RELATIVE SENSITIVITY OF MAMMALIAN CARNIVORES TO DISTURBANCE

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Summary

The mammalian carnivores are important indicators of ecosystem integrity, they influence the structure, and reflect the vigor of tropic levels upon which they depend. They are also sensitive to the abundance and behavior of the human with which they coexist. The decline and extirpation of top predators from fragmented systems may generate tropic cascades that may alter the structure of ecological communities. Understanding the ecological processes that cause some species to decline, while others remain relatively safe, may help to predict future declines and focus conservation. Although considered members of the same ecological guild, carnivores may vary in their responses to such disturbances. In particular, differences in body size among carnivore species have been proposed as an important determinant of extinction probability. It's the species biology that determines how well it is able to withstand the threats to which it is exposed. Like most species today, carnivores are also threatened by habitat loss, degradation, and fragmentation the world over. Keeping the higher level of disturbance which is occurring in the Northeast region I planned to study the impacts of disturbance such as clearing of forests for habitation, presence of domestic livestock, forestry operation such as logging and extracting of non-timber forest products, trapping and hunting for sustenance as disturbance on carnivore populations. The study was conducted in the low land semi evergreen forests of Pakke Tiger Reserve, Arunachal Pradesh.

For this study following objectives were identified

- Prepare an inventory of carnivore species occurring in Pakke Tiger Reserve.

- Study spatial and ecological distribution in terms of disturbances and environmental variables respectively.

Following key questions were put forward:

- Are there differences in species richness across sites in terms of disturbances, if any, what contributes to the variation?
- Whether occurrences pattern a reflection of species co-existences/ inter species interaction?
- What environmental variables determine the presences of species?
- Which areas are relatively species rich?

Four study sites, Khari, West bank, Dicho and Lanka were selected from within the Pakke Wildlife Sanctuary and adjoining Papum Reserve Forests, on the basis of various parameters which might have affected the habitat structure of the area. These parameters include, distances from nearest village, presences of domestic dog and domestic cow, logging history of the area, history of commercial cane extraction, presences of signs of hunting or trapping of wild animals, construction of recent road construction, extensive fishing in the streams by using gelatin and chemicals like pesticides and herbicides, history of area being used for field-gun practices by Army

Once areas were identified, three transects of length three km were chosen randomly in each area. In the transects so selected, a track plot of 3x2 m was made by loosening soil and clearing litters like leaf fall, twigs, over which fine sand particles from the surrounding was spread, at every 250 m interval. These areas on basis of disturbances

parameters scores were assign to differentiate on gradient of disturbances. To test the correlation between the habitat variables, Spearman's rank correlation test was performed on habitat variables

Of the recorded six species of Felids from the study area, signs of four species were recorded in the track plots and out of 15 small carnivores species reported, presence of nine species was confirmed through tracks, signs and skins (i.e. Mustelids, Vivverids and Herpestids). Tracks of only six species of small carnivores were recorded from the track plots. Tracks of Asiatic black bear (*Ursus thibetanus*) and of wild dog (*Cuon alpinus*) were also recorded. Dicho had the highest records of carnivore species. Small Indian civet had the highest of rate of occurrences followed by common palm civets occurrences.

Non metric multidimensional scaling was performed using SPSS 8.00 software on the presence - absence data of carnivore species of transect to examine occurrences pattern of carnivore species so recorded from the study area. All small carnivore multidimensional scaling shows that, common palm civet and jungle cat occurred together in same quarter and large Indian civet and yellow throated marten occurred together in a different quarter. All small and large carnivore multidimensional scaling shows that, tiger, leopard and wild dog occurs in each quarter separately. Jungle cat and common palm civet occurred distinctly in a quarter to dholes and leopard cat. Yellow throated marten, large Indian civet and tiger occurred in separate quadrate

Multidimensional scaling for disturbances shows that small Indian civet and common palm civet occurred more in disturbed area than large Indian civet and yellow throated marten. Areas with high presences of domestic dog had no presences of these animals. When occurrence of small cats were scaled with that of disturbances parameters, Jungle cat and leopard cat occurred away from areas with high disturbances. These matrixes of co-occurrence and differences in the body weight of carnivore species were examined, for association using mantel non parametric tests. The test shows that there is inverse association between them.

The influences of habitat variables on the occurrences of carnivore species were examined by using Classification tree analysis by using S-PLUS 4.5 software. The final output showed that, distances from village was the most important variable that determines the presence – absence of civets .Civets were absent in areas with more than 65 % shrub cover .Small cats occurred in areas with greater shrub cover and shrub height The occurrence of small cats decreased with the distances from village increased . Small cat occurred low in areas with high canopy cover.

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1. INTRODUCTION

The destruction of habitat has been targeted as one of the most serious threats to biological diversity world-wide (Wilcove et al. 1998) and in areas with increasing urbanization, the loss and fragmentation of habitat is virtually inevitable. The mammalian carnivores are important indicators of ecosystem integrity, they influence the structure, and reflect the vigor of tropic levels upon which they depend (Eisenberg 1989). They are also sensitive to presence of humans with whom they coexist (Kucera & Zielinski 1995). However, because of their low densities, nocturnal and secretive habits, and wariness of humans they are difficult to study (Sargeant et al. 1998). As a result, the ecology of many carnivore species and their responses to ecological disturbances such as fragmentation are often poorly understood. Although considered members of the same ecological guild, carnivores may vary in their responses to fragmentation. In particular, differences in body size among carnivore species have been proposed as an important determinant of extinction probability (Brown 1986, Belovsky 1987). The relationship between body size and extinction risk in animals is complex, however, and has been the subject of considerable debate, with studies predicting and reporting positive, negative, or no relation of body size to extinction probability (Johst & Brandl 1997). It's the species biology that determines how well it is able to withstand the threats to which it is exposed (Cardillo et. al. 2004). Few studies have evaluated how or why carnivore species differ in their relative sensitivities to fragmentation effects.

Tropical rainforest contain diverse carnivore assemblages that are structured by the diversity and abundance of prey (Rabinowitz & Walker 1991, Davies 1962, Mukherjee 1998, Kumar et. al. 2002). Due to the resources being limited, sharing can lead to competition for these resources and hence greater similarity between species would result

in higher levels of competition between them. Since different species would perform dissimilarly in competition due to differences in their phenotypes and genotypes, the stronger competitor would have grater access to resources and would eventually wipe out the weaker species (Hadin 1960, Mayr 1976) which will be reflected in their distribution in a habitat.

There are about 272 species of order Carnivora in world (Wozencraft 1989, Corbet & Hill 1992). The order carnivora in India is represented by 55 species (Johnsingh 1986). This order comprises of large, medium, and small sized animals that are adapted to varied habitats and habits. Among these carnivores, 58% of the species, which belong to the families Herpestidae, Viverridae, and Mustelidae (Johnsingh 1986) are commonly referred to as small carnivores. Only a few of the felids (Felidae) are small, and sometimes included along with these species, when small carnivore community is considered in it's entirely. This group of mammals exhibits a high degree of diversity and endemism in several regions of the world. Mustelidae in India are the most diverse family containing 16 species in 7 genera, followed by the Viverridae with 9 species in 6 genera and Herpestidae with 7 species in 1 genus (Johnsingh 1986, Wozencraft 1989, Hussain 1999). The Family Felide in India is represented by three genera in fifteen species. (Johnsingh 1986) of theses four are large ones, rest eleven species are of small and medium size cats weighing less than 25 kg (Mukherjee 1998).

Carnivores are critical for the functioning of natural ecosystems because of the key roles they play as predators, prey, and seed dispersers. They can affect food webs and community structures of lower trophics levels (Palomares et al. 1985, Crooks and Soulé 1999.) As predators, carnivores may regulate populations of many species of

invertebrates, rodents, herbivores and other small vertebrates (Palomares et. al. 1995, Ray 1997, Prater 1971).

Of the 55 species of carnivores found in India (Johnsingh 1986) around 49 species occur in Northeast India. Such rich assemblage of carnivore species might be because of its location at the convergences of three major bio-geographic realms - Indomalayan, Palearctic and Ethiopian (Mackinnon & Mackinnon 1974, Mani 1974). The presences or an absence of any species in a given area is determined by its biogeographical history and the outcome of the balance between local extinction and colonization. The species is usually abundant at the core of their global range and becomes rarer at the periphery probably because of decreases in the recolonization potential at the range periphery. The diversity of species can be due to presences of diverse habitats, in terms of habitat structure, benefiting the species to coexist by resources partition and spatially and temporally segregation. Many large carnivores are generally habitat specialist and require large undisturbed areas (Terborgh 1974, Pimm 1991, Seidensticker et al. 1999). Smaller carnivores those which are of habitat generalists might be positively benefited by moderate habitat conversion such as, opening up of vegetation, creation of water resources and creation of agricultural fields which might increase rodent population (Prakash et al. 1995, Johns 1983), but there might be others, whose population may precipitate due to these factors because the threshold up to which the species can withstand the habitat modification varies species to species, beyond which population declines may occur.

Keeping the higher level of disturbance which is occurring in the Northeast region I planned to study the impacts of disturbance such as clearing of forests for habitation, presence of domestic livestock, forestry operation such as logging and extracting of non-

timber forest products, trapping and hunting for sustenance as disturbance on carnivore populations.

Threats

Mammalian carnivores are thought to be particularly vulnerable to local extinction in fragmented or degraded landscapes because of their relatively large home ranges, low numbers, and direct persecution by humans (Noss et al. 1996, Woodroffe & Ginsberg 1998). The decline and extirpation of top predators from fragmented systems may generate tropic cascades that may alter the structure of ecological communities (Crooks & Soule 1999). Understanding the ecological processes that cause some species to decline, while others remain relatively safe, may help to predict future declines and focus conservation (Cardillo et al. 2004). Indeed, the persistence of these environmentally sensitive and ecologically pivotal species may be indicative of the integrity of entire ecosystems (Noss et al. 1996). The underlying cause of virtually all recent and on going declines of mammal species is the growth of human populations and associated impacts such as habitat loss, hunting and the spread of invasive species (Cardillo et. al. 2004). As such, mammalian carnivores can serve as useful tools for the study of ecological disturbances or for conservation planning and reserve design (Soule & Terborgh 1999).

Like most species today, carnivores are also threatened by habitat loss, degradation, and fragmentation the world over (Schreiber et al. 1989, Heydon & Bulloh 1996, Johnsingh 1986). Carnivores sometimes face additional threats, as they are hunted for meat, fur, pelt or extraction of secretions from their scent glands (Madhusudan & Karanth 2000). These threats may be further compounded by their need for large hunting areas and their dependences on prey species that may themselves be threatened. Despite their ecological

significance and the threats they face, carnivores especially small carnivores have been poorly studied, particularly in the tropics.

2. Review of literature

There are very few studies in India which deals with the effect of disturbance on carnivore populations. Pocock (1941), Prater (1971) gave an overview of distribution of carnivores in India. In recent years Johnsingh (1986) gave an over view of the diversity and conservation of carnivores in India. Mukherjee (1997) and Hussain (1999) gave the current status of smaller carnivores from the Indian subcontinent particularly smaller cats, Mustelids, Viverrids, and Herpestids.

Ecological study on Carnivore assemblages related to loss and fragmentations are very scanty. Kumar et al. (1997) did a study on the management of fragmented rainforests of the Western Ghats for the conservation of fauna with special reference emphasis on small mammals. Further, Kumar and Sivaganesan (1998) gave an ecological account of small carnivores in Nilgiri Biosphere Reserve. Mukherjee (1998) studied habitat use by sympatric small carnivores in Sariska Tiger Reserve, Rajasthan. Choudhury (1997, 1999) gave an account of the small carnivores in Assam and Arunachal Pradesh. Sanyal (1999), Suresh Kumar (1999), Gupta (1999) gave an account of small carnivore conservation in various states of Northeast India. Kumar and Yoganand (1999) gave an account of distribution and abundance of small carnivores in Nilgiri Biosphere Reserve. Kumar (1999), Hussain (1999) gave conservation of status of some endangered species such as malabar civet (*Viverra civetina*) and otter (*Lutra* and *Amblonyx* spp).

In a recent study entitled impacts of rainforest fragmentation on small mammals and Herpetofauna in the Western Ghats, South India, Kumar et al (2002) concluded that changes in the small carnivore community in the rainforest fragments included a decline

in the overall abundance, a decline in absolute and relative abundance of the brown palm civet (*Paradoxurus jerdoni*), and an increase in the terrestrial small carnivores such as brown mongoose (*Herpestes fuscus*) and small Indian civets (*Viverricula indica*). These changes were related to habitat features other than fragment area. For maintaining large assemblages of carnivore communities, Kumar et al (2002) suggested that in a fragmented landscape, conservation efforts should include the maintenance of relatively undisturbed and large tracts of remnant forests with high diversity of native trees and lianas. At the same time, efforts should be made to protect even small forest fragments that hold wild population of endemics.

The information on the carnivore assemblages and impact of forest fragmentation and associated disturbance such as hunting and poaching for sustenance from northeast India is lacking. For this study following objectives were identified:

3. OBJECTIVES

1) Prepare an inventory of carnivore species occurring in Pakke Tiger Reserve.
2) Study spatial and ecological distribution in terms of disturbances and environmental variables respectively.

Questions

i) Which areas are relatively species rich?

ii) Are there differences in species richness across sites in terms of disturbances, if any, what contributes to the variation?

iii) Whether occurrences pattern a reflection of species co-existences/ inter species interaction?

iv) What environmental variables determine the presences of the species?

4 STUDY AREA

4.1 Arunachal Pradesh

The state of Arunachal Pradesh is situated in the north-eastern most corner of India, surrounded by Myanmar in the east, China in north and Bhutan in west. It covers an area of 83,743 km^2, of which 82.21% is forested. (FSI 1999). The state has been able to maintain such vast expanses of forest due to its low population density (Nanda 1992) as well as due to the laws like Inner line Regulation Act, 1873, formulated by the British government, restricting the entry of people from other parts of the country. It is also partially due to the fact that the state is under the Sixth Schedule of Indian Constitution. This protects several rights of the indigenous people. As a result most of the land area is with the people, under community or private ownership.

The state of Arunachal Pradesh has more than 25 groups of indigenous peoples with distinct linguistic and cultural identities, spread over sixteen districts. The districts are named after the prominent rivers of the area. These rivers and high mountain ranges have for centuries protected and served as natural boundary between communities, paving for their distinct cultures and language. For example, the district of East Kameng is located at the eastern bank of Kameng River in the western part of the state, where communities like *Nyshis, Sulung, Aka* reside. Likewise virtually each district has its own distinct communities residing in them with their distinct culture. So the *Sherdupens, Monpa* in districts of West Kameng and Tawang. *Nyishis* in Upper, Lower Subanshiri districts along with *Apatanis. Adis* are traditionally confined to the districts of East, West, Upper, Siang. The *Tangas, Nocte, Wanchos, Mishmis, Kahamti* are found in the eastern part of the state which comprises of districts like Changlang, Tirap, Lohit.

The state due to its unique position at the confluence of the Palaearctic and Indo-Malayan BiogeoFigureical realm has great biological significance as result of the diverse habitats it harbors (Mani 1974, Rodgers & Panwar 1988), spanning a wide altitudinal range from 100m to over 6000m. Arunachal Pradesh has the world's northern most tropical rain forests (Whitmore 1998), and it is estimated that 7000-8000 species of flowering plants occur here, which is nearly 50% of the Indian flora (Chowdhury et al. 1996). Over 500 species of orchids have been recorded from the state (Chowdhury 1998). Of the 1200 bird species in India, nearly 600 species have been recorded from the state (Singh 1991, 1994). It is recognized as an important endemic bird area (Stattersfield et al. 1998) and is one of the world's global biodiversity hotspots (Myers et al. 2000). The state has around 100 species of mammals (Datta 2001) which is bound to increase with the discovery of new species of macaque.

The state has nine wildlife sanctuaries and three National parks encompassing about 11.44% of the total area. The rest such as village reserve forests and Unclassed State forests where the local people have several rights, comprise the largest (approximately 70%) forest area of the state.

4.2INTENSIVE STUDY AREA

4.2.1 Pakke Tiger Reserve

The study site was conducted in Pakke Tiger Reserve and Papum Reserve forests in East Kameng districts of Western Arunachal Pradesh. (Figure1). Pakke Tiger Reserve with an area of 862 km^2, with altitude ranging from 200 to more than 1500 above MSL is located between, 92^0 75'E to 92^0 22'E and 26^0 53.7 N to $27^0$16.2'N. It was declared as Game Reserve in 1977, in which hunting of carnivorous was permitted (Forest Department Records). It was subsequently declared as Wildlife Sanctuary in 1979 and notified as a

Tiger Reserve in the year 2002. The parks boundary is delineated by river *Pakke* in north-east and east and river *Kameng* in west, to north it is bound by river *Papu*, and towards its south-east is Nameri NP of Assam.

The Forest Divisional Headquarter is in *Seijosa*, located in Arunachal –Assam boundary at about 60 km from Tezpur, the nearest town with airport. Administratively the park is divided in two Ranges, Seijosa Range which comprises of Beats like *Dicho* and *Khari* and Tipi Range.

The area was commercially selective logged before it was declared as Game Reserve. This continued till its notification as Wildlife Sanctuary in 1979. The area was extensively worked under Assam Cane Mohal system till 1991. In this the contractors were allotted vast area on lease for extraction of cane for ten years (Arunachal Pradesh Forest Department. Areas like *West-bank, Khari*, and *Tipi* were extensively worked under this system. The surrounding hills of *Dicho* were heavily denudated by the continuous pounding, by Indian Army for their field-gun practices till 1997. At present large number of villagers daily go to this hill for collecting metals pieces to shell in the local markets as scraps. One village Mobusa, located in *Dicho* area of the park, was shifted out from sanctuary area in 1992. Papum RF with an area of 1064 km^2 was earlier part of Khellong Forest Division. It is continuous to Pakke WLS. Pakke River separates the park and the Reserve. The reserve area is extensively used by the villagers for jhum cultivation and for commercial extraction cane.

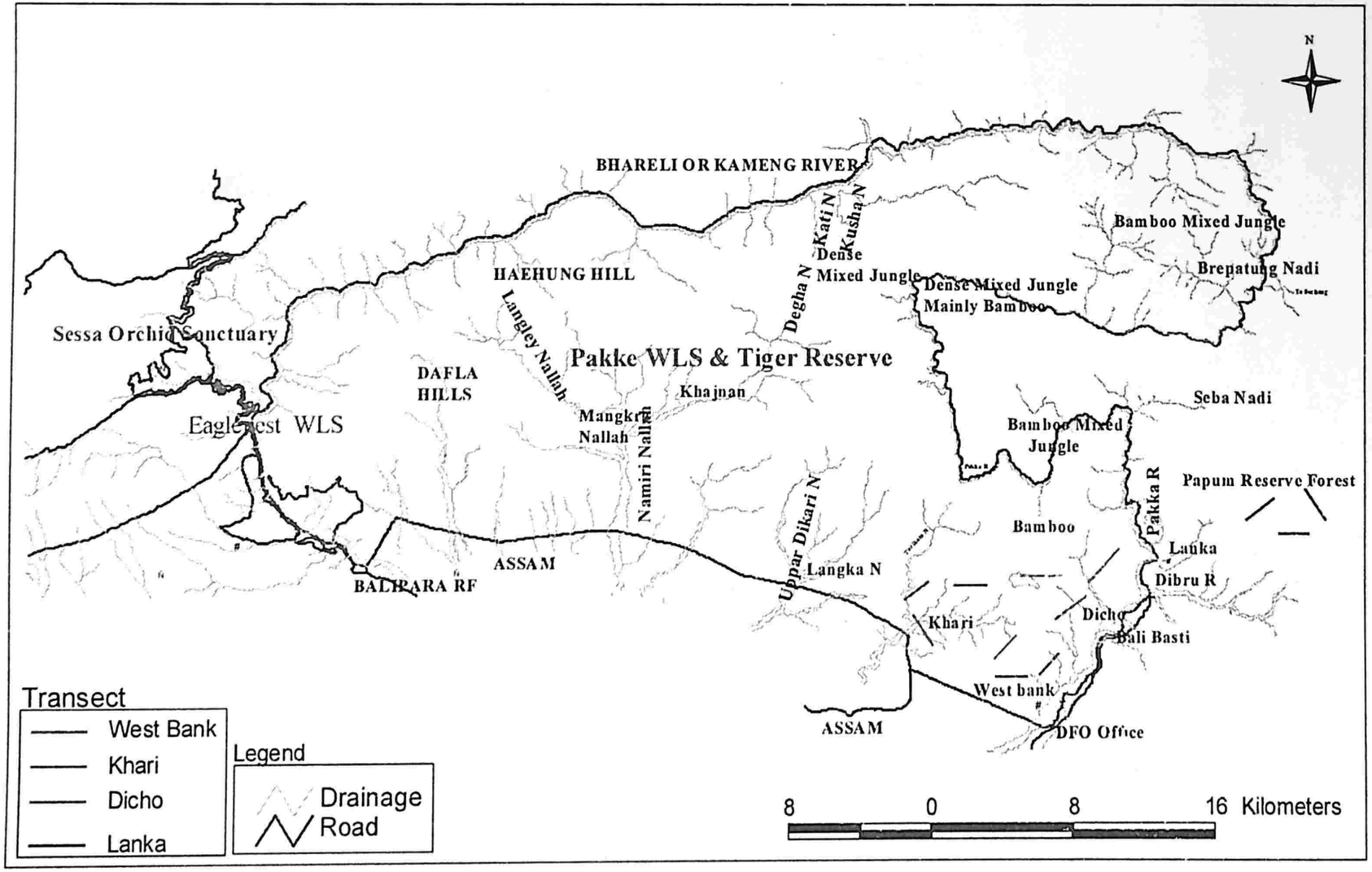

Figure 1. Map of Pakke wild life Sanctuary and Tiger Reserve showing extensive study sites and location of transects.

4.2.2 Climate

The study area receives on average rainfall of 2500 mm per year (Datta 2001). Rainfalls are received both from the south-west monsoon during the months of May – September and the north-east monsoon during December to April. With relatively dry period between the months of November and February, which is the cold period for the area.

The hottest part of the year is the months of April to June with occasional rainfall. The temperature ranges between 29^0 C ± 4.2 and 18.3^0 C± 4.7 (Datta 2001).

4.2.3 Vegetation

The general vegetation of the area is Assam tropical semi-evergreen forest 2B/C1 (Champion & Seth 1968). The vegetation is dense with a high plant and woody lianas and climber's diversity. A total of 234 plant species (Angiosperms) were recorded with high representation of species from the Euphorbiaceae and Lauraceae (Datta & Goyal 1997). The forest has a typical layered structure and the major emergent species are *Tetrameles nudiflora, Ailanthus grandis* and *Altingia excelsa* (Singh 1991). There is distinct middle storey, largely made up of shrubs like such as *clerodendron.* The forest types include Tropical semi-evergreen forests along the lower plains and foothills dominated by *Polyalthia simiarum, Pterospermum acerifolium, Sterculia alata, Duabanga grandiflora* (Singh 1991, Data & Goyal 1997). The Tropical evergreen forest are scattered along the lower plains and foothills, dominated by *Altingia excelsa*, *Mesua ferrea* and other middle storey trees belonging to the Lauraceae and Myrtaceae. Hill slopes are dominated by *Mesua ferrea* and *Castanopsis* spp. Moist areas near streams have a profuse growth of bamboo, cane and palms. About eight species of bamboo occur in the area (Singh 1991), in moist areas in gullies, in areas previously under settlements or subjected to some form of disturbances on the hill slopes (Datta 2001).

4.2.4 Fauna

Among mammals, large herbivore fauna found here include elephants (*Elephas maximus*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*), hogdeer (*Axis porcinus*) and wild pigs (*Sus scrofa*). There are also reports of goral (*Nemorhaedus goral*) and serow (*Nemorhaedus sumatrensis*) occurring in higher reaches of the park. The carnivore fauna includes tiger (*Panthera tigiris*), leopard (*P. pardus*), clouded leopard (*Neofelis nebulosa*), wild dog (*Cuon alpinus*) and smaller cats, like leopard cat (*Prionailurus bengalensis*), jungle cat (*F. chaus*) etc. Among Viverrids and Mustelids; Common palm civet (*Paradoxurus hermaphroditus*), Himalayan masked palm civet (*Paguma larvata*), Binturong (*Arctictis binturong*), Yellow throated marten (*Martes flavigula*), large Indian civet (*Viverra zibetha*), small Indian civet (*Viverricula indica*), spotted linsang (*Prionodon pardicolor*) (Datta 1999), small Indian mongoose (*Herpestes auropunctatus*), common mongoose (*Herpestes edwardsi),* striped backed weasel (*Mustela strigidorsa*), yellow-bellied weasel (*Mustela kathiah*) (Datta 1999), ferret badgers (*Melogale spp*) are also reported. During this study period tracks and scats signs of Eurasian otter *(Lutra lutra)* and small-clawed otter (*Amblonyx cinereus*) were observed. The arboreal mammals are represented by rhesus macaque (*Macaca mulata*), Assamese macaque (*M. assamensis*), capped langur (*Trachypithecus pileatus*) and four species of squirrels viz, Malayan giant squirrel (*Ratufa bicolor*), Pallas red bellied squirrel (*Callosciurus erythraeus*), hoary-bellied squirrel (*C. pygerythrus*) and Himalayan striped squirrel (*Tamiops macclellandi*). The area has several amphibian species which are least studied, there are reports of three species of turtles - Assam roofed (*Kachuga sylhetensis*), Asian leaf (*Cyclemys dentate*), Indian peacock turtles (*Aspideretes hurum*) and more than twelve species of snakes (Datta 1999) such as like reticulated python (*Python reticulates*) and Burmese python (*Python molurus bivittatus*) have been reported from the area (Datta 2001), During the period of this study a twelve foot long king cobra

(*Ophiophagus Hannah)* was rescued and crab-eating mongoose (*Herpestes urva*) was also sighted.

From the area around 256 bird species have been recorded (Datta et al. 1998). These include three species of hornbills, the great hornbill (*Buceros bicornis*). Wreathed hornbill (*Aceros undulates*), the oriental pied hornbill (*Anthracoceros albirostris*) and Rufous-necked hornbill (*Aceros nipalensis*). Apart from this, eight species of bulbuls, five species of mynas, four species of green pigeon, four species of parakeet, cuckoos, red-headed trogon, and four species of flowers-peckers has been recorded (Datta et al. 1998). Among pheasants, jungle fowl (*Gallus gallus*) and black crested khaleej pheasants (*Lophura leucomelana lathami*) are most abundant and frequently encountered. (Datta 2001), though the calls of grey peacock pheasants (*Polyplectron bicalcaratum*) is also frequently heard.

The main study sites falls in Seijusa range of the Pakke Tiger Reserve. Four sites were identified for monitoring the presence and absence of carnivore species and its relationship to habitat attributes and disturbance levels.

5. METHODOLOGY

5.1 Selection of study sites

Study sites were selected from within the Pakke Wildlife Sanctuary and adjoining Papum Reserve Forests, on the basis of various parameters which might have affected the habitat structure of the area. These parameters include, distances from nearest village, presences of domestic dog and domestic cow, logging history of the area, history of commercial cane extraction, presences of signs of hunting or trapping of wild animals, construction of recent road construction, extensive fishing in the streams by using gelatin and chemicals

like pesticides and herbicides, history of area being used for field-gun practices by Army. On the basis of above mentioned parameters, areas selected were West bank, Khari, and Dicho blocks which are all within sanctuary and Lanka Block in Papum Reserve Forests for laying track plots. The distances between the two adjoining sites were on an average eight kilometer.

5.2 Laying of track plots

Once areas were identified, three transects of length three km were chosen randomly in each area. In the transects so selected, a track plot of 3x2m was made by loosening soil and clearing litters like leaf fall, twigs, over which fine sand particles from the surrounding was spread, at every 250 m interval. In areas where such sand particles were not available, a soft layer of soil was sprinkled all over by sieving soil particles through 3 mm mesh wire. In a transect twelve track plots were laid, so in each study site thirty six track plots were laid ,which covered an area of nine kilometer.

5.3 Measurement of habitat attributes

A circular plot of five meter from the center of each plot was laid to measure habitat attributes such as, canopy cover, canopy height, shrub cover, shrub height ,distances from nearest village, number of lianas (>10 cm), number of trees (>20 cm at breast height), number of tree species, canopy cover within each circular plot was measured by using Densitometer at four side and center of the circular plot. The lowest continuous branch layer within the circular plot was taken for measurement of canopy height. Canopy height was measured by a calibrated pole. Shrub cover was estimated occularly. Average heights of most dominate shrub cover was measured by a calibrated pole. Number of trees (>20

cm at breast height) within the circular plot were counted and their vernacular names were noted.

Number of lianas (>10 cm) within each circular plot were counted at the base. The GPS location of each track plot was noted. The distances from the nearest human habitation to the track plot was noted from GPS.

5.4 Identification of track and signs

Guwahati and Itanagar zoos were visited to identify and differentiate the tracks of various carnivore specie found in the study area. With the help of zoos staff, I took photograph and measured the length, breadth and stride of targeted carnivore species. These measurements were the index for species identification in track plots. These measurements were taken by lying wet track plot within the enclosures. During the study period, villagers caught a leopard cat (*Prionailurus bengalensis)*. Its track shape and size recorded. I had two sightings of jungle cat, its tracks were search and recorded for identification. During the study period, I could record the shape and size of tracks of one dead large Indian civet (*Viverra zibetha*), two small Indian civet *(Viverricula indica*), which were caught in traps laid for pheasants by the villagers. Castings of these dead animals' tracks were taken on plaster of paris cast. I took help of experience trackers to identify the tracks in field.

Field guide for identifying tracks by Gurung and Singh (1996) was extensively used for identifying, especially small carnivore's tracks.

5.5 Records of track plots

I laid 36 track plots in the three randomly selected transects in each area. A total of 144 plots could be laid. The selected areas were on an average separated from the nearest site by eight kilometers, though forest connectivity was present, except for site Lanka in Papum Reserve Forests which was separated from the rest by Pakke River.

A transect was on an average visited every fifteen days. On an average six visits were made to each site. The total plots thus monitored were 864. At every visit, date, time, weather and general condition of track plot were noted. Track signs of every species captured in tracks plots were recorded. The presence of other indirect evidences such as scats of carnivores, pellets and dung of herbivores were also recorded. Wherever possible tracks length, breadth, stride and steps of every carnivore species visiting the plot was recorded and if possible was identified to species level. When ever a carnivore track was not identified to species level it was recorded as guild of civets, and small cats. Civets included tracks with distinct nail marks, other than that of wild dog and jackal tracks. Those unidentified small sized tracks with toes without distinct nail marks were included as small cats. The unidentified tracks were assigned to respective guilds only after consultation with my experienced assistants. Records of sightings of animals and of indirect evidences, such as scats, pellets of herbivores and tracks of carnivores between two track plots were also recorded.

6. Disturbance parameters

The various disturbance parameters were scored from 3 to 1 as degree intensity of disturbance. Presence or absence of carnivore species in an area might not have direct

link with these parameters. The different parameters were selected on the basis of disturbances per se, these were,

Disturbance parameters	Disturbance score
i) Presence of cattle	2
ii) Logging history/present cane working	2
iii) History of firing (by Army)	2
iv) Trap signs/hunting	3
v) Fishing	2
vi) Presence of domestic/feral dogs	3

Presences of cattle have negative affect on the presences of rodents (Mukherjee 1998), which are one of the major diet of small cats (Mukherjee 1989, Kitchener 1991). Cattle are signs of wealth for the local people and are reared for meat and to meet the cost of any eventually. The cattle are left free in forest without any herdsmen. The effects of selective logging range from an alteration in the distribution and abundance of resource to the changes in microclimate and a reduction in availability of breeding sites, nests and refuges for birds and arboreal mammals (Johns 1983). All the study area was worked under Assam *mohal* system of cane extraction. In which contractors were allotted ten years of lease for extracting cane from allotted area. Large number of labourers was employed for these purposes (Arunachal Pradesh Forest Department).

Indian army has been using the hill tops of *Dicho* for field-gun practice since 1965 till 1997 (Arunachal Pradesh Forest Department). Around four hilltops were the target spot. The impact areas have completely removed the tree cover from these areas. At present hundred percent of vegetation of this area composes of tall grasses. A scat of tiger was found in one of this hill tops. The villagers from the nearby villages frequently go these hilltops for collecting shell metal pieces.

Hunting and fishing in the area is widespread. There is strong perception among the local people about hunting being as their traditional right. And they regularly indulge into it. Presences of domestic/feral dogs indicate disturbances for being associated with human activities (Johnsingh et.al. 2004).

7. Data analysis

All statistical analysis was carried out using *EXCEL*, *SPSS* and *S-PLUS 4.5.* Descriptive statistics and non-parametric tests were used wherever appropriate (Zar 1974, Siegel & Castellan 1988). Chi-square Test for Proportions (Gibbons 1971) was preformed to examine the difference of track occurrence of various carnivore species across sites. Classification and Regression tree (*CART)* model (De'ath & Fabricius 1999) was used to explore relationship between observations of carnivores' species and their corresponding habitat variables. *EstimateS* (Version 7.5, Colwell, unpublished) was used to determine species richness between sites. Mantel non parametric test (Liedloff 1999) was also used to examine the association between co-occurrence species and their differences in mean body weight.

8. RESULTS

8.1 Habitat variables

Habitat attributes such as, canopy cover, canopy height, shrub cover, shrub height, distances from nearest village, number of lianas (>10 cm), number of trees (>20 cm at breast height),and number of tree species, for each transect was recorded (Table 1). The number of lianas in a plot was recorded as an index of disturbances level. As people moves in forest they generally cut the lianas first to clear walking path.

To test the correlation between the habitat variables, Spearman's rank correlation test was performed on habitat variables (Table 2). The mean canopy cover was highly correlated with tree density per plot (r_s = 0.474, n = 144, p = 0.05) and number of trees in each plot (r_s = 0.272, n = 144, p = 0.05) Canopy height was not correlated with any habitat variables. Shrub cover was negatively correlated with tree density (r_s = 0.-316, n = 144, p = 0.05), and with number of tree species in a plot (r_s = 0.-300, n = 144, p = 0.05) and was not correlated to canopy height (r_s = 0.-023, n = 144, p = 0.05). Shrub height was negatively correlated with tree density (r_s = 0.-268, n = 144, p = 0.05), number of tree species (r_s = 0.-266, n = 144, p =0.05), and was positively correlated to shrub cover (r_s = 0.268, n = 144, p = 0.05).

Table 1. Habitat variables at four different study sites in Pakke Tiger Reserve, Arunachal Pradesh

Sites with Transects	Mean canopy cover (%)	Canopy height	Shrub cover (%)	Shrub height (m)	Number of lianas	Tree density	Number of tree species/ plot	Distances from nearest village
Dicho 1	60	4	42	1.31	4	0.10	5	2720
Dicho 2	46	4	48	3.61	4	0.11	5	1475
Dicho 3	58	5	36	1.10	4	0.16	8	1828
Khari 1	66	5	39	1.21	11	0.13	6	7280
Kahri 2	61	6	28	1.18	9	0.13	6	7120
Kahri 3	65	5	41	1.39	14	0.13	6	7380
West bank 1	46	4	52	1.23	3	0.41	4	827
West bank2	68	6	41	1.75	6	0.65	4	2674
West bank3	68	4	39	0.83	8	0.69	4	2813
Lanka 1	35	5	68	1.67	2	0.12	6	1246
Lanka 2	51	7	49	0.88	2	0.12	6	2146
Lanka 3	57	5	43	1.47	6	0.12	6	3410

The distances from village correlated to mean canopy cover (r_s = 0.458, n = 144, p = 0.05). Number of lianas per plot was correlated with tree density (r_s = 0.464, n = 144, p = 0.05). It was also positively correlated with to number of tree species present in plot (r_s = 0.464, n = 144, p = 0.05).and mean canopy cover (r_s = 0.507, n = 144, p =0.05).

Kruskal - Wallis one way analysis of variance test was performed to examine the differences of habitat variables across site. The habitat variables such as number of trees in a plot (KW, χ^2 =13.558, p <0.05), canopy height (KW, χ^2 = 8.718, p <0.05), canopy cover (KW, χ^2 = 38.653, p <0.05), and number of tree species (KW,χ^2 = 8.940, p <0.05) were different between areas except for shrub cover (KW, χ^2 = 2.854, p >0.05) and shrub height(KW,χ^2=0.152,p>0.05).

Table. 2. Spearman's Correlation of habitat parameters in Pakke Tiger Reserve, Arunachal Pradesh.

	tree density/plot	number of tree species	Mean canopy cover (%)	Canopy height (m)	Shrub cover (%)	Shrub height (m)	Distance from village (km)	Lianas number.
tree density/plot	1.000							
	.							
number of tree species	.474	1.000						
Sig. level	.000	.						
Mean canopy cover (%)	.557	.272	1.000					
Sig. level	.000	.001	.					
Canopy height(m)	-.077	-.007	.004	1.000				
Sig. level	.361	.931	.958	.				
Shrub cover (%)	-.316	-.300	-.346	-.023	1.000			
Sig. level	.000	.000	.000	.782	.			
Shrub height(m)	-.268	-.226	-.145	-.051	.265	1.000		
Sig. level	.001	.006	.084	.547	.001	.		
Distances from village (km)	.058	.026	.458	.043	-.136	-.011	1.000	
Sig. level	.489	.753	.000	.611	.104	.900	.	
Lianas number	.464	.179	.507	.035	-.243	-.191	.455	1.000
Sig. level	.000	.032	.000	.676	.003	.022	.000	.

8.2 Disturbances rating

According to the disturbances parameters encountered in the four areas and their intensity a score of 1, 2 and 3 was given to low, medium and high disturbance leve3ls. The scores for each area were multiplied with the corresponding disturbances scores. Lanka had the highest score of disturbances at 33 and Khari having the least score of eight.

Table 3. Disturbances rating for four intensive study sites in the Seijusa Range of Pakke Tiger Reserve, Arunachal Pradesh.

Disturbances parameters	**Scores**	**Dicho**		**Lanka**		**West Bank**		**Khari**	
		Rating	***Score***	***Rating***	***Score***	***Rating***	***Score***	***Rating***	***Score***
Presences of cattle	2	2	4	3	6	3	6	0	0
Logging or cane history	2	2	4	3	6	2	4	2	4
Present cane working	2	0	0	3	6	0	0	0	0
Army field firing	2	2	4	0	0	0	0	0	0
Trapping or hunting	3	2	6	3	9	2	6	2	4
Presences of dog	3	2	6	2	6	2	6	0	0
Total			**26**		**33**		**22**		**8**

8.3 Carnivore species richness

Of the recorded six species of Felids from the study area (Table 2) signs of four species were recorded in the track plots and of the 15 recorded small carnivores (i.e. Mustelids, Vivverids and Herpestids) (Datta 1999) evidences of seven species of small carnivores

were recorded during the study (Table 4). The tracks of Asiatic black bear (*Ursus thibetanus*) and of wild dog (*Cuon alpinus*) were also recorded. Among the four sites, Dicho had the highest records of carnivores species of eight species using Cole Rarefaction compared at standardized sampling effort (Figure 2).

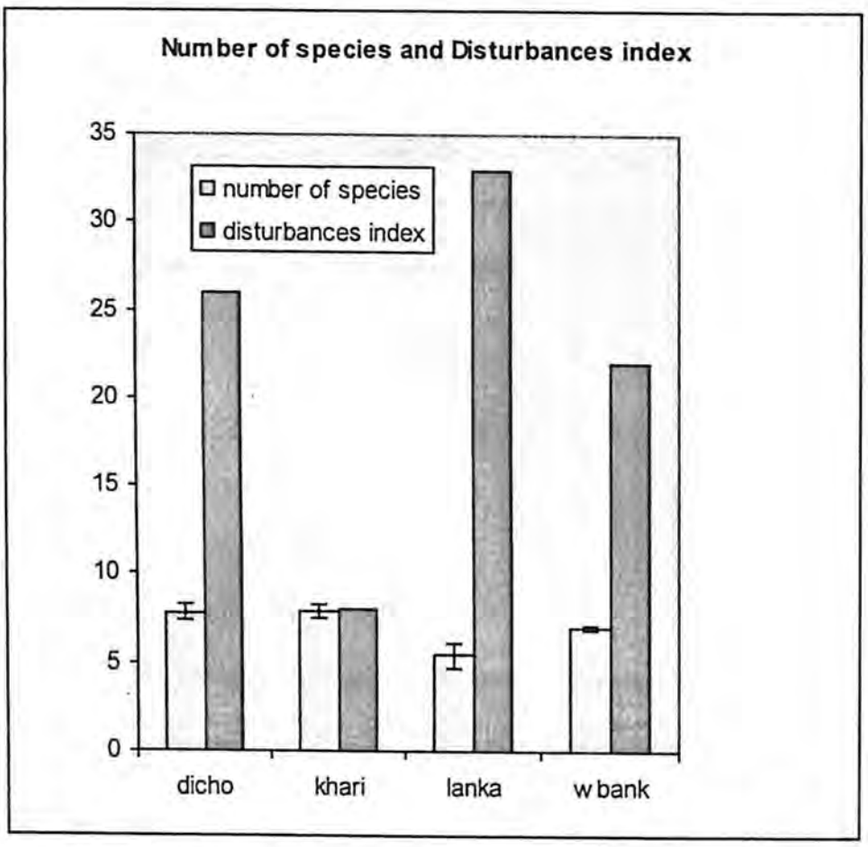

Figure 2. The number of carnivore species and disturbance index in each intensive study sites in Pakke Tiger Reserve

8.4 Species occurrences

Of the all carnivores recorded in the tracks, small Indian civet had the highest of rate of occurrences followed by common palm civets occurrences. (Figure 3), though large part of records (20%) of the tracks has been classified as either unknown civet or as unknown cat species. Chi-square Test for Proportion was performed on proportion of occurrences of carnivore species tracks (Figure 4) tracks between sites. The records of Himalayan

black bear and small clawed otter of tracks plots has been omitted for analysis, as they were recorded only once.

Table 4. Carnivore species reported from the Pakke Tiger Reserve, Arunachal Pradesh and the list of species seen/evidences found during the present study

Family	Common name	Scientific name
Mustelidae	Yellow-throated marten *	*Martes flavigula*
	Yellow-bellied weasel	*Mustela kathiah*
	Back-striped weasel	*Mustela strigidors*
	Large-toothed ferret badger	*Melogale personata*
	Eurasian otter ✓	*Lutra lutra*
	Small-clawed otter*	*Amblonyx cinerea*
Viverridae	Binturong	*Arctictis binturong*
	Common palm civet✓	*Paradoxurus hermaphroditus*
	Masked palm civet**	*Paguma larvata*
	Large Indian civet✓	*Viverra zibetha*
	Small Indian civet✓	*Viverricula indica*
	Spotted linsang	*Prionodon pardicolor*
Herpestidae	Small Indian mongoose ✪	*Herpestes javanicus*
	Grey mongoose	*Herpestes edwardsii*
	Crab-eating mongoose✪	*Herpestes urva*
Felidae	Tiger*	*Panthera tigris*
	Common leopard*	*Panthera pardus*
	Clouded leopard	*Neofelis nebulosa*
	Jungle cat✪	*Felis chaus*
	Leopard cat✪	*Prionailurus bengalensis*
	Fishing cat?	*Prionailurus viverrinus*
Ursidae	Asiatic Black Bear*	*Ursus thibetanus*
Canidae	Wild dog	*Cuon alpinus*

*✪= sighting, ✓= skin collected, * = track of these species, ** = skin seen, ? = probable*

Proportion occurrences of track of common palm civet (χ^2 = 7.412, df = 3, α = 0.05), Jungle cat (χ^2 = 1.130, df = 3, α = 0.05) across sites were similar. Whereas proportion occurrences of tracks of Large Indian civet (χ^2 = 8.875, df=3, α =0.05), leopard (χ^2= 284.40 df = 3, α = 0.05), leopard cat (χ^2 = 14.90, df =3, α = 0.05), Small Indian civet (χ^2 = 253.61, df = 3, α =0.05), Tiger (χ^2 = 69.65, df=3, α =0.05), Yellow throated marten (χ^2

= 22.949, df = 3, α = 0.05) and of wild dog (χ^2 = 72.713, df = 3, α =0.05) across sites were different.

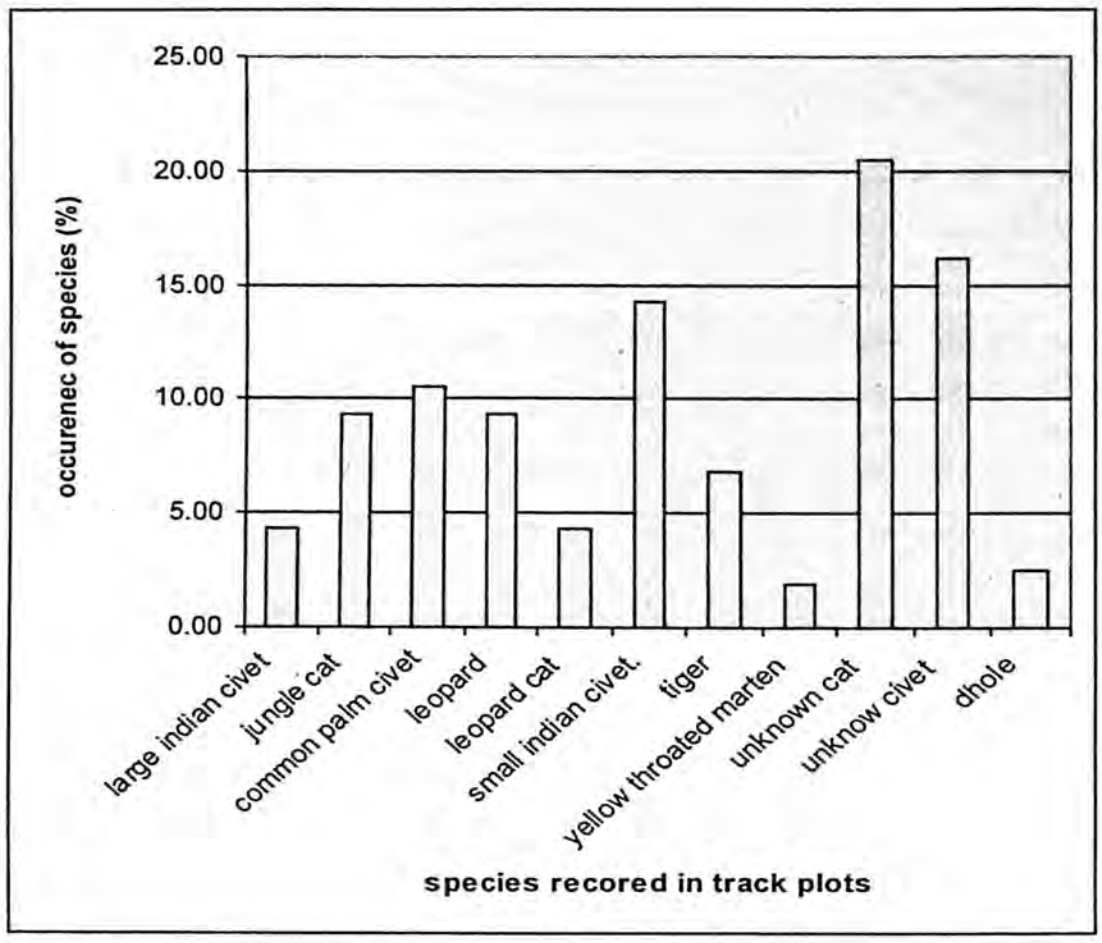

Figure 3. Shows percentage occurrence of each species of total track records

8.5 Species co-existences

Non metric multidimensional scaling was performed using SPSS 8.00 software on the presences - absences data of carnivore species of transect to examine occurrences pattern of carnivore species so recorded from the study area. Two major gradients captured most of the variance in carnivore communities; higher dimensions improved the model very little. The distances of occurrences between the species in the two dimension plane were measured using Euclidean measure. The minimum stress convergence was set at 0.001 with minimum stress value of 0.005. The final results were obtained, after five hundred iteration.

All small carnivore multidimensional scaling shows that, common palm civet and jungle cat occurred together in same quarter and large Indian civet and yellow throated marten occurred together in a different quarter of the Figure.5

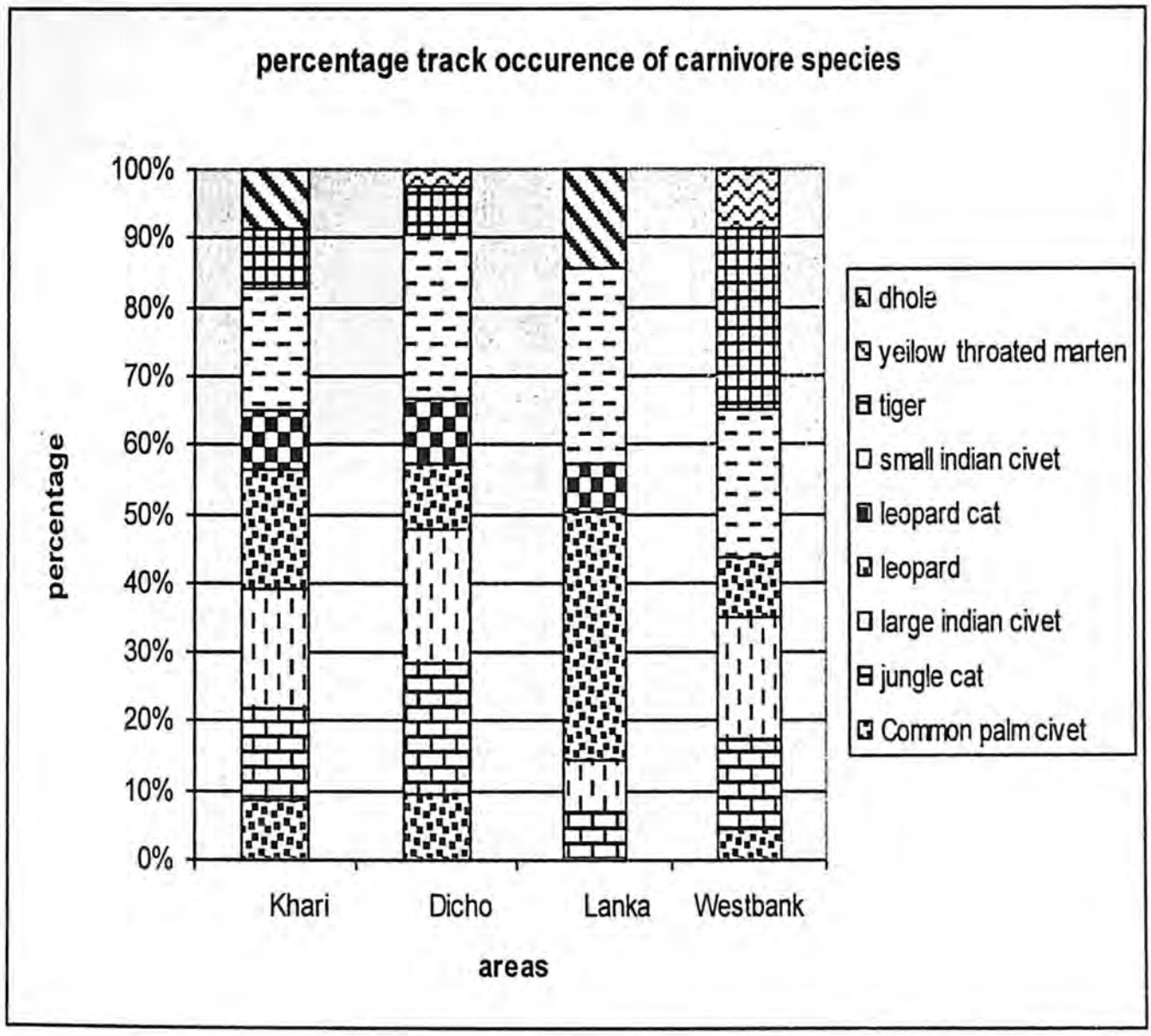

Figure 4 Proportion of tracks of carnivore species in each intensive study site

Leopard cat occurred separately from the quarter of jungle cat and common palm civet. Similarly small Indian civet occurred in separate quarter which was farthest from the quarter of yellow throated marten and large Indian civet. The stress value was 0.1093, at R square of 0.90 (Figure 5).

All small and large carnivore multidimensional scaling shows that, tiger, leopard and wild dog occurs in each quarter separately. Jungle cat and common palm civet occurred distinctly in a quarter to dholes and leopard cat. Yellow throated marten, large Indian civet and tiger occurred in separate quadrate which was farthest to the quadrate of leopard and small Indian civets. The stress value for this matrix was 0.15 with an R square of 0.83, (Figure 6).

The occurrence of herbivores recorded on transects and that of occurrences of tiger and leopard shows that, leopard occurred with sambar, barking deer and wild pig in the same quarter of the figure. Tiger occurred distinctly. The stress value for this matrix was 0.007 at R square value of 0.99. (Figure 7)

The occurrence data of wild dog with that of other large carnivores and herbivores of the study area shows that, wild dog and tiger occurred distinctly to that of leopard which occurred with sambar, barking deer, wild boar and porcupine. The stress value for this matrix was 0.045 at R square value of 0.99. (Figure 8).

When occurrences data of all species recorded in the track plots were scaled, it shows that, small Indian civet, porcupine and leopard, occurred in quarter distinct to quarter of tiger, yellow throated marten and large Indian civet. The wild dog and leopard cat occurs in quarter distinct to quarter of sambar, barking deer, common palm civet, wild boar, and jungle cat. The stress of this matrix was 0.148 at R square value of 0.89 (Figure 9).

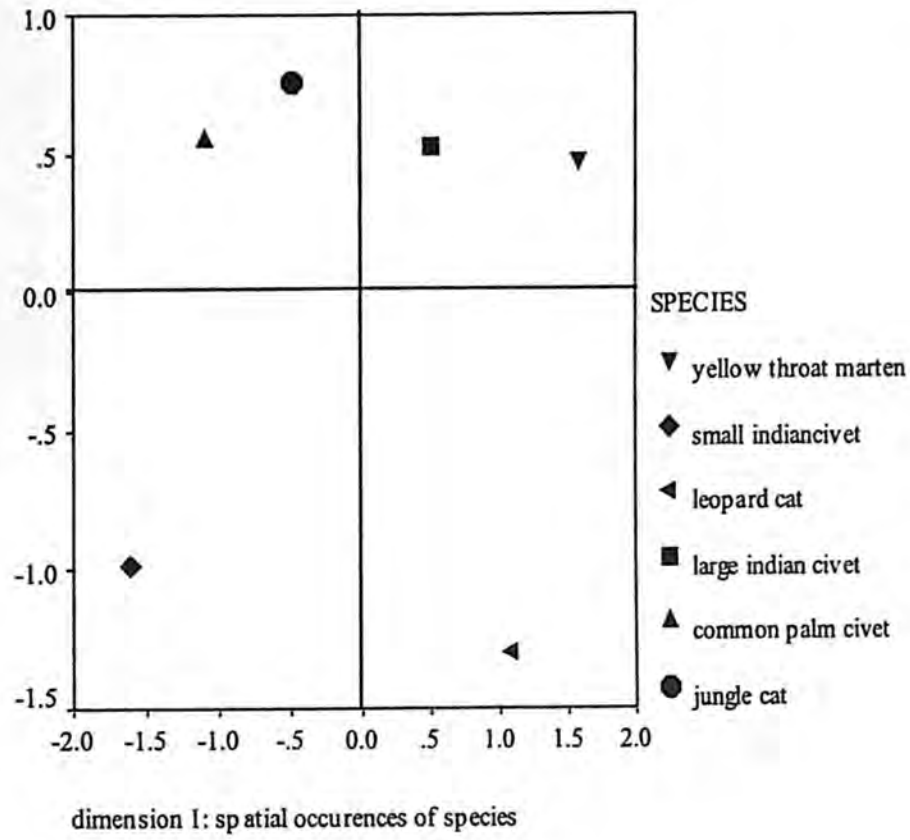

Figure 5. Multidimensional scaling of occurrences of small carnivores.

Stress = 0.10, $R^2 = 0.90$

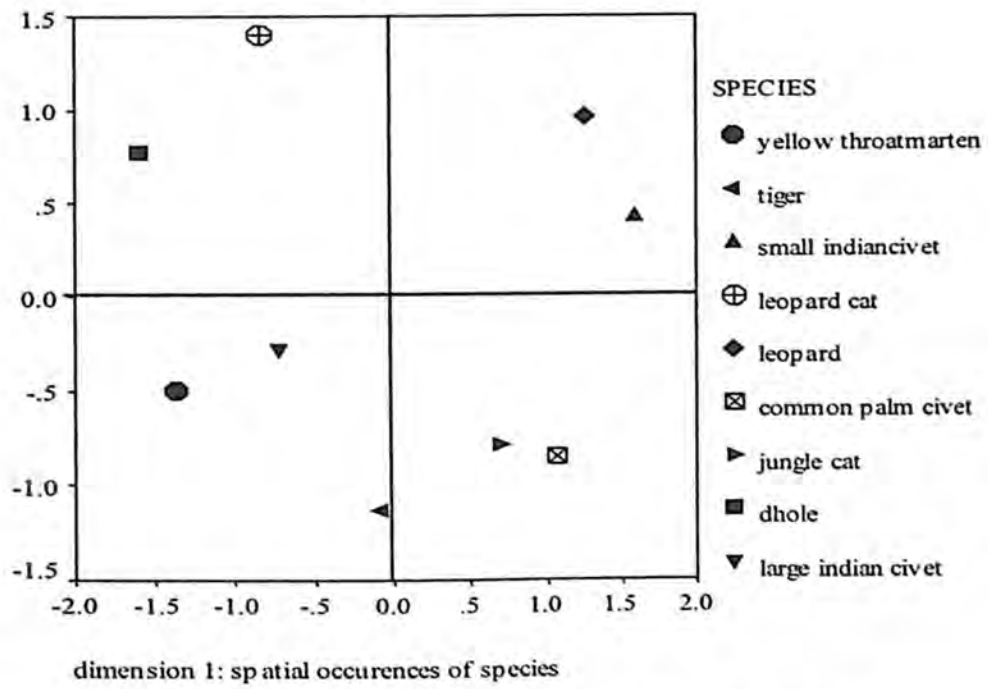

Figure 6. Multidimensional scaling of occurrences of all carnivores

Stress = 0.15, $R^2 = 0.83$

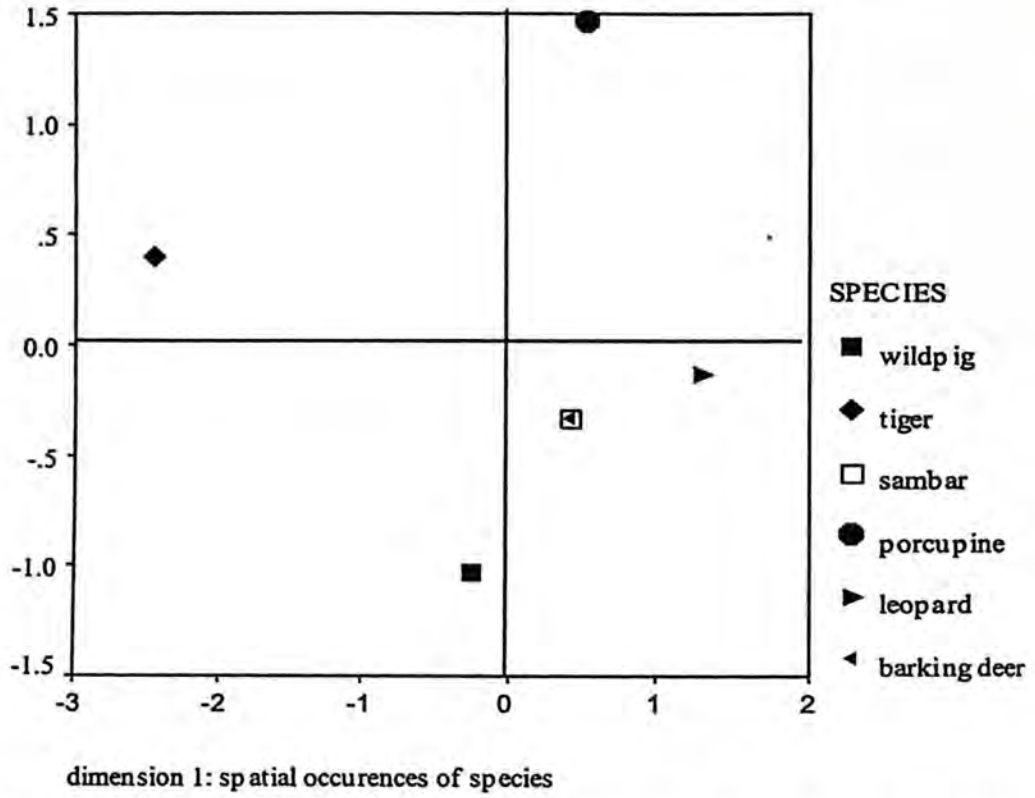

Figure 7. Multidimensional scaling of occurrences of herbivores, tiger and leopard

Stress = 0.007, $R^2 = 0.99$

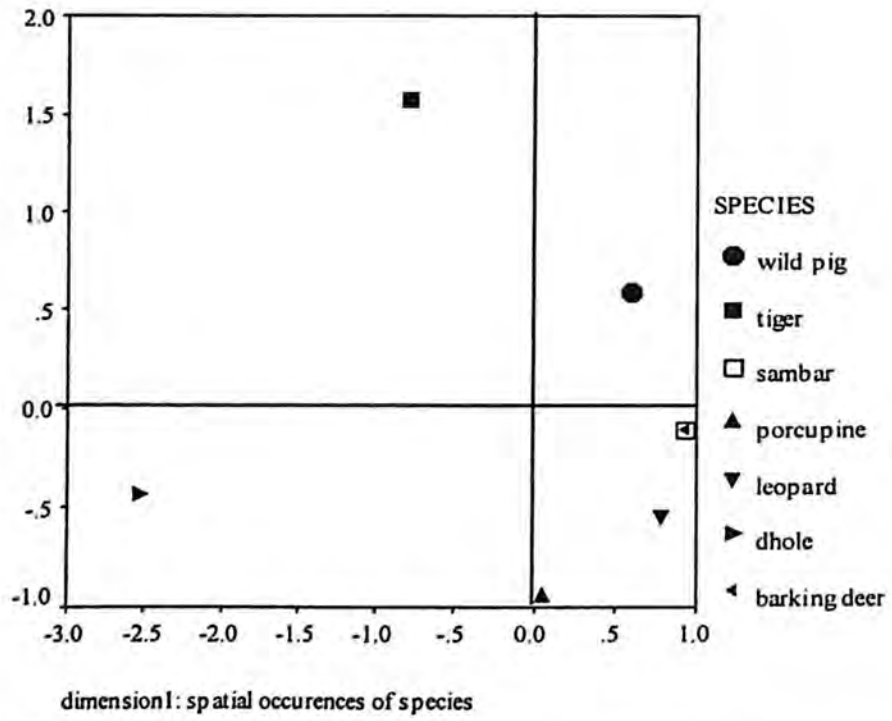

Figure 8. Multidimensional scaling of occurrences of herbivores and all large carnivores

Stress = 0.045, $R^2 = 0.99$

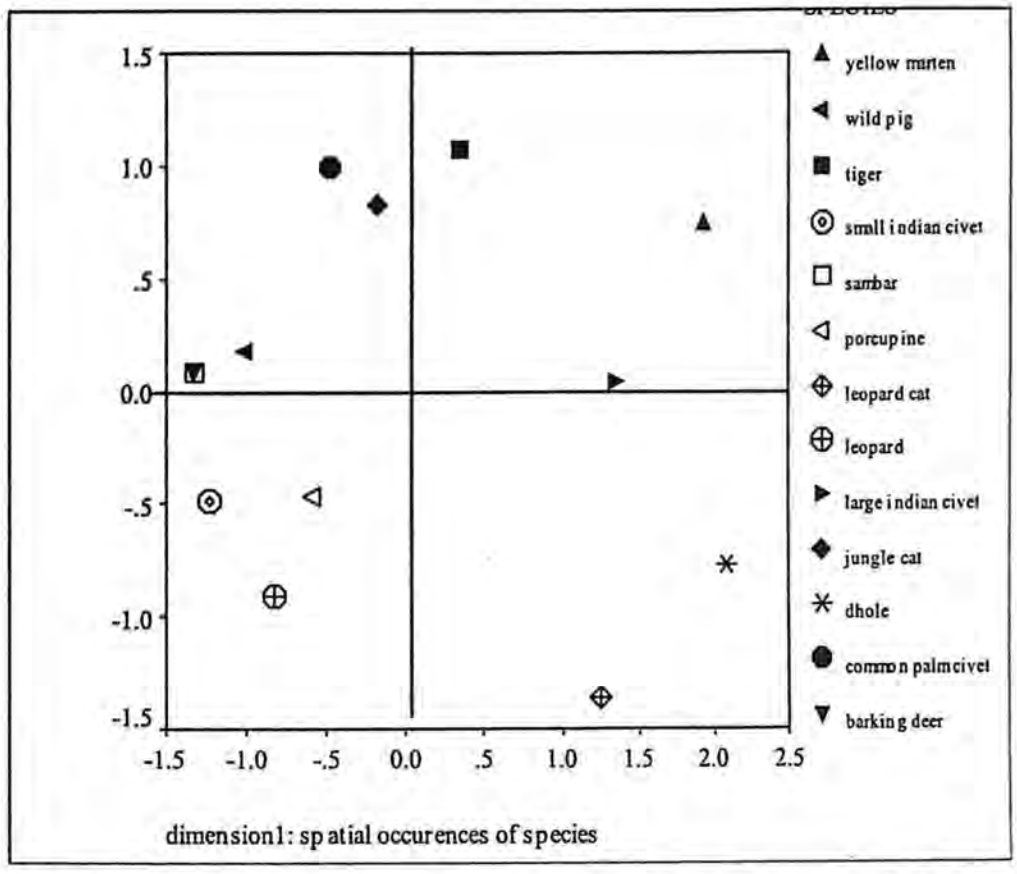

Figure 9. Multidimensional scaling of occurrences of herbivores and all large carnivores

Stress = 0.148, $R^2 = 0.89$

8.6 Responses of carnivore species to disturbance

Software SPSS 8.00 was used for performing non metric multidimensional scaling on the presences - absences data of carnivores so obtain in track plots, with that of presences-absences record of various disturbances parameters so identified. The disturbances parameters were scored as 1 for being present and 0 for being absent. A disturbance parameter was present, if it was recorded before and during the monitoring of the track plots. If the disturbances parameters were present in past then it was counted as present.

Two major gradients captured most of the variance in carnivore communities; higher dimensions improved the model very little. The distances of occurrences between the species in the two dimension plane were measured using Euclidean measure. The

minimum stress convergence was set at 0.001 with minimum stress value of 0.005. The final results were obtained after five hundred iteration.

Multidimensional scaling shows that small Indian civet and common palm civet occurred more in disturbed area than large Indian civet and yellow throated marten. Areas with high presences of domestic dog had no presences of these animals. The stress value of this matrix was 0.08, at R square value of 0.96 (Figure 10).

When occurrence of small cats were scaled with that of disturbances parameters, Jungle cat and leopard cat occurred away from areas with high disturbances (Figure 11). The stress of this matrix was stress0.029, at R square value of 0.99.

When the occurrences of large carnivores were plotted with that of disturbances parameters, it shows that tiger and dhole occurred in quarter which were least disturbed. Leopard occurred in quarter which was relatively more disturbed. All the herbivores occurred more in areas where it was logged and other form of disturbances were present relatively more than other quarter (Figure 12). The stress of this matrix was 0.11 and R square of 0.93.

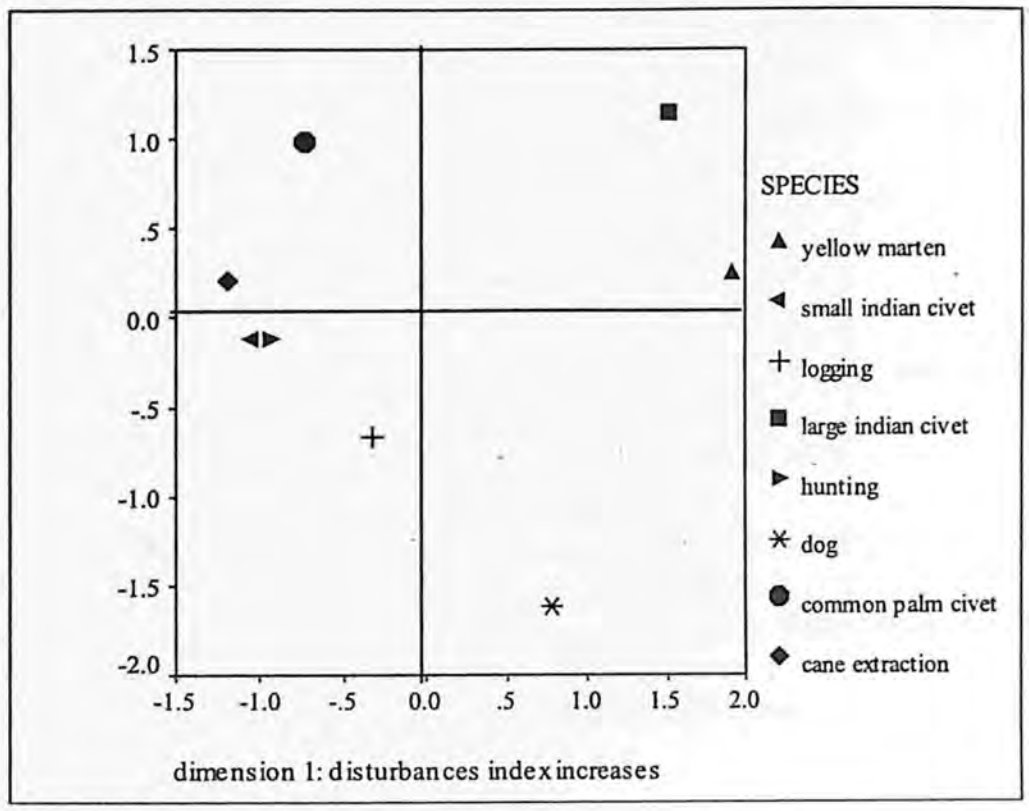

Figure 10. Multidimensional scaling of occurrences of civets, yellow throated marten and disturbances. Stress = 0.08, $R^2 = 0.96$

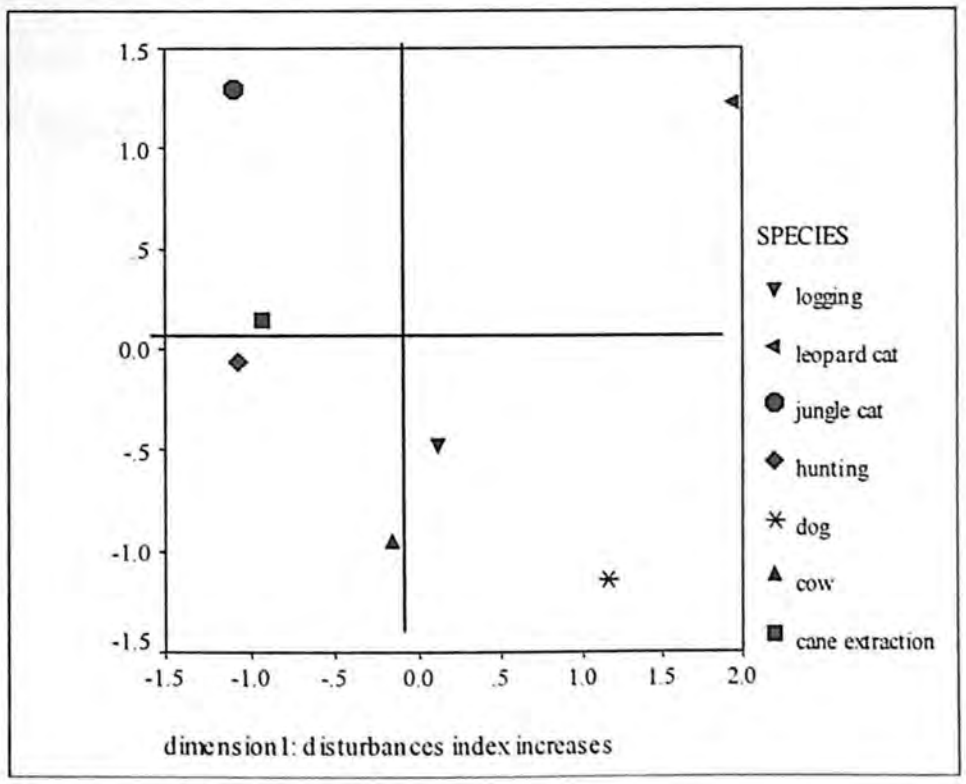

Figure 11. Multidimensional scaling of occurrences of small cats and disturbances. Stress = 0.029, $R^2 = 0.99$.

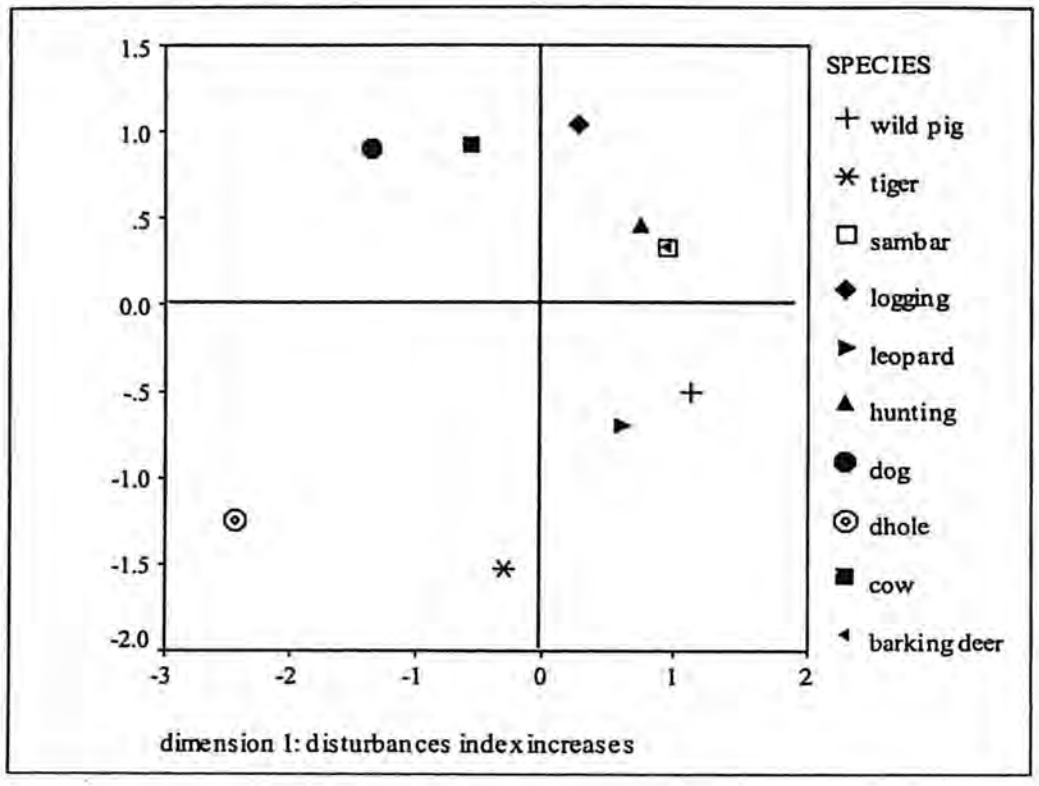

Figure 12. Multidimensional scaling of occurrences of large carnivores and disturbances.

Stress = 0.11, $R^2 = 0.93$

8.7 Body size and occurrence

Body size appears as an important variable in analyzing life history variation because most life history traits correlates with the rate of physiological activity and consequently with size (Hugget and Widdas 1951, McNab 1980, Lindstedt and Calder 1981).The relation ship between body size and home range of and species had been studied (Harvested & Bunnell 1979, Gittleman & Harvey 1982, Reiss 1988, Swinart et al. 1988). Body mass is generally acknowledged to be the most important factor setting the level of basal rate metabolism in the mammals (McNab 1980). The smaller size species have higher basal metabolic rate (McNab 1989).The basal rate of metabolism is also correlated to food habits, climate and activity level of the species (McNab 1989). Organisms expend energy for variety of tasks, including body maintenances, movement, resource

acquisition, courtship, reproduction and growth (McNab 1989). With this back ground, I examined whether body size had any association with the occurrences of the carnivore species. My hypothesis was that larger the differences in mean body weight of two species, there is more chance that they will occur together.

A dissimilarity matrix of co-occurrence of carnivore species were calculated from presences - absences data of transects using software SPSS 8.00. The measure of Euclidean distances was taken as the measure of occurrence between two species. The mean body weights of various carnivore species were obtained from various literatures. (Kruska 1990, Prater 1971, Menon 2003).The dissimilarity matrix of mean body of all recorded carnivore species was prepared.

These matrixes of co-occurrence and differences in the body weight of carnivore species were examined, for association using mantel non parametric tests. The test shows that there is inverse association between them (Mantels, r = -0.68, $p = 0.05$) (Figure 13).

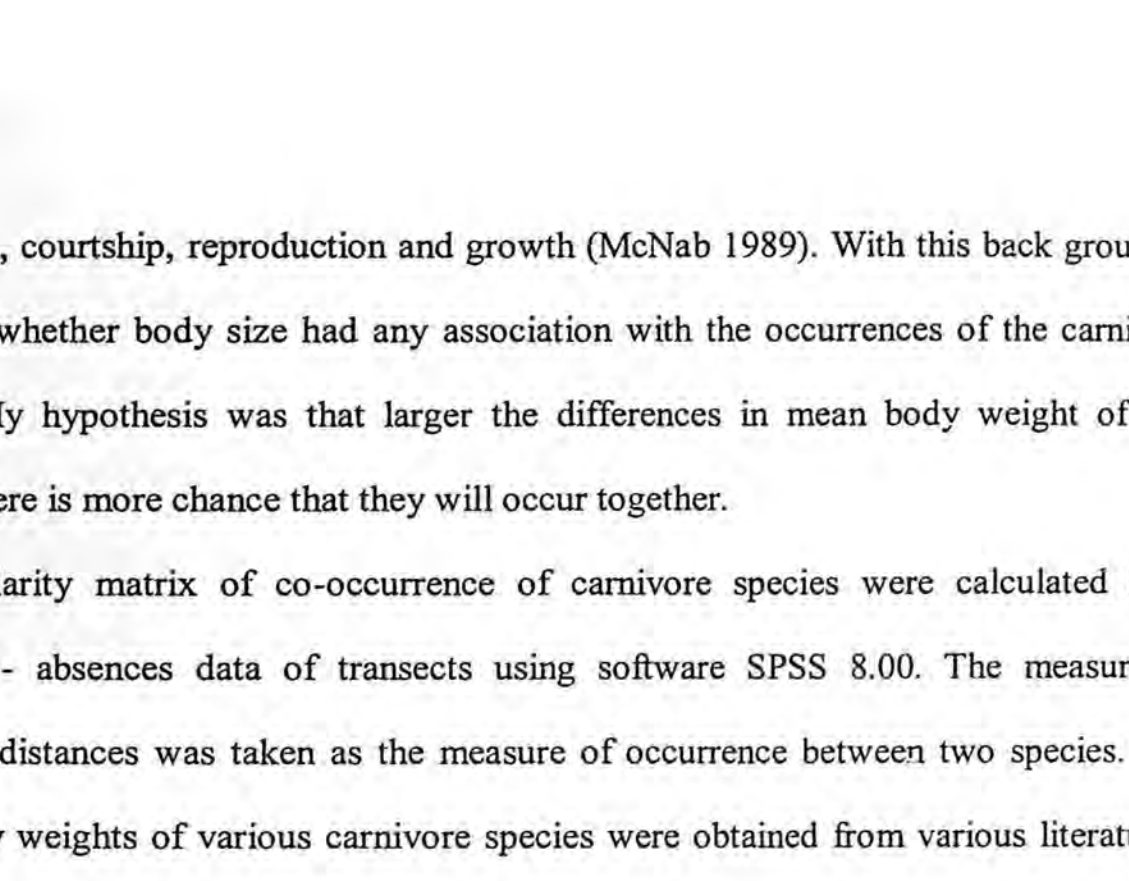

Figure13. Co-occurrence of species and difference in their body weight.
(Mantels r = -0.68, $p = 0.05$)

8.8 Habitat variables and carnivore species occurrence

The influences of habitat variables on the occurrences of carnivore species were examined by using Classification tree analysis by using S-PLUS 4.5 software. Classification tree analysis explains variation of single response variable by repeatedly splitting the data in to more homogeneous groups, using combinations of explanatory variables that may be categorical and or numeric. (De'ath & Fabricius 1999).

For performing this analysis, the records of large Indian civet, small Indian civet and that of common palm civet was represented as civets. This was done because of low tracks records of these species individually. All the species which had less than five capture records were omitted from analysis. This included Himalayan black bear, small clawed otter, dholes, and yellow throated marten. Also, the records of jungle cat and leopard cat has been grouped as, small cats for analysis due to low capture in the track plots.

Due to low record of tiger pug mark (n=11) and leopard track (n=15) out of 864 sampling plots. No analysis was done to examine their relation ship with other variables.

(i) *Occurrence of civets and their habitat variables*

Civets showed varying responses to their surrounding habitat. Their occurrence increased with distance from the village increased (Figure 15). The occurrence patterns of civet showed association with high canopy cover and low canopy height. (Figures 16 & 17). Civets occurred more in area with greater shrub cover and shrub height (Figure 18 &19).

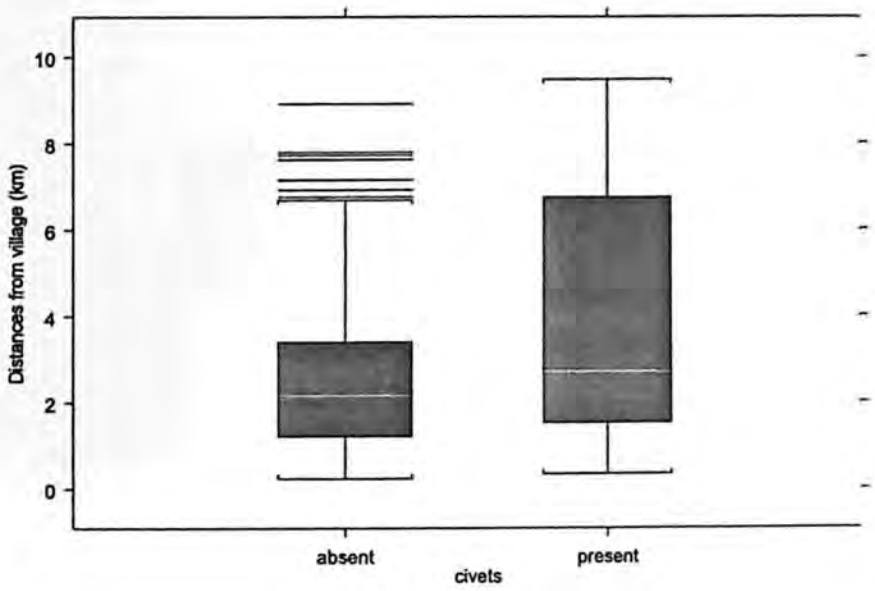

Figure 15. Presences - absences of civets from distances from village (km)

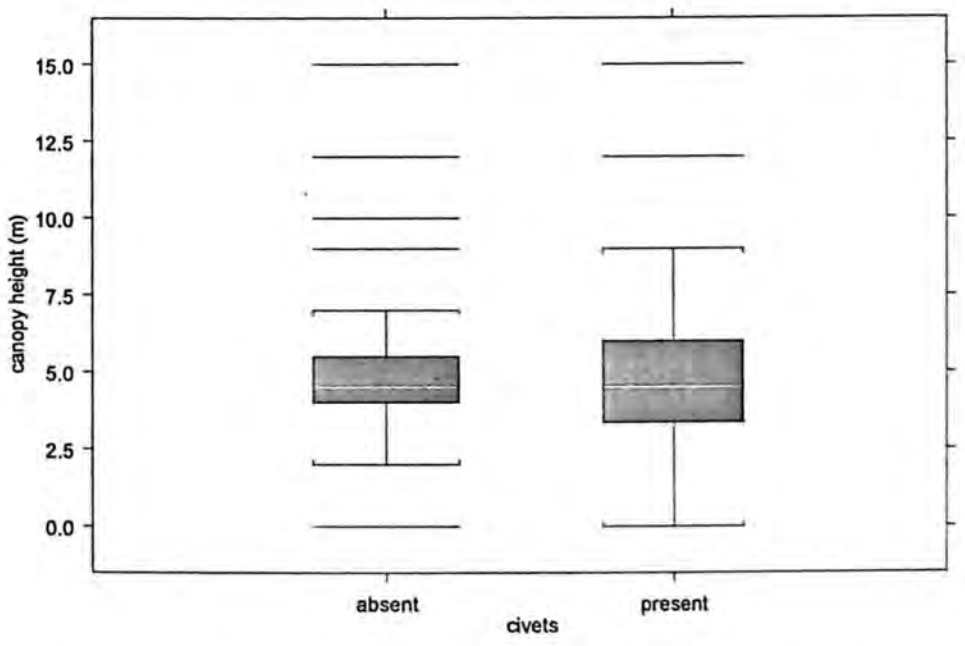

Figure 16. Presences - absences of civets with canopy height.

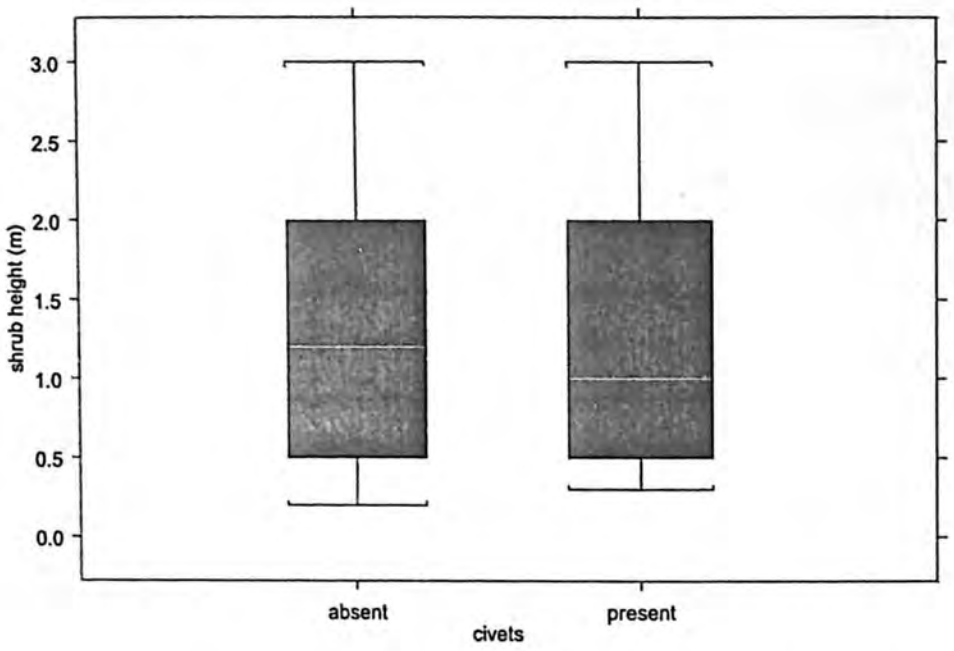

Figure 17. Presences - absences of civets with shrub height (m)

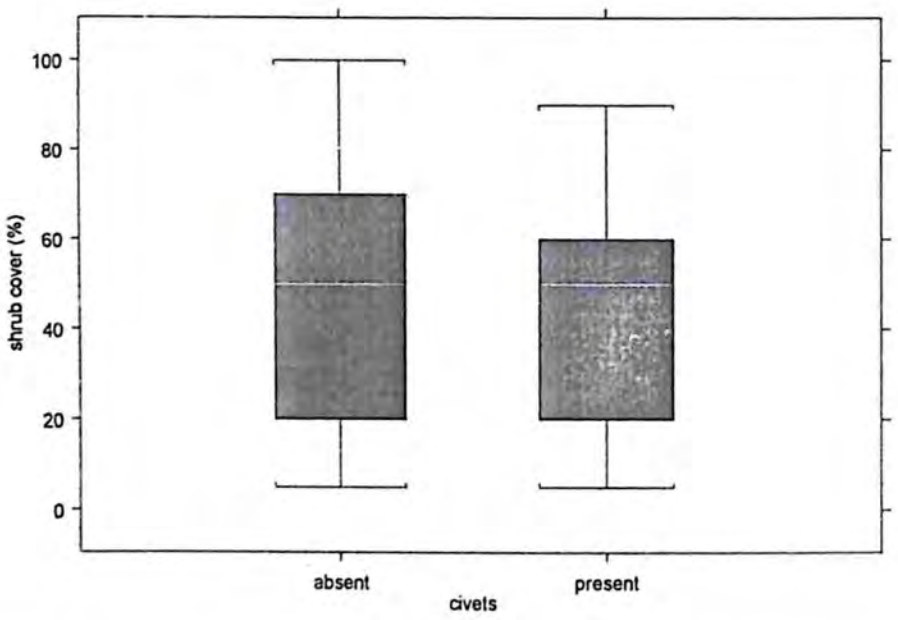

Figure 18. Presences - absences of civets with shrub cover.

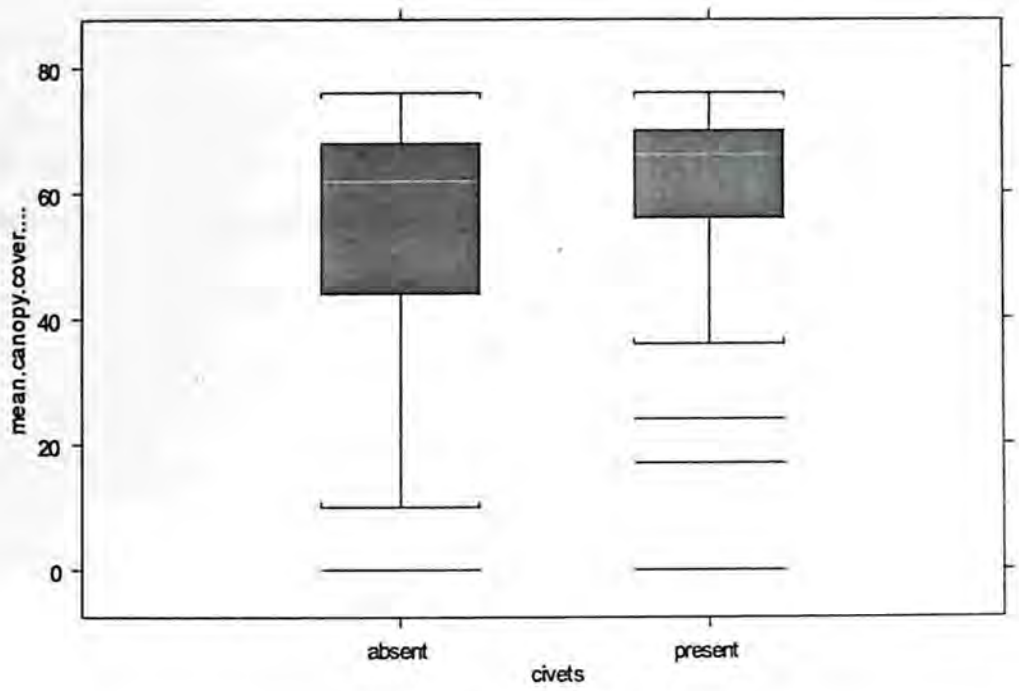

Figure 19. Presences - absences of civets with mean canopy cover

To examine the relationship of civet occurrences with that of its habitat variables, the variables such has distances from village, shrub cover, shrub height and mean canopy cover were used for analysis. These variables were used, as civets maximum occurrence were explained by them (Figure 15-19).

The analysis selected only three variables for the final out put, viz. distances from village, shrub cover, and shrub height. The minimum number of observation before the first cut on the variable was set at five. The minimum node size at which the last cut to be made was set at ten, i.e. the growing continued till there were at least ten observations in a node. The final tree was pruned to a desired sized of node after multiple cross -validation and residual mean deviance and misclassification error was kept at minimum.

The final output showed that, distances from village was the most important variable that determines the presences – absences of civets (Figure 20 a). At distances more than six kilometers from a nearest village there was 65 % probability that civets will occur. The occurrence of civets less than 6 kilometers from the village was determined by the presences of shrub cover. Civets were absent in areas with more than 65 % shrub cover, with 56 % probability of absences. Civets were absent between 6.7 kilometer to 6.2 kilometer from the nearest village. Civets were absent in areas less than 1 kilometer from village. Civets were present in areas between 6.2 kilometer to 1 kilometer from a nearest village, if shrub cover was more than 55%, with a probability of 25 % being absent. (Figure 20. b).

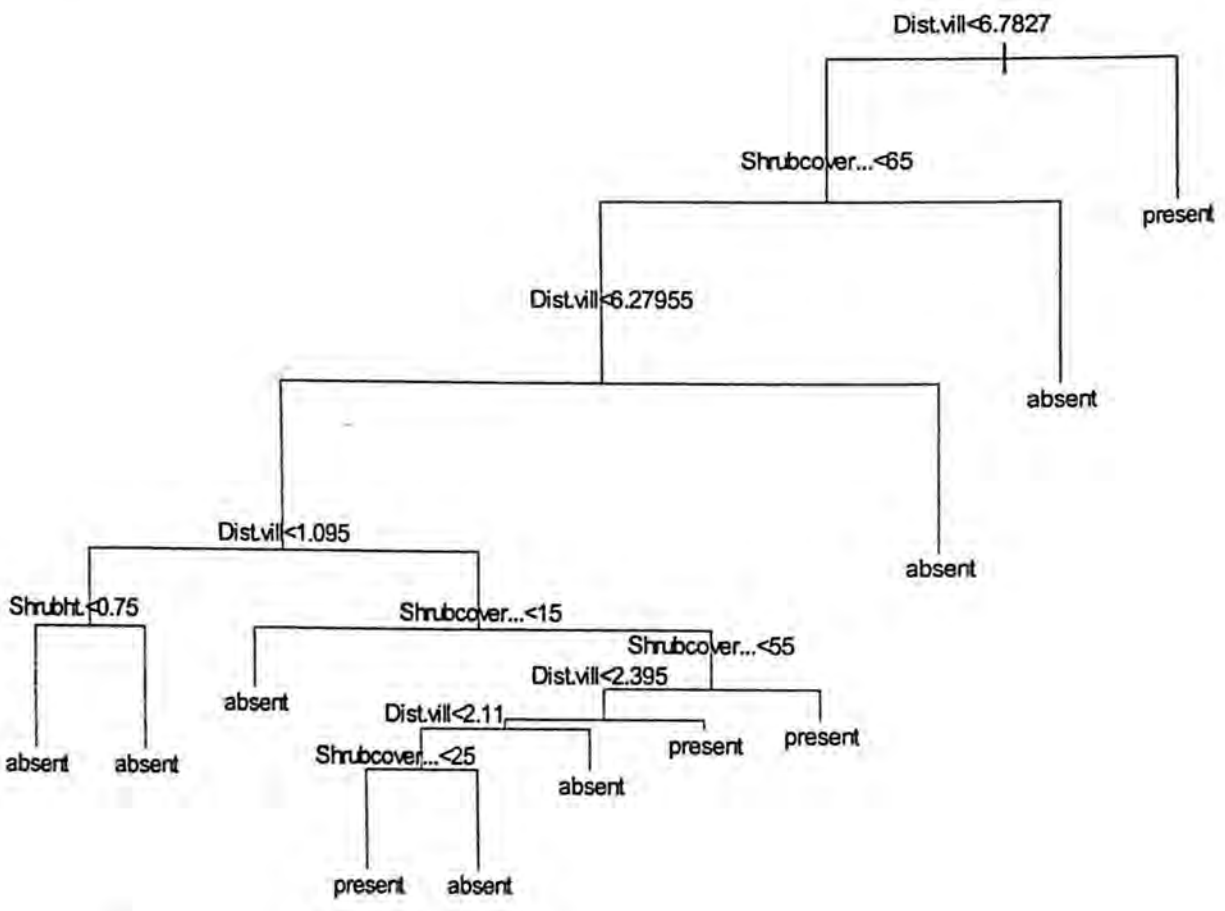

Figure 20 (a). Classification tree of civets on three habitat variables.

Figure 20. (b) Classification tree

```
Tree (formula = civets ~ Shrub cover... + Shrubht.m. + Dist. vill,
    Number of terminal nodes:  11
    Residual mean deviance:  1.082 = 144 / 133
    Misclassification error rate: 0.2431 = 35 / 144
    node), split, n, deviance, yval, (yprob)
        * denotes terminal node
1) root 144 195.600 absent ( 0.5833 0.41670 )
  2) Dist.vill<6.7827 121 159.700 absent ( 0.6281 0.37190 )
    4) Shrubcover...<65 91 124.800 absent ( 0.5604 0.43960 )
      8) Dist.vill<6.27955 80 110.900 absent ( 0.5125 0.48750 )
       16) Dist.vill<1.095 12  13.500 absent ( 0.7500 0.25000 )
         32) Shrubht.m.<0.75 6   8.318 absent ( 0.5000 0.50000 ) *
         33) Shrubht.m.>0.75 6   0.000 absent ( 1.0000 0.00000 ) *
       17) Dist.vill>1.095 68  94.030 present ( 0.4706 0.52940 )
         34) Shrubcover...<15 10  12.220 absent ( 0.7000 0.30000 ) *
         35) Shrubcover...>15 58  79.300 present ( 0.4310 0.56900 )
           70) Shrubcover...<55 50  68.990 present ( 0.4600 0.54000 )
            140) Dist.vill<2.395 28  38.820 absent ( 0.5000 0.50000 )
              280) Dist.vill<2.11 21  28.680 present ( 0.4286 0.57140 )
                560) Shrubcover...<25 10  10.010 present ( 0.2000 0.80000 ) *
                561) Shrubcover...>25 11  14.420 absent ( 0.6364 0.36360 ) *
              281) Dist.vill>2.11 7   8.376 absent ( 0.7143 0.28570 ) *
            141) Dist.vill>2.395 22  29.770 present ( 0.4091 0.59090 )
           71) Shrubcover...>55 8   8.997 present ( 0.2500 0.75000 ) *
      9) Dist.vill>6.27955 11   6.702 absent ( 0.9091 0.09091 ) *
    5) Shrubcover...>65 30  27.030 absent ( 0.8333 0.16670 )
  3) Dist.vill>6.7827 23  29.720 present ( 0.3478 0.65220 )
```

(ii) *Occurrence of small cats and their habitat variables*

The records of jungle cat and leopard cat were grouped as small cats and used for the analysis. Small cats occurred in areas with greater shrub cover and shrub height (Figure 21 & 22). The occurrence of small cats decreased with the distances from village increased (Figure 24). Small cat occurred low in areas with high canopy cover (Figure 25)

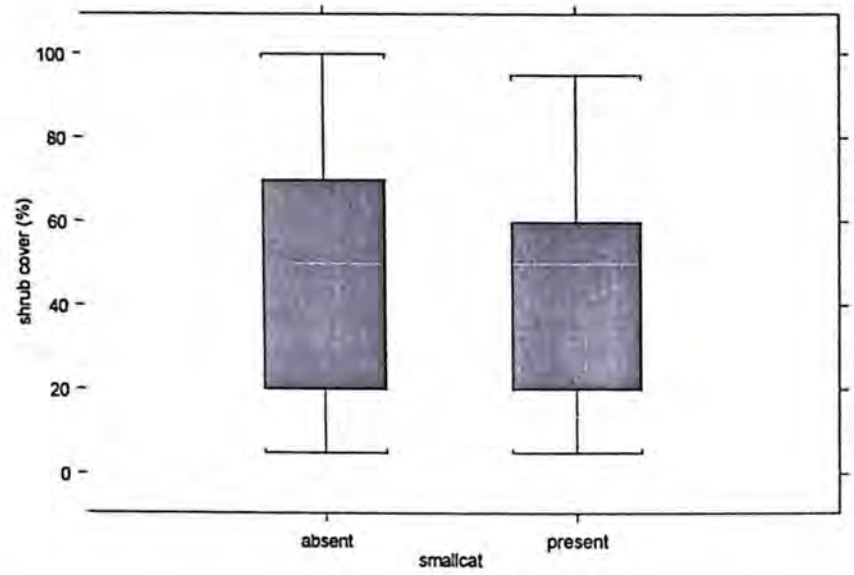

Figure 21. Presence-absences of small cats with shrub cover

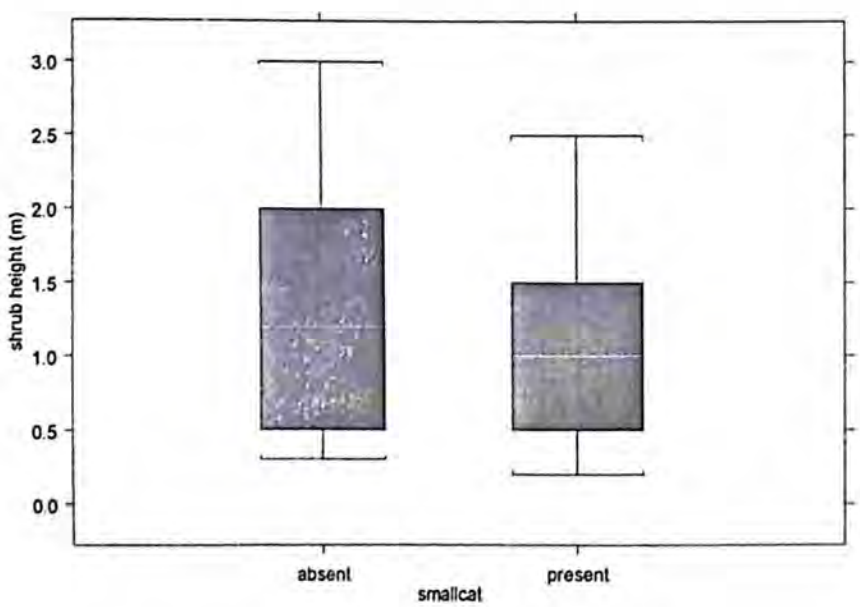

Figure 22. Presence- absence of small cats with shrub height.

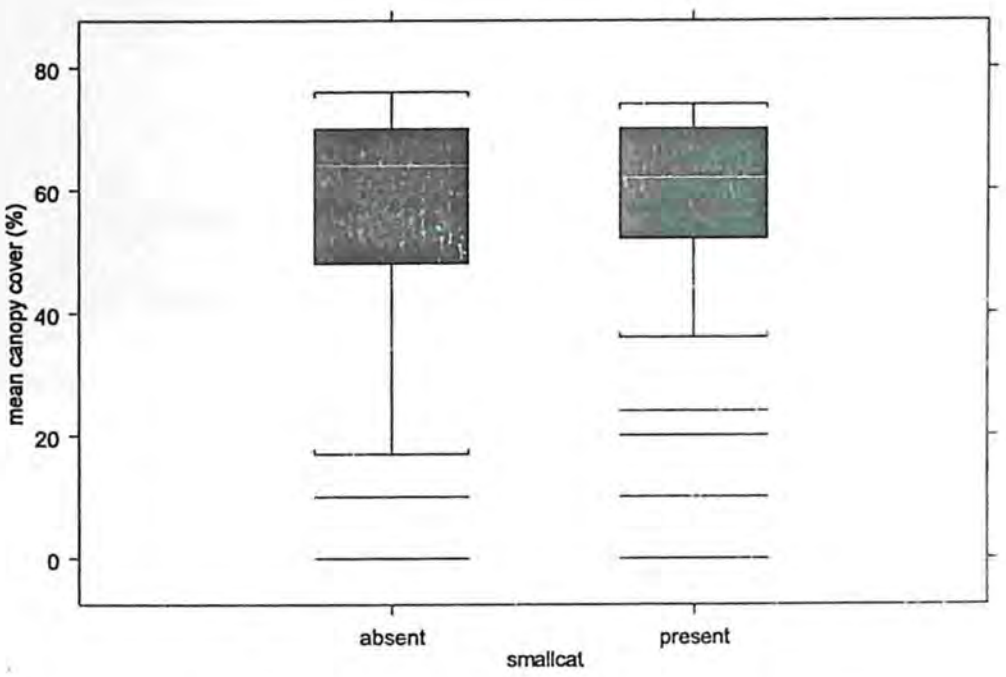

Figure 23. Presence - absence of small cats with mean canopy cover

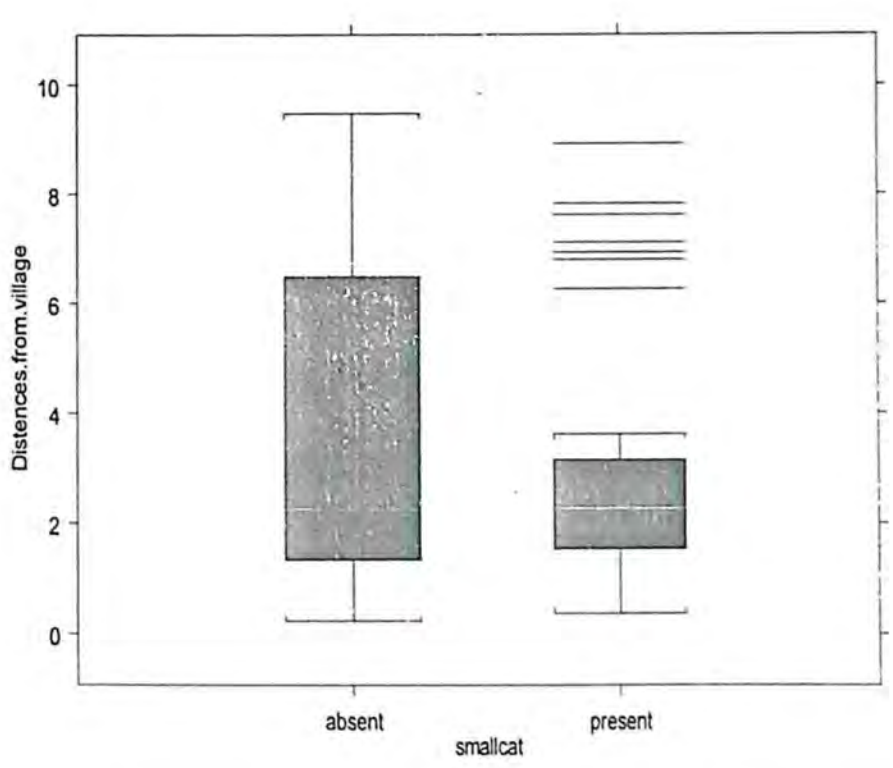

Figure 24. Presence - absences of small cats with distance from village.

To examine the relationship between small cat's occurrence and its habitat variables the analysis was performed by using variables like shrub cover, shrub height, mean canopy cover and distances from villages.

The final analysis selected only three variables for the final out put, viz. distances from village, shrub cover, and shrub height. The minimum number of observation before the first cut on the variable was set at five. The minimum node size at which the last cut to be made was set at ten, i.e. the growing continued till there were at least ten observations in a node. The final tree was pruned to a desired sized of node after multiple cross-validations and residual mean deviance and misclassification error was kept at minimum.

The final out put shows that, shrub height was the most important variable for the occurrence of small cat. (Figure 25 a). Areas having shrub height more than 2.75 m had less chance of having small cats occurring in them than the areas having shrub height less than 2.75m, with 30 %, probability of small cat's being occurring in it. Small cats were absent between 6 kilometer and 2 kilometer from a nearest village. Their occurrence in a radius of 1.5 kilometer from a village was certain with a probability of cent percent (Figure 25 b).

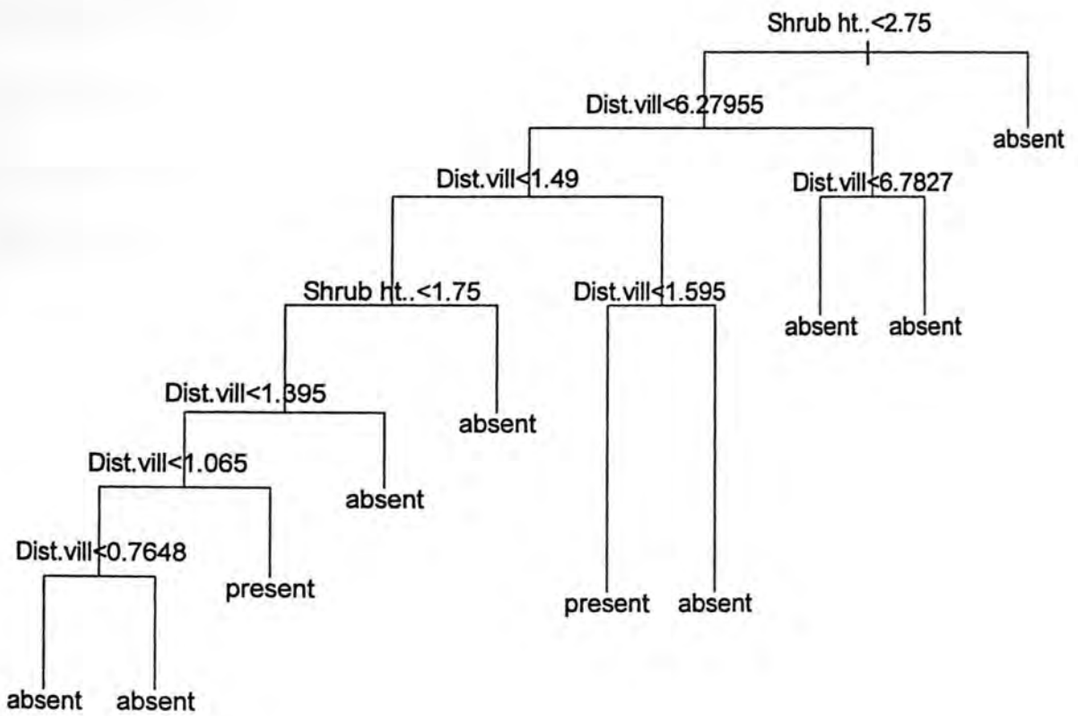

Figure 25 (a) Classification tree for small cats on two habitat variables

Figure 25 (b) Classification tree for small cats

Tree (formula = smallcat ~ Shrubcover... + Shrubht.m. + Dist.vill,

Number of terminal nodes: 10

Residual mean deviance: 0.782 = 104.8 / 134

Misclassification error rate: 0.1806 = 26 / 144

node), split, n, deviance, yval, (yprob)

* denotes terminal node

1) root 144 173.800 absent (0.7083 0.2917)

2) Shrubht.m.<2.75 139 170.300 absent (0.6978 0.3022)

4) Dist.vill<6.27955 106 135.800 absent (0.6604 0.3396)

8) Dist.vill<1.49 42 43.640 absent (0.7857 0.2143)

16) Shrubht.m.<1.75 33 38.670 absent (0.7273 0.2727)

32) Dist.vill<1.395 28 35.160 absent (0.6786 0.3214)

64) Dist.vill<1.065 17 15.840 absent (0.8235 0.1765)

128) Dist.vill<0.7648 8 10.590 absent (0.6250 0.3750) *

129) Dist.vill>0.7648 9 0.000 absent (1.0000 0.0000) *

65) Dist.vill>1.065 11 15.160 present (0.4545 0.5455) *

33) Dist.vill>1.395 5 0.000 absent (1.0000 0.0000) *

17) Shrubht.m.>1.75 9 0.000 absent (1.0000 0.0000) *

9) Dist.vill>1.49 64 87.150 absent (0.5781 0.4219)

18) Dist.vill<1.595 7 0.000 present (0.0000 1.0000) *

19) Dist.vill>1.595 57 73.870 absent (0.6491 0.3509)

5) Dist.vill>6.27955 33 31.290 absent (0.8182 0.1818)

10) Dist.vill<6.7827 11 0.000 absent (1.0000 0.0000) *

11) Dist.vill>6.7827 22 25.780 absent (0.7273 0.2727)

3) Shrubht.m.>2.75 5 0.000 absent (1.0000 0.0000) *

9. Discussion

9.1 An evaluation of survey methods

The broad methodology used for data collection follows, Kumar et al (2002), however, in this study night walk and intensive monitoring of target species could not be done. The methods followed provided enough data to describe the patterns of carnivore distribution in particular small carnivore, distribution in the rainforest landscapes. The data collected from the track plot could be used to ascertain the occurrence of theses species. In the study conducted by Kumar et al. (2002) a combination of different methods had yield better estimates of relative abundances of small carnivores. The methods such as night walk were not conducted during this study because of logistic reason. Occurrences of scat area also used an index of small carnivore abundance (Kumar and Yoganand 1999), but this was not feasible in this study, due to lack of skill of differentiating scats of various species by the investigator.

The study sites had continuous canopy cover except for Lanka which was separated by Pakke River. But the habitat variables such as number of trees in a plot , canopy height, canopy cover, and number of tree species were different between areas except for shrub cover and shrub height. This is due to the exposure of these sites to various anthropogenic pressures, which have created the current mosaic of low and high canopy and tree densities. This is reflected in the similarity of shrub cover and shrub height across sites. As shrub cover was negatively correlated with tree density and with number of tree species.

The higher success rate in tracks of carnivores in moderately disturbed area Dicho (36%) probably indicates higher abundances of carnivore species in the area

This could be due to increase of small mammals in fragmented and in moderately disturbed area (Escamilla et al. 2000) which facilitate the occurrence of species depending on them, such as small Indian civet, leopard cat and jungle cat whose major diet constitutes of rodents, insects, fruits (Prater 1971, Mukerjee 1998, Kumar et.al. 2002).

In wet and moist forest, much of the plant biomass for herbivores is in the form of inedible tree trunks and most of the leaves are heavily defended by plants secondary compounds, such as lignin and toxins (Mckey et al. 1981). Moreover, a high proportion of the primary productivity is in the canopy and available to relative small mammals, so food availability for the large ungulates in tropical forests is low (Glaziz 1982, Hart 2000). This might explain the low occurrences of carnivores in tropical forest (Silver et al. 2004). The over all occurrences of tiger and leopard of total carnivore species track was 6% and 9%.

9.2 Body size and occurrence

The occurrence of a species is mostly determined by the availability of prey, insects, fruits, cover and other resource (Rabinowitz & Walker 1991) .Species to co-exist there should be some differences in the resources they use or in the way they obtain their resources (Shoener 1975, Mayr 1976). The relation ship between body size and home range of and species had been studied, which indicate that body mass of species, its rate of metabolism determines the home range of a species (Gittleman & Harvey 1982, Harvested & Bunnell 1979, Reiss 1988, Swinart et al. 1988, McNab 1980). Competition can occur not only between species but also within species (Begon et al. 1990). This study shows that there is negative relationship between the occurrences pattern and

increase in difference, of body size between two carnivores. i.e., more the difference in body mass between species, greater is the chance that they will occur together, lesser the difference in body mass greater they have the chance to occur separately.

Carnivores have wide and diverse dietary pattern (Prater 1971, Eisenberg 1981, Gittleman 1984). Jungle cat's major preys are rodents followed by birds (Schaller 1967, Mukherjee 1989). Common palm civets are primarily frugivorous (Kumar and Yoganand 1999) and large Indian civet is known to feed on anything worth killing (Hussain 1999). Small Indian civet is omnivorous in nature, its diets include rodents, lizards, insects, small birds (Hussain 1999) and leopard cat diet include rodents, insects, carrions and even young ungulates (Nowell & Jackson 1996). The multidimensional scaling of small carnivores shows that these species occurs distinctly in their use of habitat this separation might be due to their difference in body weight, and their niche. The difference in body weight of small Indian civet and large Indian civet is about 5 .5 kg and that jungle cat and leopard is 2.75 kg and they seem to exhibit spatial difference of occurrences. Despite differences in body size among tiger, leopard and dole there is substantial dietary overlap among them (Karanth & Sunquist 1995). Tiger preferentially select large prey (> 176 kg), whereas leopard and wild dog preferred medium sized prey in the 31-175 kg body size class (Karanth & Sunquist 1995). The occurrence of these large carnivores in tropical forests may depend largely on relative densities of different size classes of potential prey (Karanth & Sunquist 1995). However in areas where habitat and the prey population of theses carnivores are under constant anthropogenic pressure, the interaction among these large carnivores will favor to those which are able to cope such medication, such as leopard. In this study leopard occurrence accounted about 10% of total carnivore occurrence, against 7% occurrence for tiger and 2 % occurrence of dhole.

9.3 Response to disturbance

Secondary forests, fallows and mosaics of pasture and forest which are created and influenced by human activities might have greater wildlife biomass than undisturbed forests (Robinson & Bennet 2004). Studies in Africa and South east Asia have reported that civets and other omnivores species to increase in abundance in slightly disturbed or logged forest (Johns 1983). In this study occurrence of small Indian civet was most common and abundant of all carnivores recorded. Study by Kumar et.al (2002) in Kalakad-Mundanthurai Tiger Reserve also recorded higher abundances of small Indian civet in fragmented areas, which is contrary to study of Heydon and Bullohs (1996) findings. Persistence of small Indian civet in such area could due to it being more omnivores and being more terrestrial, has under storey cover to forage and take shelter. In contrast arboreal and predominantly frugivorous palm civets may suffer in matrix of open and closed forests (Kumar & Yoganand 1999). Yellow throated marten and large Indian civet occurred in sites of least disturbances.

Jungle cat is known to be tolerant of disturbance and human presence and might even get benefited from it due to increased abundance of rodents which are their major diet (Mukherjee 1998). This study shows that jungle cat occurred in areas of moderate disturbances. Nothing much is known about habitat preferences of leopard cat (Kumar & Yoganand 1999), typically the leopard cat occurs in moist forested areas (Nowell & Jackson 1996). In this study the leopard cat occurred in least disturbed areas.

Carnivores are been preyed upon and destroyed by their own and other species (Prater 1971). The rivalry and competition for food has marked influence on the habits these carnivores especially among large carnivores (Prater 1971). So the response of these large carnivores to disturbances will be mostly influenced by these habits and the abundances

of herbivores in such areas. In this study tiger and wild dog occurred in areas of least disturbances where as leopard occurred in areas of disturbances. This can be attributed to the leopard's ability to climb, catch food on trees and ability to survive in thin cover and with less water (Johnsingh 1983). The presence or absences of civets in a site were mostly determined by the distances from the nearest village and presences of shrub cover civets were mostly absent in radius of one kilometer from the nearest village where else for small cats shrub height and distances from village was important criteria of occurrences. Small cats were mostly present in a radius of 1.5 km from a nearest village. Another difference between occurrence of civets and small cats was that occurrence of civets increased with distances from village. This could be due to increase in presence of high canopy cover and shrub cover. Whereas small cats occurrence reduce as distances from village increased.

10. Conclusions

Monitoring of carnivore abundances in areas of high species diversity by track plots alone was not that effective. It is not suited to areas with high diversity of carnivore's species, as there was high percentage of tracks being classified as unknown in this study. It is proposed that combination of camera trap and track plots might yield better in monitoring of theses species.

Response of carnivores to disturbances depends on the biology of a species, its ability to cope with causal factor and the intensity of the causal factor. I found that carnivores were heterogeneous in their sensitivities to varying level of disturbances. Body weight differences partially accounted for this heterogeneity in response/occurrence (Fig.13).

Small Indian civets were the most abundant carnivore species encountered in the study area .this could be because it being more terrestrial and having wide range of dietary habits. Large Indian has more or less similar dietary habit of that of small Indian civet, but its occurrence was low due its avoidances of high disturbed sites (Fig 10).

Civet's occurrence increased with increase in distance from village. It seems that civets are more sensitivity to disturbances than small cats, small cats mostly occurred in a radius of 1.5 km from a village. The most important habitat variables for both civets and small cats were the presence of shrub cover and shrub height. .

Among large carnivores leopard was the most abundant in occurrence. It can be attributed to its wide range of menu, from rodents to large herbivores.

Among the study sites, Dicho was most species rich in terms of carnivore species occurrences, whereas Lanka had very less occurrences of carnivore species. This might suggests that carnivore species can withstand moderate amount of disturbances.

Number of lianas presences was positively correlated with mean canopy cover and with distances from village. Its can be better indicative of disturbances in tropical forests.

One of the major finding of this study, is sighting of crab eating mongoose (*Herpestes urva*) which has been recorded after many years doubt of its existence since its description by Pocock in 1930 and definite proof of occurrence of small clawed otter (*Amblonyx cinerea*).

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