sq. km spatial grids and the same was over laid on the base map to identify individual sampling units (grids). All the full grids were alone selected for sampling and the incomplete grids were not considered for sampling. In addition, few in accessible grids were left un-sampled. Large mammals were surveyed in 133 grids that covered 532 sq. km. In all the selected grids, systematic grid walk was carried out with every 100 m as segment and every 500 m as spatial replicate. A minimum of five spatial replicates were sampled and thus 20 segments.

The selection of grid size (sampling unit) and spatial replicate should also corroborate with the home range size of focal animal. Our focal animal's (large mammals) body size is ranging from few kilograms (Indian chevrotain) to tonnes (elephants) and the home range size of most of the mammals in the Western Ghats has not been properly documented. Hence, we selected a flexible window for both grid size and length of spatial replicate. In this way we selected 4 sq. km as spatial unit and with respect to the size of the animal the grid size can be increased by merging four grids together i.e. 16 km. Similarly, the replicate size can be modified according to the size of the animal. In this background, within each segment (100 m length), all tracks and signs (pellets, feeding signs, scratch marks, kill etc.) were recorded along with site (that influence the distribution of species) and sampling covariates (that influence the detectability of species or its sign). The presence and absence of direct and indirect evidences of large mammals were recorded in each spatial replicate.

Sampling covariates

The soil characteristics such as texture (loamy, sandy, lateritic) and nature (wet and dry) were recorded for each detection of tracks/pugmarks and in each 100 m segments, the percent of composition of these soil characteristics were qualitatively assessed to understand the availability pattern. However, due to inadequate sampling we could not really use the data as such. Other than these, understory characteristics such as shrub height, shrub cover, grass height, grass cover, litter cover and invasive weed's height and cover were also quantified systematically (details provided in methodology section).

Site covariates

Tree and understory structural characteristics of each segment were assessed using point-centred quarter method of Dumbois & Ellenberg (1974).

Point-Centred quarter method

Point-Centred Quarter method (PCQ) is the most commonly used distance sampling method for the estimation of plant communities, in particular the forest plant communities. In each segment, minimum of one sampling point was taken and within each sampling point four quarters were marked. Within each quarter, nearest tree with more than 20 cm GBH was selected and the distance from the sampling point was measured. Similarly, distance to nearest trees was estimated in all four quarters. The measured distances of four trees were used for calculating tree density. The formulae used to estimate tree density were obtained from various published sources (Mark & Esler, 1970; Dombois & Ellenberg, 1974; Kevin, 2005). Details of habitat covariates estimated/derived are presented in table 4.1.

Table 4.1 Brief details of habitat covariates used in occupancy estimation of mammals and its method of quantification

Sl.No.	**Parameters**	**Method of measurement**	**Scale/ Unit of measurement**
1	**Tree covariates (Arboreal)**		
	tree density	PCQ method	Hectares
	tree height	Visual assessment	Meter
	GBH	Visual assessment	Meter
	canopy cover	Visual assessment	Percent
	canopy contiguity	Visual assessment	Percent
2	**Understory covariates (Herbivore)**	Visual assessment	Percent
	under story height	Visual assessment	Meter
	understory cover	Visual assessment	Percent
	grass height	Visual assessment	Meter
	grass cover	Visual assessment	Per
	weed height	Visual assessment	Meter
	weed cover	Visual assessment	Percent
3	**Spatial variable (Herbivore & Arboreal)**		
	mean of NDVI	Derived from spot-vegetation	
	cv of NDVI	Derived from spot-vegetation	

Spatial covariates

Field habitat covariates provide data for a small proportion of land mass that may not provide clear picture for the large mammals hence few remotely sensed data were derived to address broader scale questions. We have chosen two covariates namely mean Normalized difference in vegetation index (highly correlating with certain vegetation related parameters) and coefficient of variation in NDVI (indicates the degree of variation in NDVI which is low for evergreen forests and high for dry forests). Multi season satellite data were used to extract NDVI values and its coefficient of variations, which is helpful in identifying different forest types.

Threats including live stock grazing, illegal hunting, conflict with wild animals, NTFP collection, fuel wood, fodder extraction and presence of human settlements in each segment and the grids were recorded qualitatively.

Data scrutiny

All the continuous habitat and sampling covariates were transformed to meaningful categories by ensuring equal number of values for each category.

Analysis

History of detection of droppings/signs of mammals contributed to detection histories for each grid, where '1' indicates detection of the animal, '0' indicates non-detection and '-' indicates a missing observation. For example, a detection history of '00-1000000000001' indicates that the animal dropping/sign was detected only in the fourth and sixteenth plots whereas the third plot was not sampled. We constructed detection histories for all grids and the two model parameters; the probability that a grid is occupied by the species (ψ) and the detection probability (p) were estimated using likelihood functions (MacKenzie et al. 2002). The program PRESENCE ver. 3.0 was used to derive maximum likelihood estimates of the model parameters.

Model selection, computation of model weights, and averaging of parameters followed the framework of Burnham & Anderson (2002). We calculated model-averaged parameters using

Akaike weights for proportion of sites used and detection probabilities. To infer the relative influence of each covariate on occurrence, model weights were summed over all models containing the particular covariate. Akaike weights are equivalent to Bayesian posterior model probabilities and indicate the relative support of a model (Burnham & Anderson 2002).

Results

A total of 133 grids were sampled for large mammals in the Highwavy environs. The transect length was ranged from 1.5 to 2.5 km. In this way, a total of 285.6 km were sampled in 532 sq. km (133 X 4) area. Twenty species of mammals were recorded from the grid walk; indirect evidences of cats and civets were not identified up to species level but herbivore and large carnivores were identified up to species level. Direct sighting of large mammals were low compared to indirect evidences. Maximum of five species of mammals were recorded from a grid.

Southern Red Muntjac: The detection probability of the species was 0.29. Of the sampling covariate, none of the covariates affected the detection probability of indirect evidences of Southern Red Muntjac. Results of the occupancy model were presented in the table 4.2. The constant model, ψ (.) p(.), performed poorly as it is evidenced by summary statistics of the models. The subsequent models were developed with an assumption that the detection probability was not affected by any sampling covariate. Among the developed occupancy models, the candidate model indicated that grass coverage and disturbance negatively influenced the distribution however tree structural characteristics (GBH, Tree Canopy Cover and Tree Height) positively influenced the distribution of Southern Red Muntjac (Table 4.4). This model is corroborated with the earlier observations that Southern Red Muntjac prefers dense forests with intermediate openings. The average occupancy estimate corresponds to a difference of 46% from the naive estimate of occupancy.

Chital: The average occupancy and detection probability of the species were 0.326 (SE = 0.052) and 0.31 respectively (Table 4.2). This occupancy estimate is 31% higher than the naive estimate of occupancy. Not much difference in AICc weight was found between candidate model and constant model ($\psi(.),p(.)$) so we did model averaging and summed model weights, which indicate that CV_NDVI supported the distribution of Chital (Table 4.4). The high CV_NDVI indicates that the habitat is dry forests and Chital prefers such habitat.

Sambar: The average occupancy and detection probability of sambar was comparatively higher than other herbivore (ψ= 0.7218, p=0.635)**.** The occupancy estimate is 2.77% higher than the naive estimate (Table 4.2). The results of summed model weight indicate that the weed coverage and M_NDVI positively influenced but shrub cover and disturbance negatively influenced sambar (Table 4.4).

Gaur: The detection probability of gaur was 0.55 and detection of indirect evidences of gaur was not influenced by any sampling covariate so we developed model with an assumption that all the indirect evidences of gaur were sighted. The average occupancy estimate corresponds to a difference of 8% from the naive estimate of occupancy (Table 4.2). Two habitat covariates namely M_NDVI and weed cover were positively influenced but disturbance, shrub and grass cover negatively influenced the distribution of gaur (Table 4.4).

Indian Chevrotain: The detection probability of the species was 0.22. The estimated occupancy is 56% higher than the naive estimate of occupancy (Table 4.2). The average occupancy estimate for the species was estimated as 0.321. Disturbance and CV_NDVI showed negative association and grass coverage showed positive association with the species (Table 4.4).

Porcupine: The average estimate of occupancy and detection probability of the species was 0.708 and 0.556 respectively (Table 4.3). Summed model weights indicate that grass cover positively influences the distribution of porcupine but weed cover negatively influence the species (Table 4.4). The first two candidate model highlights the relative role of grass cover in the distribution of the species. AIC model weight indicates that constant model ($\Psi(.),p(.)$) poorly predicted the distribution of the species. The estimated occupancy is around 7% higher than the naive estimate.

Sloth Bear: Average occupancy and detection probability of the species was 0.584 and 0.318 respectively (Table 4.3). Around 34% higher estimate of occupancy was obtained compared to naive estimate of occupancy. Weed cover, tree structural characteristics and M_NDVI were showing positive correlation with the habitat use of the species (Table 4.5).

Indian giant squirrel: The detection probability of the species was 0.313. No sampling covariate was observed to influence the detectability of the species. Among three candidate models, the first model identified tree structural characteristics, CV_NDVI and disturbance as best predictor variable for understanding the habitat use of the species (Table 4.3). The AIC weight for the candidate

model was very high compared to other models, which is also evidenced in summed model weights (Table 4.5). The estimated average occupancy is around 40% higher than the naive estimate.

Nilgiri langur: The detection probability of the species was 0.301. Among the five models, constant model had poorly predicted the habitat use of Nilgiri Langur which is evidenced by low AIC values (Table 4.3). Summed model weights indicate that CV_NDVI and disturbance showed negative association with habitat use however canopy cover showed strong positive association with the species (Table 4.5). The average occupancy estimate is 48% higher than the naive estimate. The grid wise estimated occupancy of each mammal species is presented in Figure 4.1 to 4.9.

Table 4.2 Summary of model selection procedure for factors affecting site occupancy of selected mammals in Highwavy environs, Western Ghats, India (AICc (AIC adjusted for small sample size), ΔAICc (AICc – min AICc), wi (AICc weight for model i), k (the number of parameters in the model)

Species	SI	Model	Ψ	(SE)	AICc	ΔAICc	wi	k
Southern Red Muntjac	1	*ψ(grass+tree+ disturbance),p(.)*	0.528	0.10	433.33	0.00	0.5438	4
	2	*ψ(*grass+weed +cv_ndvi*),p(.)*	0.482	0.09	435.83	2.5.	0.1558	4
	3	*ψ(grass+tree+weed),p(.)*	0.525	0.10	435.9	2.57	0.1505	4
	4	*ψ(.),p(.)*	0.479	0.06	437.75	3.91	0.077	2
Chital	1	*ψ(cv_ndvi),p(.)*	0.326	0.047	338.55	0.00	0.3019	2
	2	*ψ(.),p(.)*	0.314	0.052	339.05	0.51	0.2339	2
	3	*ψ(weed+cv_ndvi),p(.)*	0.337	0.069	340.2	1.65	0.1323	3
	4	*ψ(cv_ndvi+shrub),p(.)*	0.319	0.068	340.43	1.88	0.1179	3
	5	*ψ(cv_ndvi+grass),p(.)*	0.327	0.068	340.55	2.00	0.111	3
	6	*ψ(weed+cv_ndvi+disturbance),p(.)*	0.335	0.083	342	3.45	0.0538	4
	7	*ψ(cv_ndvi+grass+shrub),p(.)*	0.321	0.083	342.18	3.63	0.0492	
Gaur	1	*ψ(shrub+weed+m_ndvi+disturbance),p(.)*	0.5138	0.078	538.64	0.00	0.437	5
	2	*ψ(m_ndvi+disturbance+grass),p(.)*	0.5199	0.067	540.4	1.76	0.1813	4
	3	*ψ(shrub+weed+grass+m_ndvi +disturbance),p(.)*	0.514	0.088	540.64	2.00	0.1608	
	4	*ψ(m_ndvi+weed+disturbance),p(.)*	0.529	0.068	541.08	2.44	0.129	4
	5	*ψ(.),p(.)*	0.4951	0.045	557.16	18.52	0	2
Indian chevrotain	1	*ψ(cv_ndvi+disturbance+grass),p(.)*	0.323	0.082	270.14	0.00	0.646	
	2	*ψ(grass+weed+cv_ndvi+disturbance),p(.)*	0.321	0.101	272.12	1.98	0.2401	5
	3	*ψ(shrub+weed+grass+cv_ndvi +disturbance),p(.)*	0.317	0.11	273.92	3.78	0.0976	
	4	*ψ(shrub+disturbance+m_ndvi),p(.)*	0.359	0.105	279.13	8.99	0.0072	4
	5	*ψ(m_ndvi+weed+disturbance),p(.)*	0.381	0.11	279.94	9.80	0.0048	4
	6	*ψ(.),p(.)*	0.326	0.071	281.58	11.44	0.0021	2
Sambar	1	*ψ(weed+disturbance+shrub+m_ndvi),p(.)*	0.74	0.067	697.32	0.00	0.719	5
	2	*ψ(shrub+grass+disturbance+m_ndvi),p(.)*	0.74	0.075	699.31	1.99	0.265	6
	3	*ψ(weed+grass+m_ndvi),p(.)*	0.755	0.06	705.04	7.72	0.015	4
	4	*ψ(.),p(.)*	0.734	0.039	720.8	23.48	0	2

Table 4.3 Summary of model selection procedure for factors affecting site occupancy of selected mammals in Highwavy environs, Western Ghats, India (AICc (AIC adjusted for small sample size), ΔAICc (AICc – min AICc), wi (AICc weight for model i), k (the number of parameters in the model)

Species	SI	Model	Ψ	(SE)	AICc	ΔAICc	wi	k
Porcupine	1	*ψ(grass),p(.)*	0.708	0.04	677.54	0.00	0.2808	2
	2	*ψ(grass+m_ndvi),p(.)*	0.714	0.055	677.85	0.31	0.2405	3
	3	*ψ(weed+grass),p(.)*	0.704	0.055	678.7	1.61	0.1572	3
	4	*Ψ(cv_ndvi+disturbance+grass),p(.)*	0.700	0.068	679.48	1.94	0.1065	4
	5	*Ψ(shrub+grass),p(.)*	0.706	0.055	679.48	1.94	0.1065	3
	6	*Ψ(weed+grass+shrub),p(.)*	0.705	0.068	680.65	3.11	0.0593	4
	7	*Ψ(.),p(.)*	0.689	0.042	682.82	5.28	0.0200	2
Sloth bear	1	*ψ(shrub+weed+tree+m_ndvi),p(.)*	0.584	0.107	497.33	0.00	0.7804	5
	2	*ψ(shrub+grass+weed+tree+ m_ndvi+disturbance),p(.)*	0.584	0.127	501.2	3.87	0.1127	7
	3	*ψ(weed+tree+m_ndvi),p(.)*	0.608	0.097	502.39	5.06	0.0622	4
	4	*Ψ(.),p(.)*	0.548	0.061	503.05	5.72	0.0447	2
Indian giant squirrel	1	*ψ(tree+cv_ndvi+disturbance),p(.)*	0.241	0.027	244.29	0.00	0.9421	4
	2	*ψ(gbh+m_ndvi+disturbance),p(.)*	0.340	0.109	251.38	7.09	0.0272	5
	3	*Ψ(.),p(.)*	0.219	0.046	251.89	7.6	0.0211	2
Nilgiri langur	1	*ψ(cv_ndvi+disturbance+ canopy_cover),p(.)*	0.245	0.074	235.18	0.00	0.8242	4
	2	*ψ(gbh+cv_ndvi+disturbance+ canopy_cover),p(.)*	0.249	0.086	239.05	3.87	0.1190	6
	3	*Ψ(canopy_cover+tree_height+ cv_ndvi),p(.)*	0.266	0.083	241.43	6.25	0.0362	4
	4	*Ψ(gbh+canopy_cover+cv_ndvi),p(.)*	0.248	0.076	242.84	7.66	0.0179	4
	5	*Ψ(.),p(.)*	0.213	0.045	246.66	11.48	0.0026	2

Table 4.4 Covariates affecting the distribution and habitat use of mammals in Highwavy environs, ranked based on AICc weights with average co-efficient and SE

Species	Covariate	Summed AICc weights	β co-efficient	(SE)
Southern Red Muntjac	Grass	0.8500	-0.02524	-0.16007
	Tree	0.6943	0.25913	-0.11831
	Disturbance	0.5438	-0.49781	-0.27282
	Weed	0.3063	-0.07294	-0.12391
	CV_NDVI	0.1558	-0.55560	-0.25179
Chital	CV_NDVI	0.7661	-0.37251	-0.2054
	Weed	0.1861	0.05089	-0.08018
	Shrub	0.1671	-0.05846	-0.11472
	Grass	0.1602	0.04895	-0.14768
	Disturbance	0.0538	-0.09888	-0.222
Gaur	M_NDVI	0.9081	0.68847	-0.24509
	Disturbance	0.9081	-0.68271	-0.20886
	Weed	0.7268	0.10964	-0.1027
	Shrub	0.5978	-0.25566	-0.13502
	Grass	0.3421	-0.03713	-0.14055

Indian chevrotain	Disturbance	0.9957	-0.64517	-0.2991
	CV_NDVI	0.9837	-0.90889	-0.31238
	Grass	0.9837	0.41717	-0.1947
	Weed	0.3425	-0.01314	-0.13896
	Shrub	0.1048	-0.11171	-0.16675
	M_NDVI	0.012	0.37322	-0.30637
Sambar	Weed	0.999	0.37738	-0.12919
	M_NDVI	0.999	1.0163	-0.31519
	Shrub	0.984	-0.46797	-0.16277
	Disturbance	0.984	-0.23361	-0.21975
	Grass	0.2809	-0.18714	-0.17387
Porcupine	Grass	0.956	0.244438	-0.1226
	M_NDVI	0.2405	0.304836	-0.23785
	Weed	0.2165	-0.10111	-0.11137
	Shrub	0.1658	-0.00041	-0.12583
	Disturbance	0.1065	-0.23449	-0.19791
	CV_NDVI	0.1065	-0.11613	-0.21321

Table 4.5 Covariates affecting the distribution and habitat use of mammals in Highwavy environs, ranked based on AICc weights with average co-efficient and SE

Species	**Covariate**	**Summed AICc weights**	**β co-efficient**	**(SE)**
Indian giant squirrel	Disturbance	0.9693	-0.8739	-0.33199
	Tree	0.9421	0.175085	-0.08393
	CV_NDVI	0.9421	-0.77813	-0.24015
	GBH	0.0272	-1.37096	-0.77194
	Tree height	0.0272	1.521839	-0.79325
	M_NDVI	0.0272	0.037224	-0.42103
Nilgiri langur	CV_NDVI	0.9973	-0.95847	-0.26464
	Canopy cover	0.9973	0.34310	-3.37542
	GBH	0.1369	-0.02933	-0.44042
	Disturbance	0.1190	-0.92344	-0.37790
	Tree height	0.0362	0.65751	-0.55961
Sloth bear	Weed	0.9553	0.073934	-0.13062
	Tree	0.9553	0.100004	-0.13091
	M_NDVI	0.9553	0.528818	-0.3538
	Shrub	0.8931	-0.42135	-0.17573
	Grass	0.1127	0.073496	-0.20313
	Disturbance	0.1127	0.005958	-0.23287

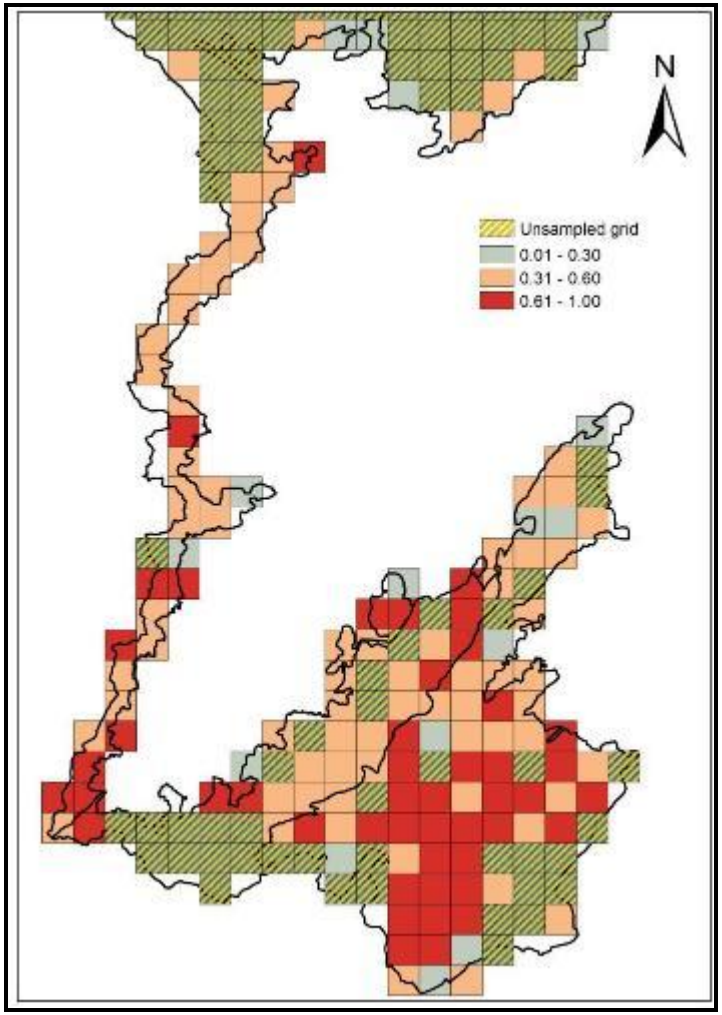

Figure 4.1.Southern Red Muntjac

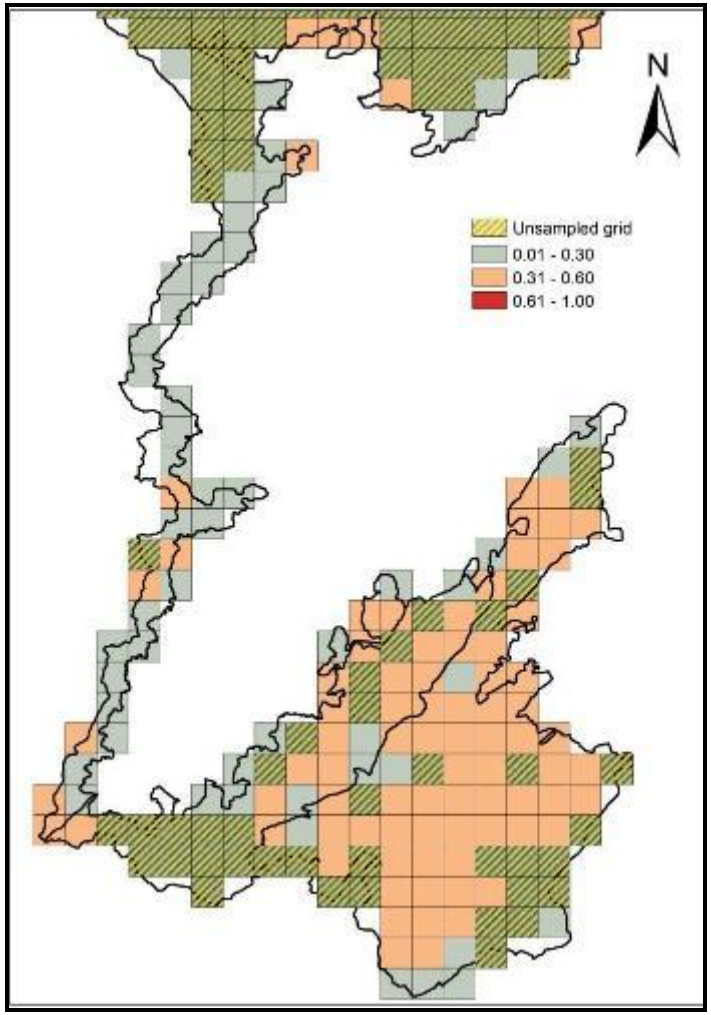

Figure 4.2. Chital

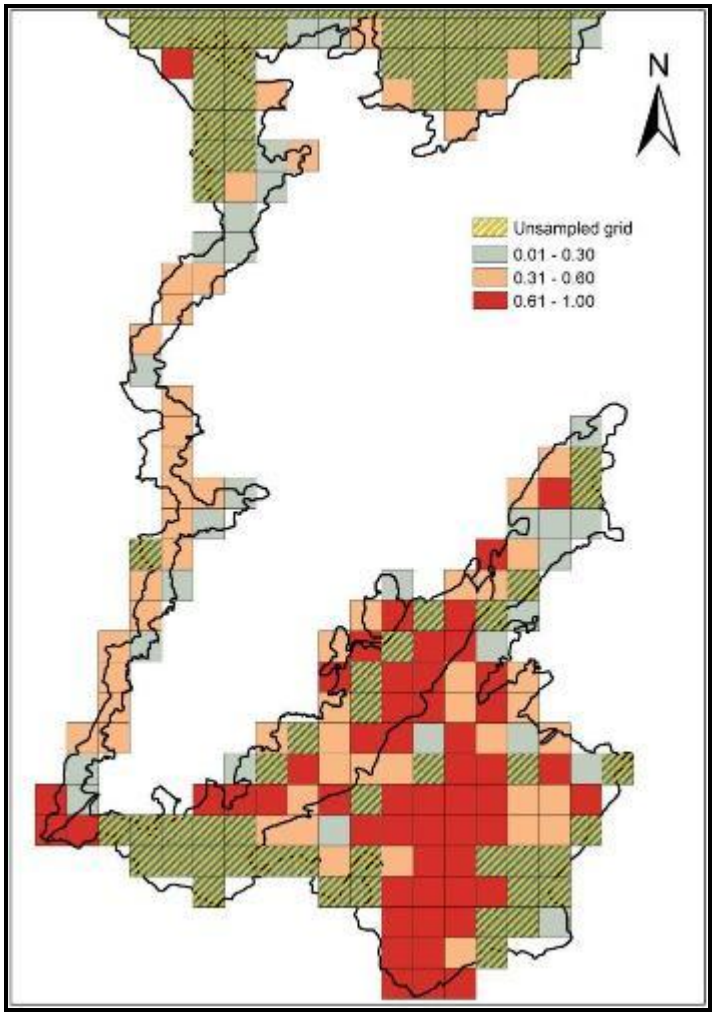

Figure 4.3. Gaur

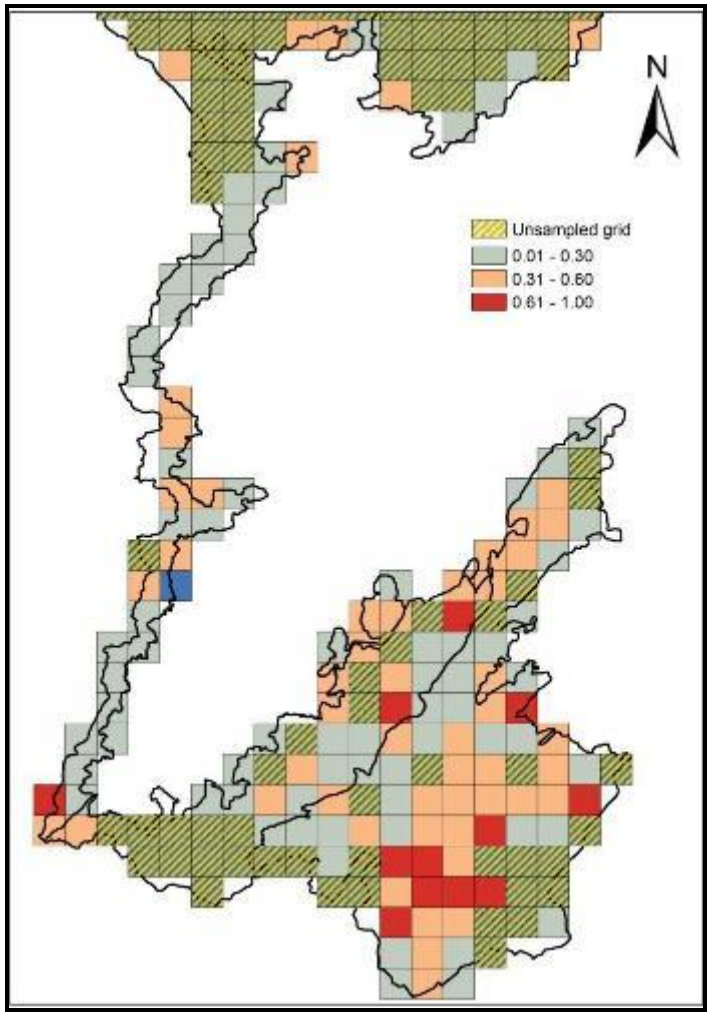

Figure 4.4. Indian chevrotain

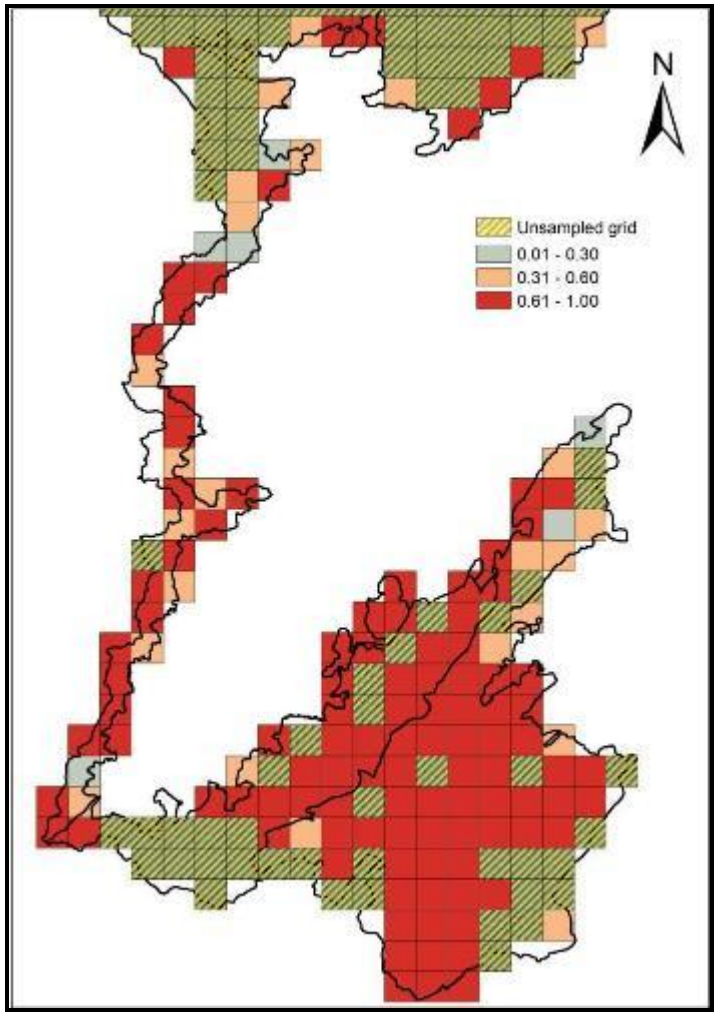

Figure 4.5.Sambar

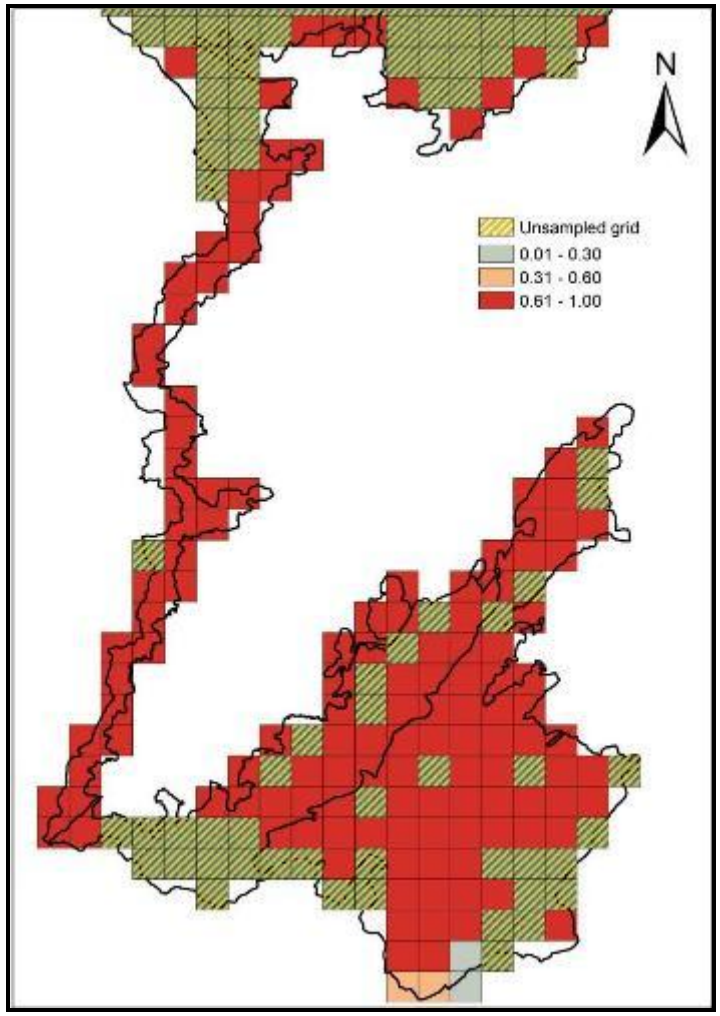

Figure 4.6. Porcupine

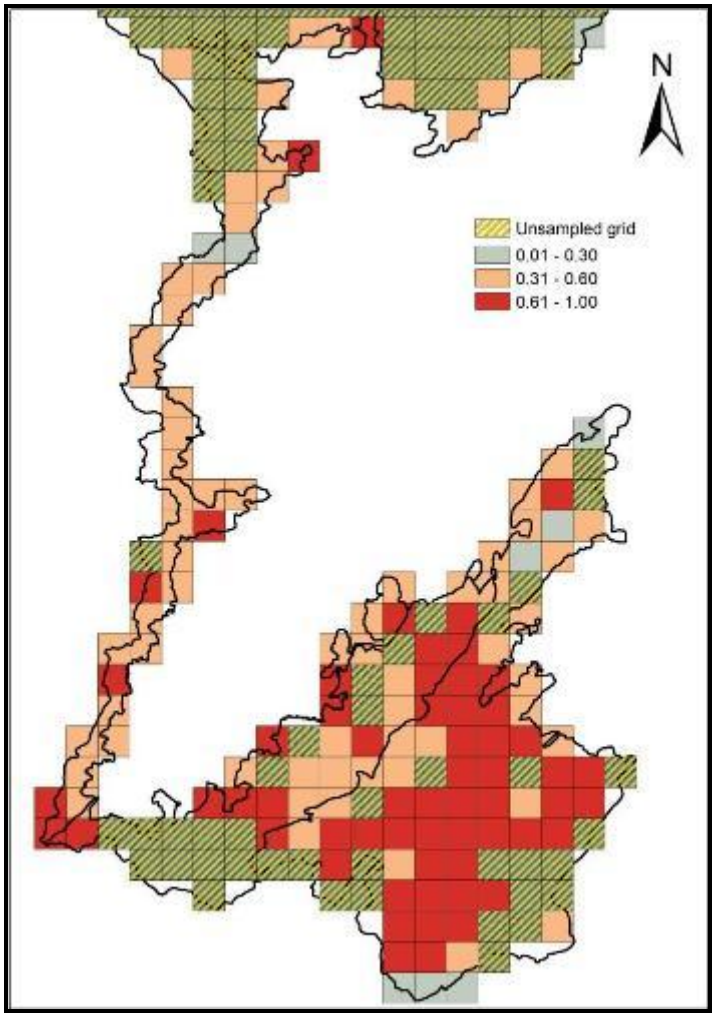

Figure 4.7. Sloth bear

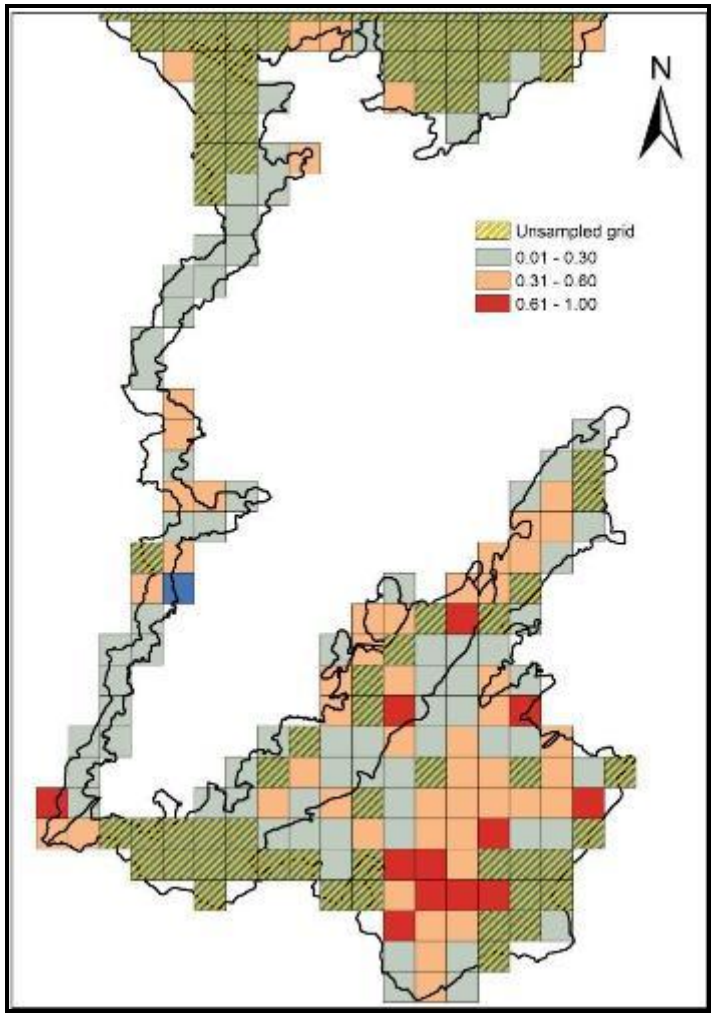

Figure 4.8. Indian giant squirrel

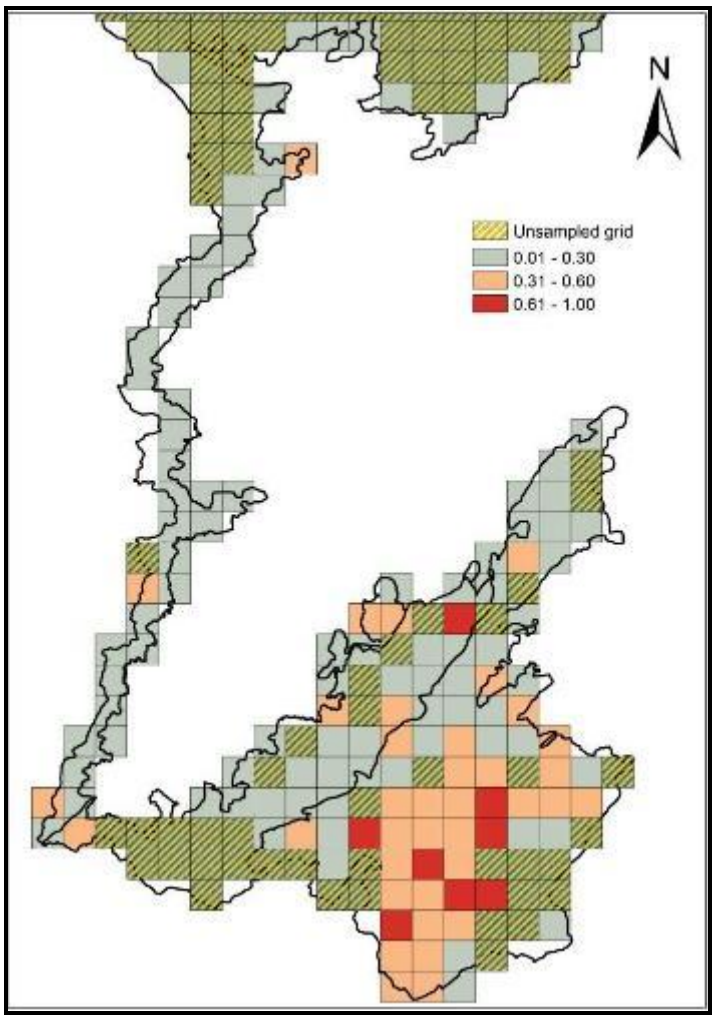

Figure 4.9. Nilgiri langur

Discussion

The results presented here were preliminary and we have not accounted the sampling covariate for estimating detection probability. Hence, it should be treated as coarse-grained results rather than fine scale. The present study sampled around 532 sq km area of Highwavy environs to address the distribution pattern and habitat-species interaction of mammals using occupancy framework. Proportion area occupied by nine mammal species (six herbivore, one omnivore and two arboreal mammals) were estimated by considering imperfect detection of the species. Species wise occupancy estimate for each grid were spatially projected to identify species rich zones for implementing conservation oriented programmes in the division.

Most of the high quality sites of large mammals in the division were predicted in un-protected areas and privately owned estates such as coffee and cardamom. It indicates that the mammals are using the enclosures to cross between the patches of natural forests. The estate also support home for

endangered primate species such as Nilgiri Langur and Lion-tailed Macaque. Hence, the opportunities for eco-restorations of degraded and modified patches of privately owned estates are more in the High Wavy environs.

Occupancy and habitat covariates

In the analysis, we have considered sampling covariate that affects the detection probability of indirect evidences of herbivores and arboreal mammals. The AIC value for detection probability was not higher than the constant model. Hence, the occupancy models were developed with the assumption that all the signs and pellets of mammals were encountered during the grid walk.

Herbivores were highly responding to the biological covariates such as weed, shrub and grass cover at field scale and NDVI at spatial scale. Besides these, few anthropogenic covariates such as cattle grazing, lopping and hunting were also regulating the herbivore distribution in the High Wavy environs. The natural forests next to encroached lands in the Varusanad Valley and hills are recorded with high probability value for all herbivores. This indicates that in spite of high degradation and disturbance from the encroacher, the area still support food resources for the large herbivores such as elephant, gaur, sambar, Chital, Southern Red Muntjac and Indian chevrotain.

Arboreal mammals habitat use were influenced by the tree structural characteristics (GBH, canopy cover and tree height) and NDVI parameters (CV_NDVI), because these species completely avoids the high CV_NDVI areas i.e. it prefers wet zones such as evergreen and riparian forests. The mean NDVI values for these habitats are not changing with respect seasons. Arboreal species also utilizes the areas with high tree characteristics, which is found along the riparian, evergreen forests and coffee and cardamom estates. The coffee and cardamom estates the upper canopy has been left intact and also harbours high density of *Cullinea exarillata* and Jack fruit. Thus the density and occupancy of arboreal mammals were high in estates and adjacent evergreen forests.

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Chapter V
Conservation of Mammals in Highwavy environs

Introduction

Declining biodiversity is a major environmental problem everywhere on the Earth, including developed countries (Hanski, 2004). Worldwide, national parks and reserves increasingly serve as critical refuges for native species and ecosystems, often harbouring the last vestiges of natural environments (Baron, 2004).

Generally long-term wildlife monitoring programs are listed as a fundamental component of Protected Area (PA) management (Dominik et al. 2011). As quoted by Redford (1992) "satellites passing overhead may reassuringly register them as forest, they are empty of much of the faunal richness valued by humans". Conserving lower taxa (for example ant) is equally important as conserving higher taxa (e.g. Elephant). Also conserving prey species ultimately will conserve the predators. Many large animals ecologically gone extinct one such example is Cheetah, once it was wide spread in India. As quoted by Janzen (1988) forests full of trees fool us into believing that all is well however, "living dead". Once a Protected Area officially gazetted, monitoring programs are essential to evaluate whether or not the protection of Wildlife has improved (Nichols & Williams, 2006).

India has rich traditions of nature conservation as well as a vigorous official program of protection of nature reserves developed over the last 40 years (Gadgil, 1992). In India, Western Ghats is a one area that has been particularly affected by human population growth and hunting (Kumara & Singh, 2004; Madhusudan & Karanth, 2002). Mammals are in the apex of vertebrate group, requires more protection than any other taxa. Large herbivores are particularly difficult to conserve in this context, because of their relatively low densities, unique habitat requirements, crop raiding tendencies, and their consumption by local people (Karanth & Sunquist 1992). Researchers from various parts of the world listed out many causes for the decline of wildlife ranging from lower taxa to higher taxa. However, hunting by local communities is among the most general threats to Indian wildlife, yet, the understanding of its nature, extent, and its impacts on wildlife has been poor (Madhusudan & Karanth, 2002). In the present chapter the conservation issues of mammals in Highwavy are discussed.

Major management issues at the Highwavy environs:

Based on the results obtained from the present study, the following suggestions are recommended for the conservation of Highwavy environs.

(1) Upper manalar-Vellimalai-Ammagajam contiguity

Long back, large tract natural forest was given on lease to different companies for a fixed period. Those forests were converted as commercial plantations such as tea, coffee and cardamom; the estates include Vellimalai, Ammagajam, Jyothi, Highwavy, Megamalai, Venniyar, Manalar, Eravangalar, Kardana etc. These estates are interspersed with rain forests, which harbour high diversity of animals including large mammals.

1. The above mentioned area hold good regional population of certain key species of mammals viz., Lion-tailed macaque, Nilgiri langur, gaur, tiger, leopard, dhole, Nilgiri tahr, Nilgiri marten and other south Indian ungulates.
2. Around 266 individuals of Lion-tailed macaque (Kumara et al. 2011) and 100 individuals of Nilgiri tahr (Davidar, 1978) were also recorded from this tract of forests.
3. The area also experience severe interruption of locals for cattle grazing, which increases the chance of spreading diseases from cattle to wild ungulates. Furthermore, the area is located next to Periyar Tiger Reserve and transmitting diseases from cattle to wild ungulates become a serious issue for the prey base of Tiger in the landscape.
4. By increasing protection in the above landscape would also reduces the hunters entering into Periyar tiger reserve through above mentioned landscape and that would facilitate the tiger to occupy these areas in near future, although there were few sporadic records.
5. This patch is contiguous with adjacent protected areas such as Srivilliputtur Grizzled Squirrel Wildlife Sanctuary in northern side, Periyar Tiger Reserve in western and south western side and Megamalai Wildlife Sanctuary in the northern side; this patch is also connecting Megamalai Wildlife Sanctuary with Srivilliputtur Grizzled Squirrel Wildlife Sanctuary and this is one of the area in the southern Western Ghats where large portion of high elevation forests (>1400 m) still persist, which is supporting high richness of endemic and threatened vertebrates (Bhupathy et al. 2012). In this context, we recommend that the lease period of these estates should not be further extended and should be gradually acquired and restored. Further, we suggest to add the above mentioned area into Megamalai Wildlife Sanctuary or to create new wildlife sanctuary for the conservation of imperative wildlife area in the Western Ghats.

(2) Varusanad Valley and Hills: A potential patch for "Conservation Reserve" program

According to forest working plan (2004-2014), there are around 5911 hectares of 2896 encroachments spread across the landscape: Varusanad range with 2060 hectares (1802 encroachments) followed by Megamalai (1721 hectare- 399) and Bodi ranges (1607 hectare=490) (Malik, 2004). Among the encroachments in the Highwavy environs, Varusanad range *i.e.* Varusanad Valley and hills were highly exploited to create monoculture plantations (silk cotton) by the encroachers, which are moved from dry plains of erstwhile Madurai district. The lands were encroached by these people around three to four decades ago. Hence, resettling these people from the Valley and hills of Varusand will be a troublesome work and that may also lead to conflict between forest department and the local residents. The Valley also holds a minor population of threatened grizzled giant squirrel and diverse number of birds (around 253 species). The encroached plantations and adjacent riparian and other natural forests support diverse species of vertebrates. In this background, it is recommended to propose the Varusanad Valley and hills as "conservation reserve" so that the people inside the Valley will not be excavated and the same time biodiversity in the landscape can also be protected in sustainable way (Fig. 5.1). The sustainable way for solving the conflict between people and wildlife in the area requires detailed study.

(3) Living critical link: Requires conservation attention

The critical link between 'Periyar-Agastiyamalai' and 'Anamalai-Palni' Corridor fall in the Theni Division. The critical link was intersected by Cumbam to Kumuly road, Cumbam to Cumbam Mettu, Bodi to Munnar roads and also penstock made for the power generation breaking the critical link. Present study shows persistence of large mammals like elephant, leopard, porcupine and sambar in these corridors of mountain, further which was evidenced by the moderate to high occupancy rate of nine species of large mammals. The indirect evidences of carnivores such as dhole and leopard were also recorded from the critical link. Further, dry eastern slopes of the critical link also connect the Mathikettan Shola National Park of Kerala in the western side. The critical link is highly disturbed and fragmented for establishing the physical structures (construction of road, penstock and deep gorge). At present, administratively, major part of this corridor is under the Theni Forest Division. Local people revealed crop raiding by elephants and wild boar along the foot hills of the corridor. This may be due to very narrow stretch of forest left, thus the animals have tendency to move out of the forest for forage which results in human-animal conflicts. Presently, these corridors experience severe anthropogenic pressure like cattle grazing and fire wood collection leading to further deterioration of the corridor. If the Anamalai-Palni should be connected with the Periyar-Agastyamalai, then these corridors should be restored and also should be protected,

otherwise loss of forests on these corridors might terminate the animal movement and lead to fragmentation of the population.

The problems in the conservation of the critical link are:

(1) Three major roads (1) Gudalur to Kumuly, (2) Cumbam to cumbam mottu and (3) Bodi to Munnar via bodi mettu) are intersecting the critical link (Fig. 5.2). These roads connect two states namely Kerala and Tamil Nadu, where vehicles are plying throughout the day and night. The intensity of vehicle and movement of mammalian species in all the roads require a study to develop appropriate plan for managing the vehicle intensity. Based on the result, it can be proposed to control the movement of vehicle at least during the night hours if it is appropriate.

(2) Penstock of hydro electric project located in lower camp is another issue. The height of the penstock is around two meters and it is difficult for animals to cross the penstock. However, we observed sambar using road bridges that comes over the penstock for crossing the penstock. If that is the situation, then it is possible to construct a bridge over the penstock for the animals to cross (Fig. 5.2), which is possible in the plains of Gudalur range.

(3) Fringes of the critical link face severe anthropogenic pressure, which is starting from cattle grazing to hunting. The intensity of cattle and other illegal activities are increasing with years. The area requires some sort of protection before the entire is fragmented and cleared.

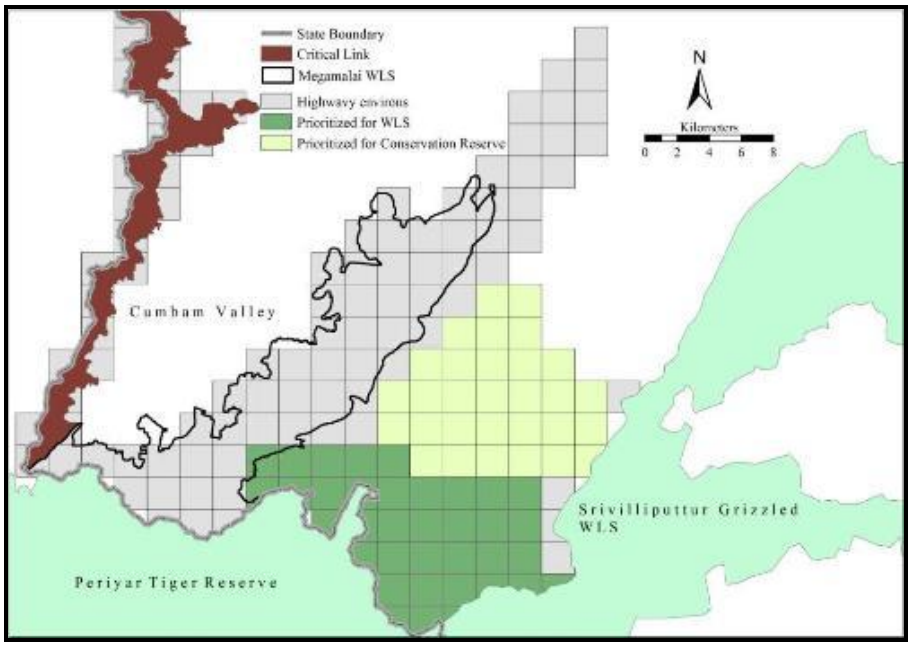

Figure 5.1 Prioritized conservation area in the Highwavy environs

Figure 5.2 Position of penstock and road in critical link and the wildlife cross points

Other issues in the area to be considered for management:

1. The lopping of tree was done by villagers and estate workers for fire wood and fodder for their live stock. Bhupathy et al. (2009; 2012) highlighted lopping and cattle dung piles were relatively high in the lower elevation (400-1000 m) and it was low in mid elevation (1000-1400 m) in Highwavy. This is due to the presence of villages and settlements in these elevation bands. Excess of grazing by livestock would affect the regeneration of vegetation in an area. LPG gas replacing firewood and stall feeding of the cattle's may solve the problem to a greater extent, which is very much possible with the participation of estate management who are dealing with plantation activities.
2. Lemon grass collection for the preparation of pain palms is still in operation in Indira nagar near Arasardi. The impact of this issue has not been studied in for the region. We suspect negative impact of this grass collection on some of the animals, however, this requires proper study.
3. The estates in the region uses considerable amount of various fertilizers and pesticides, which eventually peculate to all the water sources. The both direct and indirect impact of this has to be studies and the guidelines for the use such chemicals should be developed.
4. Now-a-days Highwavy environs have become tourist spot attracting many people from various parts of Tamil Nadu and neighbouring states of Kerala. Also Suruli falls near Cumbam town also attracts tourists and pilgrims. Frequently the macaques were teased by people. There should be signboards explaining laws pertaining to teasing of animals. Provisioning of wild animals should be curbed.

A portion of the forests of this area have been declared as Wildlife Sanctuary Government Order: G.O. (D) No. 63, Environment and Forest (FR V), dated 26 June 2009, declaring a part (269.11 sq.km) as Megamalai Wildlife Sanctuary, which was a long pending (Rodgers and Panwar 1988). This is an encouraging sign with respect to Wildlife conservation in Highwavy. However, many wildlife habitats are outside the Protected Area.

Plate 5.1 Showing tea plantation in Highwavy environs

Plate 5.2 Forest fire in dry forests of Highwavy environs near Arasardi

Plate 5.3 Bonnet macaques Highway road

Plate 5.4 Porcupine in Highwavy tea plantation

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