1. INTRODUCTION

1.1 Background

In the world, there are 36 species of wildcat exists (Sunquist and Sunquist 2002). Among the seven large wildcat species; *Panthera tigris* (Tigers), *Panthera leo* (Lions), *Panthera pardus* (Leopard), *Puma concolor* (Cougars/Puma), *Panthera onca* (Jaguars), *Acinonyx jubatus* (Cheetahs) and *Uncia uncia* (Snow Leopard). Leopard is the second largest cat; family Felidae and order Carnivora (Sunquist and Sunquist 2002). Nepal harbours 11 species including four large size cats: Tiger, Leopard, Snow Leopard and *Neofelis nebulosa* (Clouded Leopard) (Baral and Shah 2008) including *Ontocolobus manul* (Pallas cat) (Shrestha et al. 2014).

Leopards are most common and widely distributed species of big cat (Bailey 1993, Nowell and Jackson, 1996) which are found in almost every kind of habitat, ranging from the desert to rainforests of the tropics and temperate regions (Kitchener, 1991) as well as degraded areas (Pocock 1939, Prater 1971, Bailey 1993, Daniel, 1996). Leopards are distributed from Northward of South Asia to Central Asia and east to the Amur Valley in Russia to Africa (Bailey 1993, Edgaonkar and Chellam 1998) reflecting the adaptability of the species in wide range of habitats (Turnbull-Kemp 1967, Guggisberg 1975, Bailey 1993, Daniel 1996).

In Nepal, Leopards are recorded throughout the country (Shah et al 2004) ranging from the Terai to the Himalayas. Depending on forest cover and prey availability the vertical distributional range of Leopard extends as high as 4000msl (KMTNC 1998). However, Leopards are recorded up to 5200msl with Snow Leopard (Jackson 1984), but they commonly live below the tree line (Roberts 1997, Green 1987).

Besides, natural habitats, elusiveness and behavioural flexibility (Daniel 1996), Leopards are sited very often nearby village and human settlements (Nowell and Jackson 1996, Edgaonkar and Chellam 2002, Goyal et al. 2007, Athreya et al. 2014). The Leopards are found in human modified landscapes with territories in the proximity of human population which are known to prey on livestock (Hamilton 1986, Seidensticker et al. 1990, Daniel 1996, Goyal et al. 2007, Gurung 2008, Athreya et al. 2007, 2014).

Leopard is considered as habitat generalist predator due its wide habitat tolerance (Nowell and Jackson 1996). It feeds on a variety of prey species ranging in size from a smallest birds/rodent to young Buffalo which also makes them most successful predator among big cats (Schaller 1967, Essenberg and Lockart 1972, Johnsingh 1983, Rabinowitz 1989, Seidensticker et al. 1990, Karanth and Sunquist 1995, Daniel 1996, Edgaonkar 2008).

Leopard preferentially preys upon species in a range of 10-40 kg weight of prey species even if preys greater than this range are more abundant (Hayward et al. 2006a). When suitable prey are lack then Leopard shift to alternative prey (Murdoch 1966, Bergerud 1983, Jedrzejewski et al. 2000, Sankar and Johnsingh 2002) and livestock as well as dogs (Chauhan 2008, Goyal et al. 2007, Thapa 2011, Athreya 2014). The predator's mass exceeding 21.5 kg of body mass attend to prey on vertebrate species of its own body mass (Carbone et al. 1999) and sub-optimal predation in diet of large carnivores may be an early indicator for a population at risk of extinction (Hayward et al. 2006).

1.2. Conservation Status

The Leopard have low conservation priority because of their widespread distribution and ecological flexibility, however, global population status is still uncertain (Nowell and Jackson 1996, Henschel et al. 2008). The Wild Cat Status Survey (IUCN/SSC Cat Specialist Group) has categorized Leopard as the Near Threatened species (Henschel et al. 2008). Due to habitat conversion or fragmentation, trade of body parts, trend in decreasing number of Leopard, the International Union for Conservation of Nature (IUCN) listed its eight subspecies as endangered or critically among 14 sub species of Leopard (Henschel et al. 2008).

The Leopard is placed in Appendix I in the Convention on International Trade in Endangered Species (CITES) (Nowell and Jackson 1996), Under the CITES treaty, use of Leopard's pelts or body parts for commercial purposes is banned. But in the absence of effective public relation campaign, Leopard killing for commercial purposes could not be checked (WWF 1997). In Nepal Leopard is not on the list protected species under the National park and wildlife conservation (NPWC) act 1973. There is no specific management strategy for its conservation where Leopard are surviving in considerable conflicts with people outside the protected areas (shah et al. 2004, Pokharel 2014).

1.3. Major threats

There is declining trend of Leopard population in many parts of Africa and south Asia due to habitat loss, trade and depletion of prey species (Santiapillai et al. 1982, Khan and Beg 1986, Ilany 1986, Green 1987, Bailey 1993, Karanth et al. 2004), Human-Leopard conflict (Athreya 2007) and human induced mortality (Thapa 2014). In South Asia, Leopard has an advantage over Tiger due to its ability to survive outside protected area (Seidensticker et al. 1990). Leopard continue to get killed for socio-economic reasons, as demand for bones and skin is high (Hamilton 1986, Bailey 1993 and WWF Report 1997). Incidences of killing and trades of Leopard's body parts have been reported high compared to Tiger or other large felid (Shrestha 2012). According to Pokharel (2015) the study from 2003 to 2013 showed that Leopard killing tends to decrease due to Human-Leopard conflict in Kathmandu valley than the illegal trade (Shrestha 2012, SNNP 2014).

1.4. Objectives

The general objective of study was to assess diet composition of Leopard in Shivapuri Nagarjun National Park. The specific objectives were:

1. To determine abundance of prey species of Leopard,
2. To assess the occurrence of prey species in Leopard scat and
3. To examine the threat to the survival of Leopard.

1.5. Rationale

Numerous researches on big cat species are available in Nepal. However, those researches are confined to Tiger and Snow Leopard which are enlisted as protected species by National Park and Wildlife Conservation Act, 1973. Studies on Leopard relating demography, diets, home range, and interaction with Tiger (Seidensticker 1976, Sunquist 1983, MacDougal 1988, Seidensticker et al. 1990, Eliassen 2003, Odden and Wegge 2005, Odden et al. 2010, Thapa 2011, Thapa 2014, Thapa et al 2014, Lovari et al. 2015) are available but are confined to low land. While the similar study in mountainous region in Nepal is limited in spite of their prominent role in smooth functioning of the ecosystem in mountainous region of Nepal. Few study regarding on Leopard in the mountainous region of Nepal are available; status of Leopard (Yadav 2006), diet composition (Aryal

and Kreigenhofer 2009), Human-Leopard conflict (Koirala 2011, Thapa 2014, Pokharel 2015) marking the need of study and bring forth the present status. Furthermore, there are no specific management strategy for conservation and protection of Leopard. If Leopard have to conserve in natural habitat, it is necessary to carry study of Leopard on remaining protected areas in order to maintain coexistence with people and viable populations of Leopard in ecosystems and landscape.

Leopard, an umbrella species, is top predator in the ecosystem of Shivapuri Nagarjun National Park which determines the condition of entire National Park. This study has assessed the abundance of prey and diet composition of Leopard which will be helpful in formulation of management plan for the conservation of predator as well as prey in and around the National Park.

1.6. Limitation

The study of diet composition of Leopard was confined only to Shivapuri forest area of Shivapuri-Nagarjun National Park. The finding stated in this study is based on data obtained in two seasons (Pre-monsoon and monsoon) denying the seasonal analysis because of inadequate scat sample. For seasonal diet analysis, a reasonable number of scat should be collected to best describe the dietary composition (Mukherjee et al. 1994, Trites & Joy 2005). The estimation of prey density could not be performed because of inadequate time, financial resources as well as lower abundance of prey species. Due to inaccessibility in reach, the data from steep topography is excluded though animal trails were noticed revealing the presence of scats.

2. LITERATURE REVIEW

Leopard is most common and widely distributed species among the wild cats of the world (Nowell and Jackson 1996) which are tolerant to habitat conversion, found in every habitat, ranging from subtropical to temperate region (Kitchner 1991). Leopard are distributed across Africa to South Asia northwards to Central Asia and east to the Amur Valley in Russia (Bailey 1993). In Nepal, Leopard is widely distributed throughout the country (Shah et al. 2004).

Large mammalian predators are in declining trend due to depletion of prey population (Seidentiscker 1986, Rabinowitz 1993). There are two criteria of carnivore for the selection of resources; landscape parameter and prey abundance/density (Balme et al. 2007). Predation of prey in habitat is highly dependent on abundance of prey species and its prey availability (Karanth and Nichols 1998, Carbone and Gittleman 2002). For the interaction and spatiotemporal activity of carnivore both prey abundance as well as behavioural factor play important role (Carter et al. 2013). The foraging behaviour of Leopard is associated with the presence of herbaceous layer with high vegetation cover (Wessels et al. 2006) and highly productivity patches in landscape (Smith 2011).

In the past, density and abundance of prey species were estimated using the line transect sampling method (Anderson et al 1979, Burnham et al. 19980, Buckland et al. 1993, Karanth et al. 2004, Thapa 2011). Line transect sampling is one of the reliable method for abundance estimating approaches collectively known as distance sampling methods in a known area and boundary (Thomas and Karanth 2002).

In Indian subcontinent, line transect sampling were used for the estimation of herbivore population in the tropical forest (Karanth and Suquist 1992, Varman and Sukumar 1995, Edgaonkar and Chellum 2002, Edgaonkar 2008, Mondal 2011) and subtropical forest in Terai Nepal (Wegge et al. 2009, Malla 2009, Thapa 2011, Dhakal et al. 2014). In the mountainous region line transect sampling method were employed for the estimation of prey species of Snow Leopard (Devkota 2010). The abundance of herbivore through indirect sign were also estimated from the line transect method (Ale 2007).

The diets of cat species are known to reflect easy catch, with individual animals developing local and individual taste (Kingdon 2003). Leopard preferred to kill/prey on

medium sizes prey (primary) species and also wide variety of small animals (sub-optimal) (Bailey 1993). Leopard forced to switch to more abundant sub optimal prey such as rodents in area with low densities of medium sized ungulates prey (Ramakrishnan et al. 1999, Sankar and Johnsingh, 2002) or secondary prey; livestock and dogs (Seidensticker et al. 1990, Edgaonkar and Chellam 2002, Goyal et al. 2007, Chauhan 2008, Shah et al. 2009, Shehzad et al. 2014, Athreya 2014).

Diet of Leopard in Kruger National Park, South Africa, constitute medium-sized prey, mainly Impala and with wide variety of small animals including Hyrax, Civet and Mongoose (Bailey 1993). In the Kalahari Desert Leopard diet comprises small prey such as Bat-eared Foxes, Jackals, Genets, Hares, Duiker and Porcupines (Bothma & Le Riche 1984). In Sambru community group ranches, Kenya, the Leopard's diet consists of both the domestic prey and wild ungulate. Wild prey contribute relatively higher than domestic in Leopard's diet (Ogara et al. 2010). In Sarigol National Park Iran; Wild Sheep, Wild Pig, Wild Goat, Red Fox, Porcupine, and Pika constitute in Leopard diet along with domestic Prey (Tagahdisi et al. 2013). In Wilpattu National Park, Srilanka, Leopard's diet comprises Chital, Wild Pig, Sambar, Langur, Hare, Porcupine and domestic Buffalo calves (Eisenberg and Lockhart 1972).

In the Himalayas of Pakistan, Leopard's diet mainly consists of Wild Goats as well as livestock and small mammal such as Hare and Porcupine (Schaller 1977). In Ayubia National Park, Pakistan, Shehzad (2014) revealed that the frequency of occurrence of domestic Goat predominated the diet (64.9%), followed by Dog (17.5%) and Cow (12.3%) in the diet of Leopard in the absence of natural prey.

Leopard scats contained medium prey as well as rodents in Sariska Tiger Reserve (Sankar and Johnsingh 2002). Mondal (2011) studied the diet of Leopard in the Sariska Tiger Reserve, India, frequency of occurrence of prey remains in Leopard, Sambar contributed maximum (35.2%) in Leopard's diet followed by Chital (20.5%), Common Langur (8.2%), Nilgai (8.0%), Cattle (8.0%), Peafowl (6.8%), Rodent (4.6%), Hare (3.4%), Porcupine (2.9%), Wild Pig (1.7%), Goat (0.7%) and domestic Dog (0.1%).

The Leopard on the Mundanthurai plateau have been praying mainly on Sambar (Sathyakumar 1992). Leopard living near urban areas, Mumbai, survive to a large extent on domestic Dogs and Rodents (Edgaonkar & Chellam 1998).

In Hui Kha Khaeng Wildlife Sanctuary, Thailand, Leopard feeds on primary prey species marking Deer, Primates, Wild Boar, Sambar Deer, Restless Himalayan Porcupine and Hog Badger and secondary prey species *Paguma larvata, Manis javannica, Arctictis binturong, Rhizomys sumatrensis, Tatufa bicolor, Callosciurus* spp., *Masomys surifer*, Bird , Lizard, Crab (Rabinowitz 1989). Predation of *Macaca* and *Prestybis* in large cats has been shown to be direct correlate with availability and abundance of alternative prey species (Seidensticker 1983).

In Bandipur Tiger Reserve, India, Leopard diet composed of Sambar, Chital, Barking Deer, Four-Horned Antelope, Chevrotain, Wild Pig, Gaur, Langur, Hare, Cattle and other small prey species. Chital found to be most dominant followed by Wild Pig, Gaur, Langur. Medium size prey are dominant than large size prey and small prey species in the diet of Leopard (Andheria et al. 2007).

In plantation and rainforest landscape, Anamalai Hills, Western Ghats, frequency of occurrence of Leopard composed of medium as well as small mammals with the absence of the domestic prey. The medium preys *Munticaus* (41.18%) found to be the most important in diet of Leopard followed by Indian Chevrotain (23.53%), Indian Porcupine (26.47%). The rodents were found in lower portion 20.59% in the diet of Leopard (Sidhu et al. 2015).

In Armenia Wild Goat accounted for a major portion in Leopard diet (Khorozyan and Malkhasian 2005). Similarly Wild Pigs comprised a small portion of Leopard diet, especially in forested habitats.

In human dominated landscape of Maharastra, India, the Leopard diet consists of both domestic and wild prey species in which frequency of occurrence of domestic prey species (76.1%) becomes most prominent in the diet of the Leopard than the frequency of occurrence wild prey species (29.03%). Small mammal along with the rodents were accounted more than that wild medium prey species in term of frequency of occurrence in the scats (Athreya et al. 2014).

In Mandi district, India Kumar (2011) revealed that the Leopard were found to prey mainly on rodents and Sheep and Goats because there was scarcity of other wild prey species like Sambar (*Cervus unicolor*), Chital (*Axis axis*), Barking Deer (*Muntiacus*

muntjak) and Nilgai (*Boselaphus tragocamelus*) in the study area. The diet of Leopard was found to have higher proportion of domestic prey species (59%) than wild prey (53.7%).

The factor of changing Leopard activities and behaviour are not only by the anthrogenic activities but also interspecific competition with sympatric carnivore (Seidensticker 1976, Karanth and Sunquist 2000, Hayward and Slotow 2009, Wang and Macdonald 2009, Odden et al. 2010, Vanak et al. 2013). Leopard avoid open habitat inhabited by tigers, despite abundant suitable prey in Kaziranga National park (Karanth and Nichols 1998). Leopard in Kuiburi depend on alternative prey species; arboreal animal which are rarely consume by Tiger as medium prey, ungulates, were preyed by Tiger (Holt and Huxel 2007). Increase in density of Tiger in Rajaji National Park force Leopard switch to move to the margin outside the home range of Tiger thereby decreasing the density of Leopard by fivefold and changing the dietary and foraging behaviour of Leopard (Harihar et al. 2011).

In Bardia National Park high biomass of prey support dense Tiger population but due to low density of large prey Tiger force Leopard to switch to medium-sized prey and displaced to margin of protected are outside the home range of Tiger which caused increased interface of local with Leopard there by predation of livestock (Odden et al. 2010). In mountainous region; Dhorpatan Hunting Reserve, Nepal, Leopard have been known to take medium as well as small mammal prey species in which small mammal becomes most significant part for the diet of Leopard (Aryal and Kreigenhofer 2009). In the Chitwan National Park, Leopard diet consists of Chital, Sambar, Barking Deer, and livestock (Thapa 2011). The prey spectrum of Leopard in and around Chitwan National Park, had a minimum of 15 taxa including at least 10 wild and 5 domestic species, and is found to be as diverse as other areas in Nepal (Thapa 2011) and south Asia (Karanth and Sunquist 1995, Sankar and Johnsingh 2002, Edgaonkar and Chellam 2002). In Suklaphanta Wildlife Reserve Leopard are known to prey upon 14 number of species in which diet comprises of medium prey species, small mammal and birds which shows that small prey dominate in Leopard diet (Lovari et al. 2015).

The knowledge of a carnivore's diet is essential to assess the role of species in the ecosystem such as potential competition with other carnivores and impact on prey populations. A primary tool for assessing the carnivore diet is scat analysis, especially

when focusing on individual prey items (Macdonald et al. 2011). From the diet analysis impact on the development of carnivore management plans especially if economically important or endangered species are involved (Macdonald et al. 2011). It is impossible in field survey for direct observations of feeding behaviour. This method can only differentiate broad food categories (Darimont and Reimchen 2002). The occurrence of prey from scat analysis is the qualitative method which only shows the absence and presence of prey species.

Large-scale conservation planning initiatives, such as eco-regions and biodiversity hotspots have been among the effective response global conservation investment however they lack to identify targets for fine-scale conservation action (Myers et al. 2000 and Olson 2001). Existing protected areas systems are rarely designed to conserve biodiversity systematically and they often fail to include all species which need site conservation (Pressey 1994). Much effort in conservation assessment has been concentrated at the species level, assessing the emergence of quantitative and threshold-based criteria of extinction risk (Henschel 2008) which need to be addressed to protect and conserve wildlife from extinction.

Besides natural factors such as; biological traits of wild animals, low population, diet requirement, and habitat ranges, growth rate and maturation etc. factors causing the wildlife species prone to extinction, anthropogenic activities in addition have been altering the natural world at an unprecedented scale causing global extinction rates to rise by an estimated three or four orders of magnitude (Pimm et al. 1995, May and Tregonning 1998). Hunting has been recognized as a major factor in historical declines of wildlife in India (Rangarajan 1998, Sankhala 1978, Schellar 1967) while overexploitation followed by habitat destruction is found as the major threat to endangered vertebrates in China (Yiming and Wilcove 2005). Similarly, habitat loss followed by introduced species is the most common contributing factors causing wildlife species vulnerable to endanger in United States (Czech and Krausman 1997, Wilcove et al. 1998). And, habitat loss along with over exploitation is the major threats to species in Canada (Oscar et al. 2006). To be more specific, habitat loss and degradation is suggested as the most pertinent threat to Leopard in Pakistan and Africa.

3. MATERIALS AND METHODS

3.1. Materials

3.1.1. Study area

This study was carried out on the Shivapuri Nagarjun National Park (SNNP) which lies within the boundary of Kathmandu, Nuwakot, Sindhupalchwok and Dhading district (Figure 3.1). The park covers an area of 159 km^2 area between 27^0 45' to $27^0$72' N and 85^0 16' to 85^0 45' E. Shivapuri forest covers an area of 144km^2 while Nagarjun forest covers 15$km^{2.}$. The National Park encompasses a wide diversity of habitats and species within the elevation range between 1370 and 2732msl. It is a major watershed providing drinking water to northern urban population of Kathmandu. The area was gazette as the country's ninth National Park in 2002. Prior declaration as National Park it was managed by Shivapuri Watershed and Wildlife Reserve (SWWR).

3.1.2. Geology

Geologically the Shivapuri area occupies the inner Himalayan region and dominant rocks of the area contain metamorphic rocks such as phyllite, limestone and dolomite and gneiss which are loamy on the northern aspect and sandy on the southern aspect (Shrestha 1993). Eo-cambrian bands of quartzite and limestone are also present in this area (Mohammad et al.1998). Shivapuri area has steep mountainous topography more than half of the land has slopes greater than 30 degree (Sotomayor 2002). The Shivapuri Nagarjun National Park is drained by many smaller rivers and rivulets. Important rivers are Bagmati, Vishnumati, Sangla and Syalmati.

3.1.3. Soils

The nutrients in the soil are very high and the runoff rate is relatively slow because of dense vegetation and high humus deposits in the Shivapuri forest but the runoff rate was very fast in the degraded forest (Shrestha 1993). Soil pH had negative relationship with increasing altitude but soil nitrogen, organic matter, soil moisture and water holding capacity was found to be increasing with increasing altitude (Sigdel et al. 2015). Sotomayor (2002) classify the soil of Shivapuri forest area into three; soil of hilly lands, soil of mountain and soil of tectonic valley.

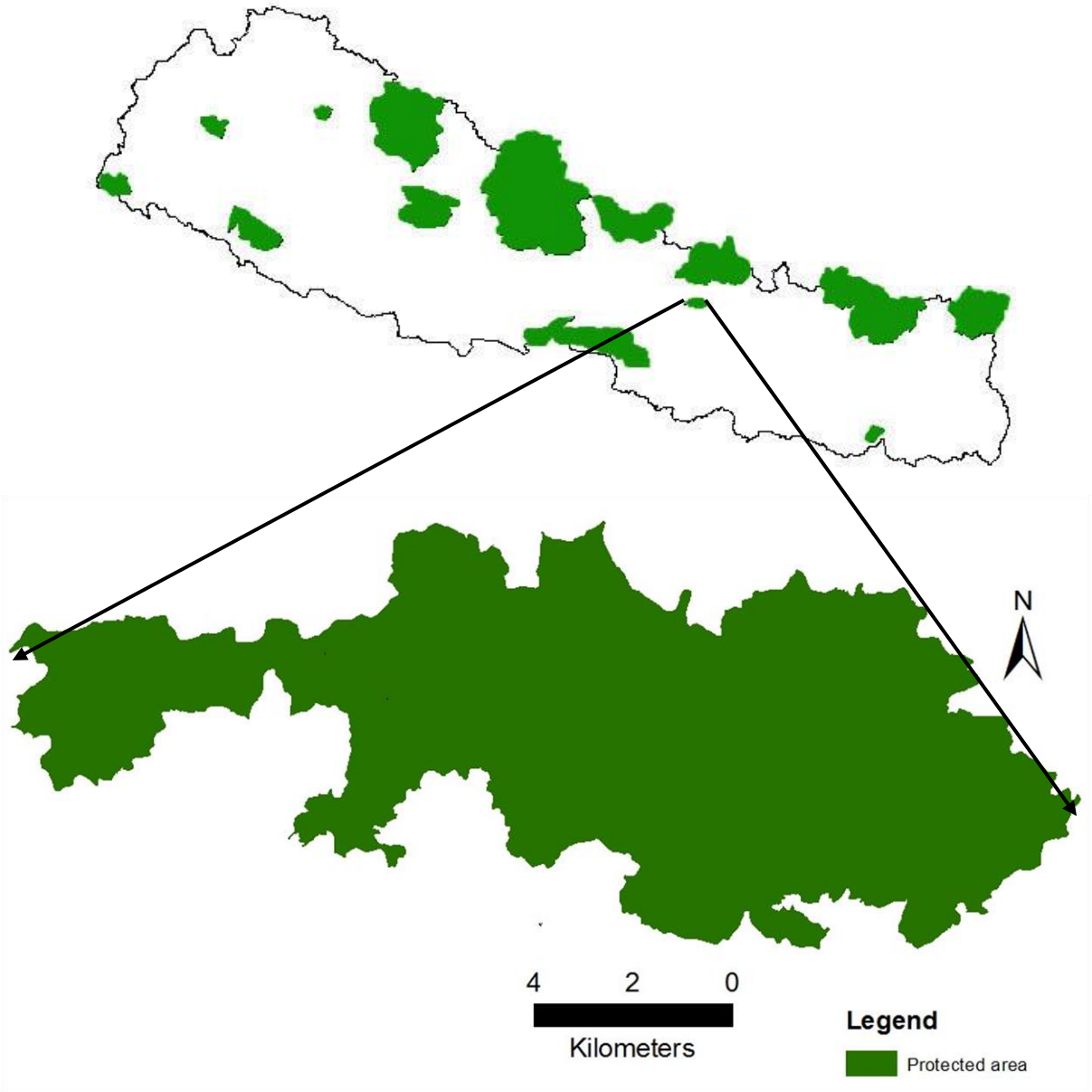

Figure 3.1 Map of study Shivapuri Nagarjun National Park.

3.1.4. Topography

Mohammad et al (1998) has described the topographical features of the range which has steep mountainous topography inside the protected area in which half of the land has greater than 30^0 slope. In contrast to the mid hills of Nepal, only the concave types of sloping terraces are found in the Shivapuri area. The width of the terraces varies from place to place depending on geology and land forms of the terrain.

3.1.5. Climate

SNNP lies in a transition zone between subtropical and temperate climates. The average monthly rainfall ranged from 2.9 mm in December to 925 mm in July. Greater amount of precipitation occurs in the monsoon period between June and September (Figure 3.2). Among two stations in the SNNP, Kakani area received more rain than Sundarijal area.

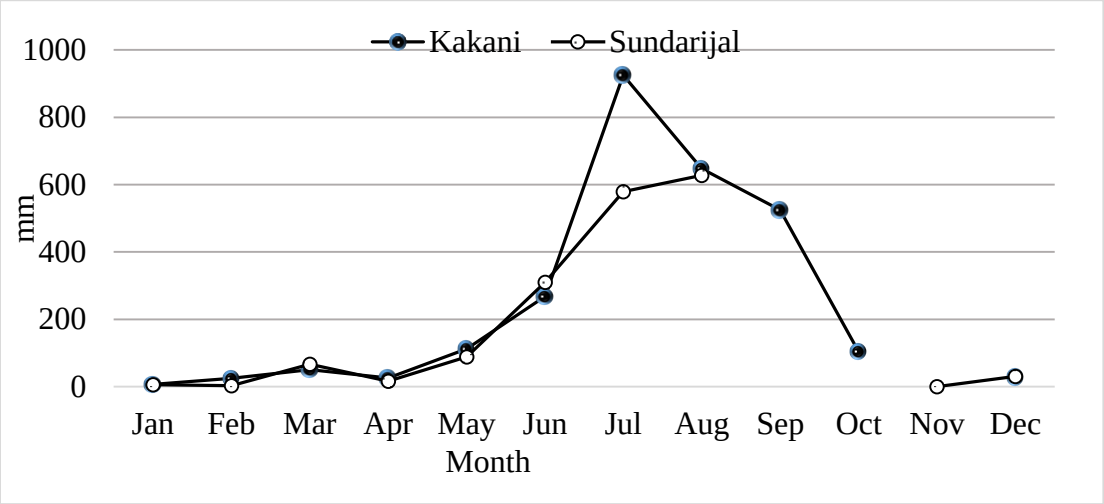

Figure 3.2 Average Monthly rainfalls in the Kakani and Sundarijal Meteorological Stations.

The climatic data recorded from meteorological stations in Kakani 2014 A.D showed that the average monthly temperature ranged from 4.4 ^{0}C in January to 25.1 ^{0}C in the months of May (Figure 3.3).

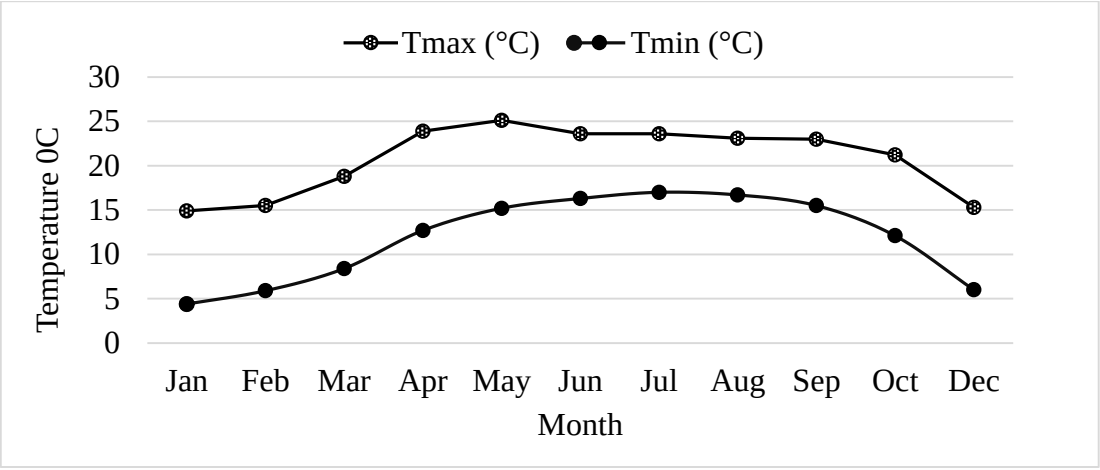

Figure 3.3 Average monthly maximum and minimum temperature at the Kakani Meteorological Station.

Relative humidity at the Kakani station in SNNP showed the highest value from June to September. Its value was 93% in September and more than 90% in the months from June to July. It has relatively high humidity all throughout the year (Figure 3.4). There was high variation in the annual temperature and precipitation.

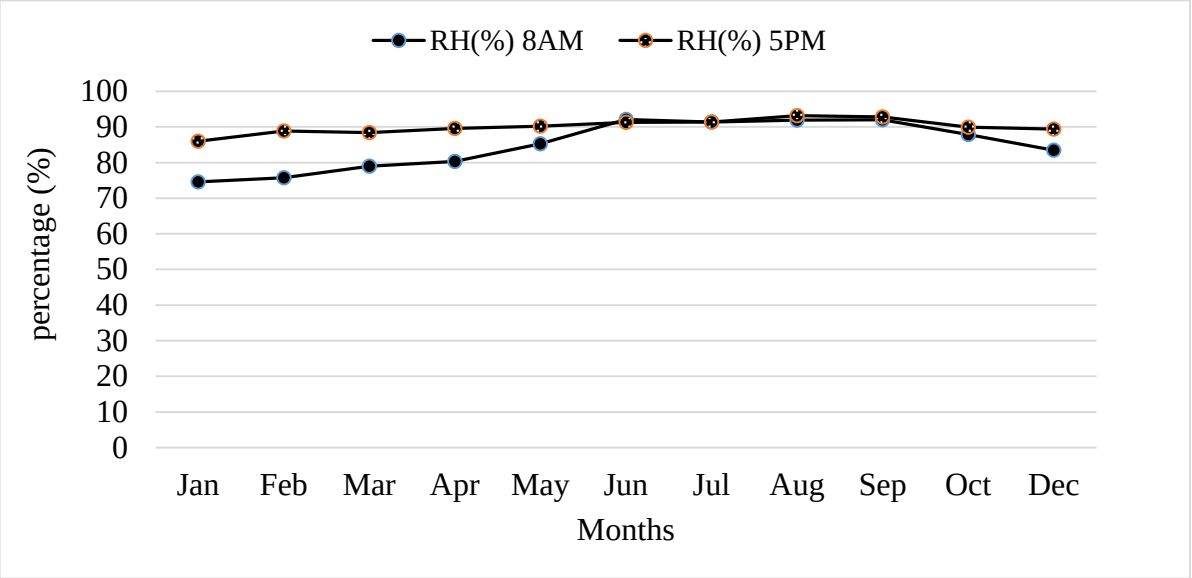

Figure 3.4 Relative humidity of Kakani station

3.1.6. Vegetation

The vegetation consists of variety of natural forest types including pine, oak, rhododendron, etc., depending of altitude and aspect. The altitude, climates and topographical features vary greatly from one area to another within the Shivapuri National Park due to this feature there is high diversity of vegetation are found. Amatya (1993) classified the forests into six types; Sal (*Shorea robusta*) forest, Terai hardwood forest, Lower slopes mixed hardwood, Chirpine forest, Oak (*Quercus*) forest and Upper slopes mixed hardwood forest. However, Rimal (2006) categorized the Shivapuri forest into four general types:-

1. Lower mixed hardwood forest:- This forest is ranged between the elevation of 1400-1849m which has S*chima* and C*astanopsis* as the dominant tree species.

2. Pine forest:- Pine is the dominant tree species which are in between the elevation of 1410m to 2100m. This forest also include other tree species such as C*astanopsis, Pyrus,* etc.
3. Upper mixed hardwood forest:- *Rhododendron* and *Quercus* are the dominant tree species found in between the elevation of 1500m to 2700m. The other tree species found in this forest are *Alnus, Eurya, Myrsine, Buddleja,* etc.
4. Oak forest:- This type of forest consists of *Quercus* as the dominanat species which are found in between elevation of 2300m to 2732m. The other tree species found in this forest are *Rhododendron, Symplocus, Sinamomum, Rhus,* etc.

There are 98 tree species belonging to 37 families (Sotomayor 2002), 133 species of shrub belonging to 39 families, 277 Species of herbs belonging to 63 families, 5 species of parasitic plants and over 129 species of mushroom has been recorded (Acharya 1999).

3.1.7. Fauna

Wild mammal in the park includes 33 species such as *Ursus thibetanus* (Himalayan black bear), Leopard, *Felis chaus* (Jungle Cat) and *Macaca mulata (*Rhesus Monkey*),* etc. (SNNP 2014). The park is also home to 177 species of birds, including at least 9 threatened species, 102 species of butterflies with a number of rare and endangered species (Acharya 1999).

The land use pattern in and around SNNP is predominated by forest (40.7%) followed by agriculture (35.3%), shrubs (14.8%), grassland (2.9%), grassland with shrubs (2.6%), landslide (0.5), settlements (0.9%), riverine feature (0.2%) and abandoned lands (2.0%) (Karim and Tamrakar 2004).

3.2. METHODS

3.2.1. Research design

Prior to the field survey a digitized map of SNNP was overlaid by grids of 2km x 2km size using Arc GIS 9.3 and line transect were randomly laid in the grids for prey survey.

A total of 25 line transect were laid down in random in 25 grids out of 42 grids for detection of the prey species (Figure 3.5).

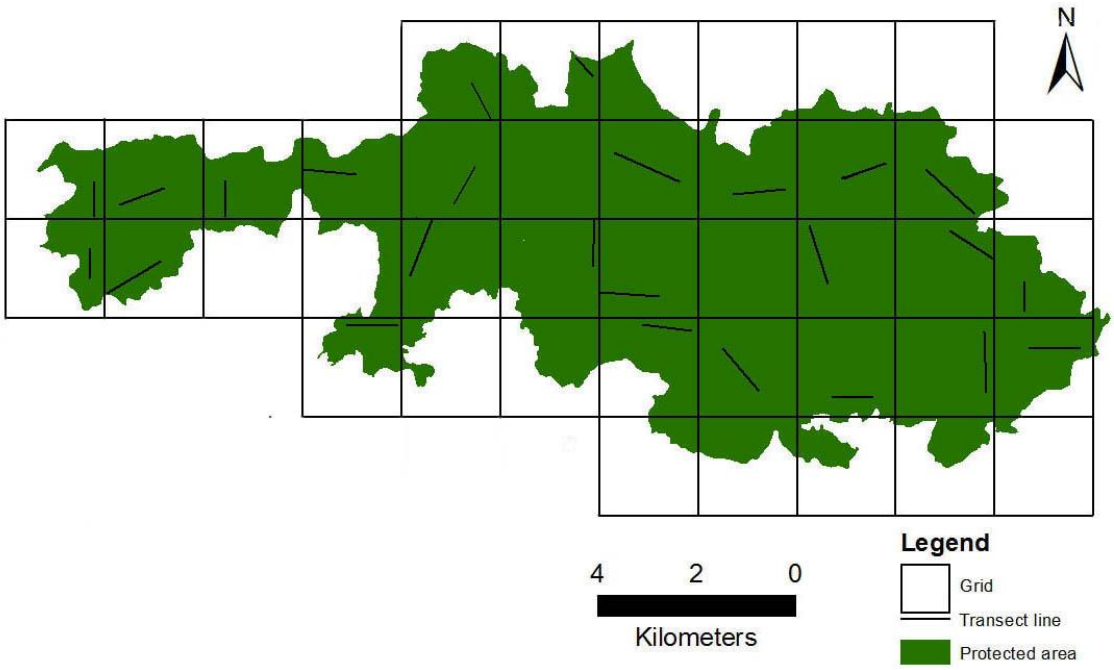

Figure 3.5 Grid design and line transect layout in the in study area.

3.2.2. Abundance of prey species

Abundance of prey species were determined using line transects sampling method. Line transect is the robust method to estimate population size of a species, in which animals are counted along in transect and their number, angular distance and sighting angle from the observer is recorded (Anderson et al. 1979, Buckland et al. 1993, Burnham et al. 1980). The length of transects ranged from 500 m to 1400 m depending accessibility and landscape features. Global positioning System (GPS) location of the starting and end point of each transect were uploaded prior to the survey and the straight line was navigated using a Compass (Silva model 10). In this survey only two persons were walked in the line transect. The first person walk in line transect straight with help of GPS (etrex 10) and Compass bearing angle along with the observing the animal. The second person recorded the GPS location, angle bearing, distance to prey from line transect. The distance from line transect to the prey was accurately measured.

The speed of walking in survey of line transect was 2 km per hour. The sampling of prey species were done at the morning (7:30 AM-11 AM) and evening (3 PM-5 PM).

3.2.3. Occurrence of prey species in leopard scats

3.2.3.1. Scat collection

Leopard's diet was determined by identifying the prey's hair remains in the scats because scat samples provide accurate diet information (Karanth and Sunquist, 1995). Scat analysis is a non-destructive tool in examining the diets of carnivore species (Mukherjee et al. 1994, Edgaonkar and Chelam 2002, Edgaonkar 2008, Chauhan 2008, Thapa 2011, Kumar 2011).

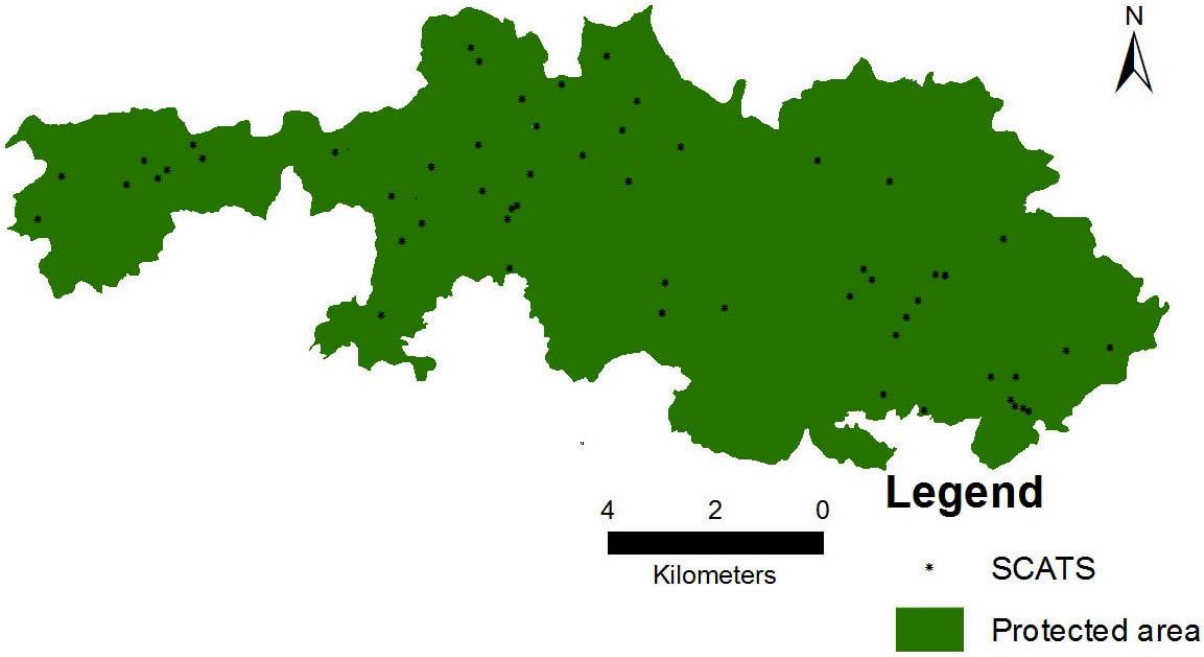

Figure 3.6 Location of scat collection in the study area.

The scat samples were collected opportunistically along animal trail, fire line and in open grassland from March to August 2014. The Leopard scats were collected with associated signs such as pugmarks, scraps, size and appearance. The location, date, associated signs and geographic coordinates were recorded for each of collected scat. These samples were sun dried, whenever necessary and preserved in tagged moisture absorbing envelope and labeled with date, place and geographic location; and taken to the laboratory for further analysis.

3.2.3.2. Sampling of hair from scat samples

Air-dried scats were taken to the laboratory of the Central Department of Zoology, Tribhuvan University. In the lab, all scats were dissected, soaked in warm water, washed through 1- 2 mm fine mesh-sieve and remains such as hairs, bones, hooves, teeth, scales, claws, etc. were separated for identification of prey eaten by Leopard (Grobler and Wilson 1972, Mukherjee et al. 1994, Henschel and Ray 2003). The hair of the prey was relatively undamaged in carnivore scat and thus can be used to identify the prey species eaten (Mukherjee et al. 1994, Ramakrishnan et al. 1999). Following Mukherjee et al. (1994), 20 hairs of prey were randomly sampled from each scat for analysis. Hair profile, cuticular and medullar slides, were prepared following methods described by Teerink (1991), De Marinis and Asprea (2006), Bahuguna et al. (2010), Thapa (2014) for the identification of prey species. Hair was identified by microscopic comparison of the features such as general appearance, colour, pigment, length, width, medullary width and cuticular patterns with reference hair.

3.2.3.3. Cuticular slides

For the preparation of cuticle slides the hair samples were dipped in the solution of ethyl alcohol and diethyl ether with 1:1 ratio for 30 minutes then hair samples were dried using blotting paper. The glass slide were painted by the transparent nail polish and hair were mounted on the polished surface of the slide. The hair were plucked carefully after slide were totally dried. The slide were then observed in the Aimscope trinocular microscope and photo were taken with different magnification (400X and 1000X).

3.2.3.4. Medullar slides

The hair samples plucked from the cuticle slide were used again for medullar slide preparation. Before dipping hair sample into the solution of acetone for 10 to 20 minutes it was cut into number of pieces for better image of medullar part in photo. The slides were observed in Aimscope trinocular microscope under 400X and 1000X magnification respectively.

3.2.3.5. Reference Hair Samples

Reference hair samples of potential wild and domestic prey species were prepared from hair samples of known species collected from the Museum of the Central Department of

Zoology, Natural History Museum (NHM), Tribhuvan University and domestic animals of local people in and around SNNP. Same procedure were applied for hair profiles, cuticular and medullary patterns, of the reference hair sample.

3.2.5. Threats to Leopard

For assessing threat to Leopard, pre-structure open-ended questionnaire with park authority and security personnel were done. Direct observation of human activities such as firewood collection, fodder collection, leaf litter collection and disturbance in field were collected. Secondary data relating to threats, were collected from SNNP, Panimuhan, reports, article and District Forest Office, Kathmandu.

3.2.6 Data analysis

3.2.6.1. Prey abundance analysis

The prey species abundance were analysed through the encounter rate method which state that how many individuals were encountered per unit distance (Kumar 2011). The encountered rate of individual species was then calculated through the formula;

$$\text{Encounter rate} = \frac{n}{L}$$

Where n is the total no of individual of a species encountered and L is the total length of line transect.

3.2.6.2. Occurrence of prey species in Leopard scats

For diet analysis of Leopard, the prey remains in the scat was extrapolated in terms of frequency of occurrence and percentage of occurrence. The frequency of occurrence was calculated using mathematical formula as shown in equation I (Pikonov and Korkishko 1992, Karanth and Sunquist 1995, Mizutani 1999, Ramkrishna et al. 1999).

$$Fi = \frac{ni}{N} \times 100 \text{……..equation I}$$

Where ni is the no of prey item in scat and N is the total no of species occur in the scat. The percentage of occurrence was calculated as;

$$\text{percentage of occurence} = \frac{n}{N} \times 100 \text{ ……equation II}$$

Where n is the number of prey species and N is the total no of scat.

Frequency of occurrence determines the presence of small and large prey species in scat equally, but percentage of occurrence of prey in scat analysis determines only presence and absence of prey species (Kumar 2011).

3.2.6.3. Threats to Leopard

For the assessing threats to survival of Leopard, primary as well as secondary data were collected. Primary data were collected from informal interviews with park authority and park protection security personnel (Army). The field data were collected regarding the human disturbance such as firewood, fodder, leaf litter and solid waste by human activities in the study area. Secondary data were collected from annual reports of SNNP and DFO, Kathmandu related data were collected during the field survey.

4. RESULTS

4.1. Abundance of prey species of Leopard

Of the total 25 line transect sampled, 7 were located on the Southern aspect, and 4 on the Northern aspect. Similarly 3, 3, 2, 2 and 4 transects were laid on northwest, southeast, west, east and ridges respectively. A total length of 41.064 km of line transect was sampled. Wild as well as domestic preys were observed in transect. The observed wild prey species were *Martes flavigula* (Yellow-throated Martin), *Macaca assamensis* (Assamese Monkey), *Muntiacus muntjak* (Barking Deer), *Semnipithecus* spp. (Hanuman Langur), *Sus scrofa* (Wild Boar), and domestic prey were *Bos taurus* (Cow) and *Capra aegagrus hircus* (Goat). The encounter rates in term of number/km of wild prey *Semnopithecus* spp. *Macaca assamensis*, *Muntiacus muntjak* and *Sus scrofa* were 0.4, 0.6, 0.6 and 0.1 respectively (Table 4.1).

Table 4.1. Encounter rate (no/km) of prey species in the SNNP

Particulars	Name of the species	Number of encounter	Encounter Rate (no/km)
Wild Prey	*Muntiacus muntjak*	24	0.6
	Macaca assamensis	24	0.6
	Semnopithecus sp	15	0.4
	Martes flavigula	14	0.3
	Sus scrofa	4	0.1
Domestic prey	*Bos taurus*	17	0.4
	Capra aegagrus hircus	14	0.3
	Total prey	**113**	

The encounter rate of *Muntiacus muntjak* and *Macaca assamensis* was highest (0.6/km) as compared to other prey species and the lowest encounter rate of *Sus scrofa*. Similarly, encounter rates of domestic prey species *Capra aegagrus hircus* and *Bos taurus* were 0.3 and 0.4 respectively (Table 4.2). The encounter rate revealed that wild prey species comprised 74% and the domestic prey was 26% (Figure 4.2).

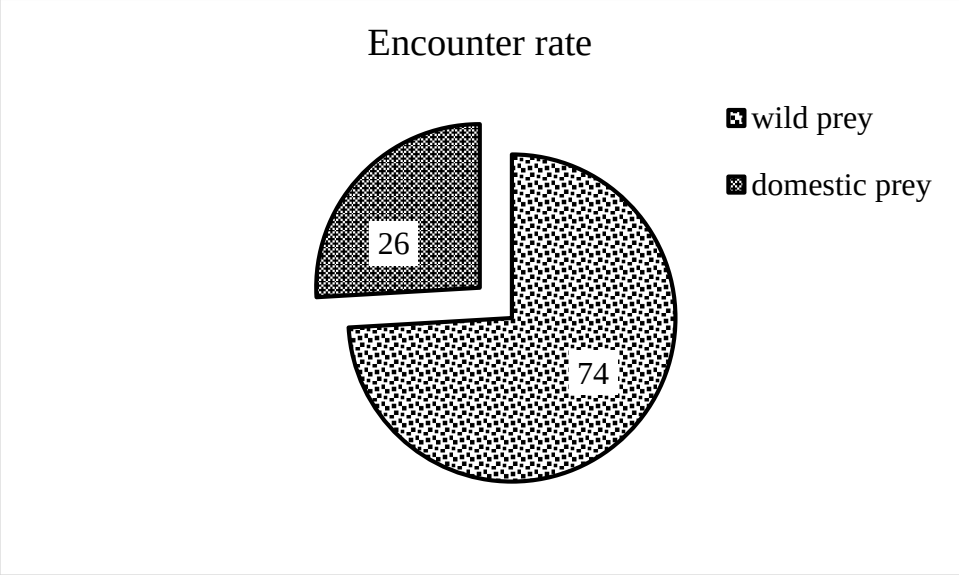

Figure 4.1 Proportions of the composition of prey species in terms of encounter rate.

4.2. Occurrence of prey species in leopard scat

Altogether 61 scats were collected and analyzed to determine diet composition of Leopard in SNNP. Among 61 scats, most of them were collected from the open grassland areas, animal trails, road in Sundarijal catchment area and fire line. From the Leopard's scat analysis a total of 14 prey species were identified, 12 species of wild prey; *Herpestes urva* (Crab Eating Mongoose), *Tamiops macclellandii* (Himalayan Stripped Squirrel), *Muntiacus muntjak, Macaca assamensis, Martes flavigula* (Yellow-throated Martin), *Rattus* spp. (Rat), *Macaca mulata* (Rhesus Monkey), *Viverra zibetha* (large Indian Civet), *Herpestes auropuntatus* (Small Indian Mongoose), *Paguma larvata* (Mask Palm Civet), *Lepus nigricollis* (Indian Hare) S*us scrofa* (Table 4.3) and two domestic prey species; *Canis lupus familiaris* (Dog) and *Capra aegagrus hircus* (Goat) (Table 4.4). A total of 83 prey items were identified. Single prey species were found in 39 scats and two species found in 22 scats.

The Leopard diet consist of prey from five different orders; Primate, Rhodentia, Lagomorpha, Carnivora and Artiodactyla. *Muntiacus muntjak*, *Herpestes urva* and *Paguma larvata* were found in higher number of scats followed by *Canis lupus familiaris, Capra aegagrus hircus, Martes flavigula, Tamiops macclellandii* (Table 4.2). Among the wild prey species the frequency occurrence of *Muntiacus muntjak*, *Herpestes urva* and *Paguma larvata* was found higher in the diet followed by *Tamiops macclellandii*, *Martes*

flavigula, *Viverra zibetha*, Rattus spp., *Macaca mulata*, *Herpestes auropunctatus*, *Sus scrofa*, *Macaca assamensis* and *Lepus nigricollis* (Table 4.2*)*. The diet of Leopard was found to have greater portion of wild prey species (70.5%) than domestic prey 29.5%).

Table 4.2. Occurrence of wild prey species.

Prey	**Name of the species**	**No of prey item in scats**	**Frequency of occurrence (n=83)**	**Percentage of occurrence (n=61)**
Wild prey	*Herpestes urva*	11	13.3	18
	Muntiacus muntjak	11	13.3	18
	Paguma larvata	10	12	16.4
	Tamiops macclellandii	7	8.4	11.5
	Martes flavigula	6	7.2	9.8
	Viverra zibetha	5	6	8.2
	Rattus spp.	4	4.8	6.6
	Herpestes auropunctatus	3	3.6	4.9
	Macaca mulata	3	3.6	4.9
	Sus scrofa	3	3.6	4.9
	Lepus nigricollis	1	1.2	1.6
	Macaca assamensis	1	1.2	1.6
Domestic prey	*Capra aegagrus hircus*	10	12.0	16.4
	Canis lupus familiaris	8	9.8	13.1
	Total	**83**		

The frequency of occurrence of domestic preys: *Capra aegagrus hircus* and *Canis lupus familiaris* were 12.0% and 9.85 % respectively. The percentage occurrence of *Capra aegagrus hircus* and *Canis lupus familiaris* were 16.4% and 13.4% respectively. Similarly the percentage of occurrence of *Muntiacus muntjak*, *Herpestes urva* and *Paguma larvata* was found higher proportion in the diet followed by *Tamiops macclellandii*, *Martes flavigula*, *Viverra zibetha*, *Rattus* spp., *Macaca mulata*, *Herpestes auropunctatus*, *Sus scrofa*, *Macaca assamensis* and *Lepus nigricollis*.

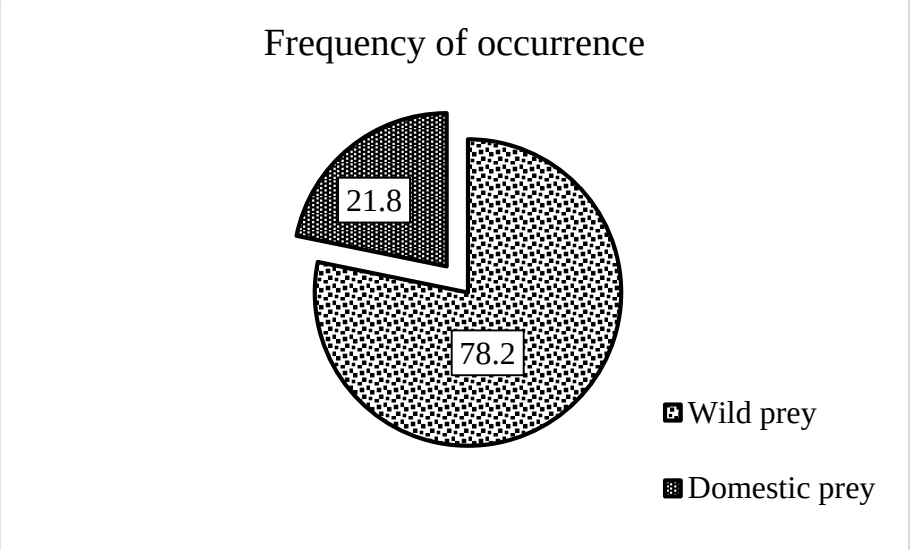

Figure 4.2 Proportion of frequency of occurrence of prey species.

4.3. Threats to survival of Leopard

The data collection from District Forest Office (DFO) Kathmandu and SNNP office Panimuhan of 2014 and open pre-structured questionnaire with park authorities and security personnel were revealed. Forest fire, visitor inflow, Human-Leopard conflict and forest degradation (firewood and fodder collection) identified as the threats to Leopard in the study area.

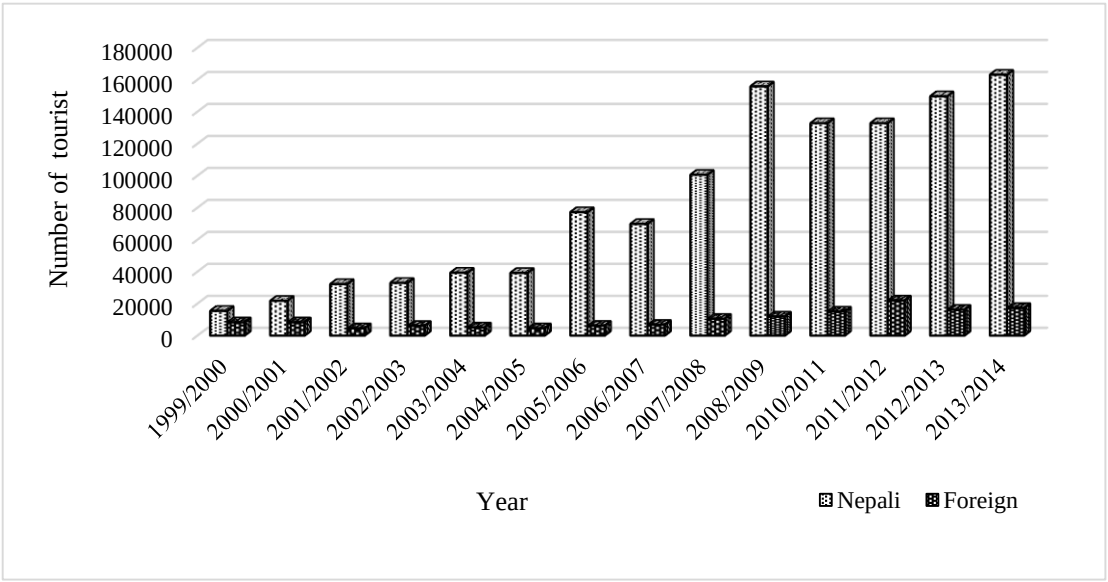

Figure 4.3. Visitor inflow in SNNP 2014

Data regarding tourists inflow obtained from 5 entry posts (Dhakalchaur, Tokha, Panimuhan, Sundarijal and Chisapani) of past 14 years showed increasing trend of visitor

number in national park. A total of 23826 visitors visited in National Park in 2000 AD which has increased by more than 7 times (180460 visitors) in 2014 AD (Figure 4.3). While, forest fire incidences was recorded in 21 different locations inside park area in a single year (June, 2013 to February 2014) marking as a one of major threat to habitat conservation of wildlife including Leopard in SNNP. Regarding the human-Leopard conflict, injury and harm caused by Leopard to human was not recorded however Leopard were spotted for 13 times in different locations outside the National Park in past 3 years (2012-2014), of which 8 Leopard were rescued while 5 Leopard were killed during the rescue process. Most of rescue locations were nearby national park or proposed buffer zone.

5. DISCUSSION

Estimation of prey abundance is the most important step in the conservation of predator (Edgaonkar 2008). Prey population is major factor responsible for decline in the large cat worldwide (Seidensticker 1986, Rabinowitz 1993). Availability of prey is important factor to determine the food composition of a carnivore (Leopold and Krausman, 1986) and density of predator (Martin and de Meulenaer 1988, Karanth and Sunquist 1995, Carbone and Gittleman 2002). Present study area harbour six medium sized wild ungulate taxa and 19 sub-optimal taxa and 5 taxa of domestic prey species but only 5 wild prey; *Martes flavigula, Macaca assamensis, Muntiacus muntjak, Semnipithecus* spp., *Sus scrofa* and 2 domestic prey species: *Bos taurus* and *Capra aegagrus hircus* were encountered during the study period. Although the National Park holds greater diversity of wild prey species, but lower abundance may influence on the ecology and behaviour of Leopard. However the *Munticaus muntjak and Macaca assamensis* were recorded relatively greater number among the prey species in the study area. Shrestha (2005) and Majupuria and Majupuria (2006) reported that prey population such as *Muntiacus muntjak, Sus scrofa, Lepus nigricollis, Macaca assemensis and Macaca mulata* were abundant in the study area.

There were several factors, human induced as well as natural, in determining abundance of wild prey. The steep topographical feature (slope > 30^0) as well as limited water resource might be important limiting factors for the lower abundance of native prey species. Although, there is no conclusive data but lack or inadequacy of salt lick as well as preferred grass species for the ungulates in the protected area in comparison to low land Terai; Suklaphanta Wildlife Reserve (Lovari et al. 2015), Chitwan National Park (Thapa 2011), Bardia National Park (Wegge and Storas 2009). Sariska National Park, India, which has high density of prey (Sankar 1994, Karanth and Nichols 1998, Chundawat et al. 1999, Mondal 2011) is due to presence of water bodies, salt licking and availability of the preferred grass species, might be contributing factor to the high density of wild ungulates. In Chitwan National Park the density of major prey were high in which gregarious species Chital was most abundant prey species followed by Wild Pig and Sambar (Thapa 2011). The high density of major wild prey species is due to mosaic habitat consisting variety of preferred habitat such as short grass, wetlands, edges and open area (Mishra 1982b, Thapa 2011).

The distribution and abundance of wild ungulates were affected by anthropogenic activities, resulting in depletion of carnivore populations (Karanth and Smith 1999). In the SNNP prey population and their dynamics were probably affected by anthropogenic pressure (SNNP 2014). The habitats inside the park as well as at the forest edges are degraded due to livestock grazing. The livestock grazing and other anthropogenic activities might results in the lower abundance of prey species. Although there was prohibition of illegal activities, due to lack of awareness and villages are close to forest local people entered deep inside the park for resource extraction. The local people living in and around the SNNP collect firewood and fodder illegally thereby not only disturbing the habitat of herbivore but also population of wild prey species. The illegal collection of firewood and fodder as well as the leaf litter reduces the hideout of the wild prey species. In addition Number of visitor inflow inside the park might affect on the ecology and foraging strategy of wild prey species. The villages inside the National Park also create negative impact to the park resources and wildlife.

Despite the availability of variety of field techniques for survey of mammals, all the method cannot be effectively applied in different ecosystem and also for all species (Smallwood and Fitzhugh 1995, Silveveira et al. 2003). The direct sighting of prey species was quite difficult in estimating the density of prey species in the area, therefore widely used distance sampling method was not used in this study. The distance sampling (Buckland et al. 2001) needs a minimum of 40 objects observation to provide robust estimates of the detection function and its variance (Burnham et al. 1980).

Dietary information of predator plays important role in predicting its impact on the dynamics of prey population (Harihar 2005). So the feeding habits of Leopard have been studied widely (Rabinowitz 1989, Mizutani 1999, Ray and Sunquist 2001, Thapa 2011). Direct observation of feeding behaviour was difficult in the field so indirect method through the microhistological analysis of hair remains in the fecal matter was used widely (Ackerman et al. 1984, Reynolds and Aebischer 1991, Trites and Joy 2005). Present study revealed that the occurrence of Primates, Rondentia, Lagomorpha, carnivore and Artiodactyla of mammalian orders in the scats of Leopard. The greater number of prey species belongs to the Rodentia and Carnivora. Due to low abundance of medium sized prey, small mammal became most significant part in diet of Leopard in present study. Wild prey species constituted significant part in diet. Although the diet consist of medium

sized wild prey; *Muntiacus muntjak* and *Sus scrofa*, the frequency of occurrence of wild ungulates (16.9%) was lower than the previous study in SNNP done by Basnet (2006) and too lower than the low land Terai; 78.57% in Chitwan National Park (CNP) (Thapa 2011), 59.1% (Eliassen 2003) and 60% (Wegge et al 2009) in Bardia National Park (BNP) and in hilly region 32.33% in Dhorpatan Hunting Reserve (Aryal and Kreigenhofer 2009). Abundance of wild ungulate prey species was very high in Lowland Terai (Wegge et al 2009, Malla 2009, Thapa 2011) in comparison to the present study area. The habitat quality of Leopard is correlated with the availability and density of different prey species in protected areas and non-protected areas (Johnsingh 1983, Ramakrishnan et al. 1999, Sankar and Johnsingh 2002, Aryal and Kreigenhofer 2009). In the SNNP, the ungulate density was very low and consequently affects the choice of diet of Leopard. Feeding behaviour and diet choice of Leopard was related with the abundance of different size classes of native prey species (Thapa 2011). Relatively higher frequency of domestic prey probably related with lower abundance of medium sized native prey.

Carnivore are likely to switch to secondary or suboptimal prey when the primary prey species were scarce (Hamilton 1986, Seidensticker et al. 1990) switching of Leopard to secondary prey (livestock and dog) was documented by Edgaonker and Chellum (2002) in such areas where primary prey species were scarce. Throughout the Leopard's range there has been a shift in its prey choices towards livestock (Spalton & Al Hikmani 2006). Domestic prey species usually constitutes only a small part of the diet of large felids and complete dependency on domestic species has rarely been observed (Athreya et al. 2014) but can be higher than that of wild prey (Seidensticker et al. 1990, Mizutani 1999). If the required wild prey species declined then actual loss of livestock might be even higher than that observed in diet of Leopard as it was easy to catch (Athreya 2014). The frequency of occurrence of domestic prey (29.5%) in the SNNP was lower than the previous study (33.36%) (Basnet 2006), and higher than the mountain region in DHR (4.52%) (Aryal and Kreigenhofer 2009) and low land Terai; CNP 11.67% (Thapa 2011), in BNP 17.1% (Eliassen 2003), 21% (Wegge et al 2009). Edgaonkar and Chellam (1998) also found that diet of Leopard in Sanjay Gandhi National Park, India, comprises 63.7% occurrence of mean percentage frequency of dog followed by buffalo and rodents. Many records of Leopard preying Dogs from either close to or even inside human habitation were observed by the Athreya (2014). Availability of domestic prey does not always

indicate accessibility as it may be guarded at day and enclosed in predator-proof enclosures at night (Edgoankar and Chellum 1998, Shehzad et al. 2014). From this study it showed that there were sizeable population of *Canis lupus familiaris* and *Capra aegagrus hircus* they were prey upon some extent by Leopard although there were other domestic population such as *Bos Taurus* and *Bubalus bubalis* (Buffalo). These might be due to sparse and scattered distribution of domestic prey in the periphery of national park.

Small wild species were preyed by Leopard in the habitat where there were lower abundance of large ungulates (Norton et al. 1986, Jhonson et al. 1992, Edgoankar and chellum 1998, Kumar 2011). The present study also revealed that Leopard consume small mammal frequently followed by ungulate species and domestic prey. The sub optimal prey such as *Herpestes urva* and *Paguma larvata* were frequently eaten by Leopard followed by *Macaca mulata*, *Capra aegagrus hircus*, and *Canis lupus familiaris*. Aryal and Kreigenhofer (2009) also found that small mammal were most significant prey in the diet of Leopard in DHR. Jhonson et al. (1993) reported that a considerable amount of rodent occurrence in Leopard diet in China. Edgoankar and Chellum (2002) in Sanjay Gandhi National park, India, , Kumar (2011) in Himanchal Pradesh, India, also found that small mammal were the second most significant part in the diet of Leopard in India. So the Leopard's feeding behaviour was difficult to say that the diet preference of Leopard was shifted towards the small mammal and domestic prey.

Higher frequency of occurrence of single prey species in the Leopard scats in SNNP is related with the killing of single prey species most of the time. Maheshwari and Khan (2009) also observed that there was not much difference between scats containing single prey and two prey. The killing of high frequency of small prey by Leopard might be one of the survival strategies in the prey poor areas. Smaller mammals are important component of predator diets (Zhirjakov 1990).

The scat analysis revealed presence of the plant material along with trace amount of soil in the diet of Leopard. Plant material was observed in many carnivore scat might be the result of accidental consumption of plant along with the main prey (Brever 2005, Rajaratnam et al. 2007). Plants, mainly grass was found in scat of tiger and Leopard of Sariskar Tiger Reserve (Sankar and Johnsingh 2002). Fox et al. (1991) suggested that consumption of plant material by animals compensate the lack of mineral in the diet. Bothma (1965,1966) reported that consumption of grass by carnivore was also reported to

keep the digestive system functioning during starvation or it might be serving to bind bone fragments in the formation of faces (Grobler and Wilson 1972) of it might act as sour (Murie 1994).

Increasing human activities for tourism and resource extraction on the nature habitat as might have exerted pressure on natural habitat as well on wildlife. Natural resources harvesting by the local people from the forest, visitor inflow though forest and illegal activities greatly influence the feeding and ecological behaviour of Leopard and their prey as well. So these sort of anthropogenic activities degrade natural habitat which threat to survival of Leopard.

Forest fire play a vital role in changing the wildlife population by changing the characteristics of the habitat. In the study area number of forest fire occurred in Sundarijal has higher that other part of protected area

Visitor inflow or tourists were the main source of increasing the economic part in the protected area which can be used in the management plan for maintaining and monitoring as well as conservation of wildlife population in the natural habitat. Visitor inflow in the SNNP showed increasing trend. The pressure of visitor inflow were high in Panimuhan and Sundarijal as there were greater number recreational activities. The facility such as off road driving, cycling and recreational entertaining decreases the hideout area of prey species, wildlife territorial disturbance increases, vegetation damage increases, reduction of rangeland which consequently impact on declining wild prey of Leopard. Development of tourist facilities in the protected area has been rapid in response to the increasing number of tourist. The pressure of tourist inflow also tend to increase pollution; solid waste inside the national park. Wildlife doesn't limited by boundary in between protected and non-protected area so due to pressure no of visitor inflow as prey population might decline due to reduction of hideout and foraging. So due to this sort of tourist inflow intensity prey get decline and consequently impact to Leopard.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

The abundance of prey species was low which constitute both wildlife and domestic too. Small mammals as well as medium sized of prey were encounter along with domestic animal. Majority of prey species recorded were sub optimal species in diet entailing deficiency of medium prey species in the study area. The poor medium prey species supports low number of leopard. Abundance of ungulates were higher than other prey species but low as compared with low land Terai.

The diet composition of Leopard constitutes 12 wild preys and 2 domestic prey in which domestic prey constitute lesser part than wild prey. Small mammal becomes most significant part in the diet of Leopard than the medium prey species which indicate declining of leopard population. The diet of Leopard preying on medium ungulates was decreased and preying on small mammal was increased.

The factor such forest fire, visitor inflow and anthropogenic activities were identified the threats to survival of Leopard. Anthropogenic factor were found to be major factor for declining of prey.

6.2. Recommendations

Based on this research, following are important recommendations.

- Estimation of Leopard, abundance of nocturnal animal as well as small mammalian prey should be done in order to know the leopard prey.
- The density of prey population must be increased through minimizing human disturbances in the park.
- Anthropogenic activities such as firewood and fodder must be controlled to minimize habitat destruction and control forest fire.
- People residing in and around protected area should be sensitized and educated on Leopard ecology and behavior so as to prevent harm from both side and channelize the correspondence mechanism between people, park authority, and park security personnel when Leopard are noticed outside the protected area boundary.

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ANNEXES

ANNEXES I Photo plate of field activities

Researcher Collectiing data

Researcher in field survey

Researcher interaction with local inside park.

Pugmarks of Leopard

Scat of Leopard

Scat of Leopard

Rhesus Monkey

Barking Deer

Squirrel

Rhesus Monkey eating waste

Grazing of domestic animal

Researcher observing Transporting of domestic animal

Cutting of firewood

collection of firewood

Researcher observing firewood collection

laboratory process

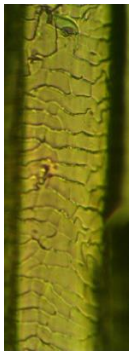
Bones in scat scat

Researcher in hair analysis

ANNEXES II Reference of cuticle with 400X magnification

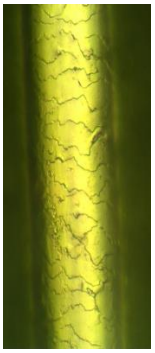
Golden jackal

Barking Deer

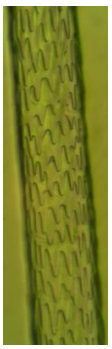


Yellow throated martin

Small Indian mongoose

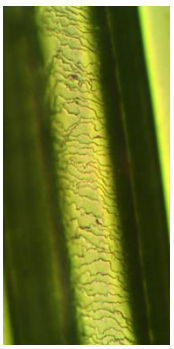


Rhesus monkey



Himalayan pika

Hanuman langur



Mask palm civet

Crab eating mongoose

Rat

Himalayan striped squirrel

Assamese monkey

Indian hare

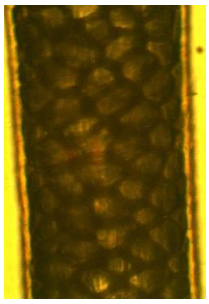
Large indian civet

Goat

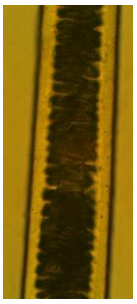
Dog

ANNEXES III Reference of medulla with 400X magnification

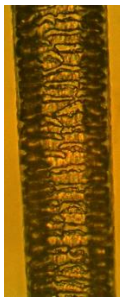

Golden Jackal

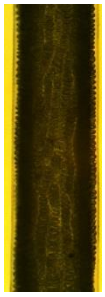

Barking Deer


Yellow throated martin

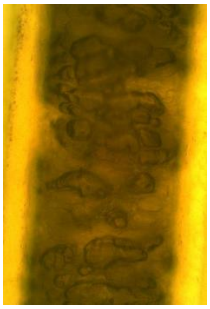

Small Indian mongoose

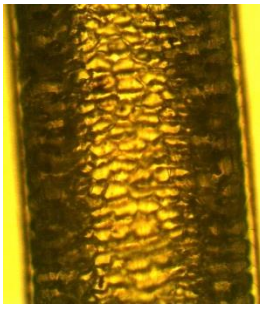

Rhesus monkey


Himalayan Pika

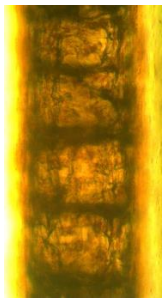

Hanuman langur

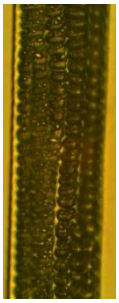

Mask palm civet

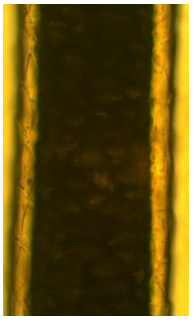

Crab eating mongoose


Rat


Himalayan striped squirrel


Asamese monkey


Indian hare


large Indian civet

ANNEXES IV Data sheet for prey survey

Transect no: - ……. Start time:-…….. Easting: - …….. Northing:-……. Elevation:- ……...

Total length:-…… End time:-…… Easting: - …….. Northing:-…… Elevation:- ……..

Location:-……..

S. No	Name of the species	Total number	Habitat type	Easting	Northing	Elevation	Aspect	Distance	Angle bearing

ANNEXES V Data sheet for scat collection

S. No	Date	Sample ID	Location	Northing	Easting	Elevation	Associated sign	% Confidence	Remarks

ANNEXES VI Check list of mammalian species of Shivapuri Nagarjun National Park

S. No.	Common name	Scientific name	Family
1	Asamese Monkey	*Macaca assamensis*	Primate
2	Barking Deer	*Munticaus muntjak*	Artiodactyla
3	Bat		Mammalia
4	Chinese Pangolin	*Manis pentadactyla*	Cimolesta
5	Clouded Leopard	*Neofelis nebulosa*	Carnivora
6	Common Mongoose	*Herpestes auropunctatus*	Carnivora
7	Crab eating Mongoose	*Herpestes urva*	Carnivora
8	Eastern House Mouse	*Mus musculus*	Rhodentia
9	Fawn-colored Mouse	*Mus cervicolor*	Rhodentia
10	Flying Squirrel	*Petaurista* spp.	Rhodentia
11	Golden Jackal	*Canis aureus*	Carnivora
12	Hanuman Langur	*Semnopothecus* spp.	Primate
13	Himalayan Black Bear	*Ursus thibetanus*	Carnivora
14	Himalayan Goral	*Naemorhedus goral*	Artiodactyla
15	Himalayan Shrew	*Soriculus nigrescens*	Rhodentia
16	Himalayan-stripped Squirrel	*tamiops macclellandii*	Rhodentia
17	Hodgson's Brown-toothed Shrew	*Soriculus caudatus*	Rhodentia
18	House Rat	*Rattus rattus*	Rhodentia
19	Indian-crested Porcupine	*Hystrix indica*	Rhodentia
20	Indian Hare	*Lepus nigricollis*	Lagomorpha
21	Indian Pangolin	*Manis carassicaudata*	Cimolesta
22	Jungle Cat	*Felis chaus*	Carnivora
23	Large Indian Civet	*Viverra zibetha*	Carnivora
24	Leopard	*Panthera pardus*	Carnivora
25	Leopard Cat	*Felis bengalensis*	Carnivora
26	Mask Palm Civet	*Paguma larvata*	Carnivora
27	Orange-bellied Himalayan Squirrel	*Dremomys lokriah*	Rhodentia

28	Rhesus Monkey	*Macaca mulata*	Primate
29	Royle's Pika	*Ochotonaroylei*	Lagomorpha
30	Sambar Deer	*Cervus unicolor*	Artiodactyla
31	Wild Boar	*Sus scrofa*	Artiodactyla
32	Yellow-throated Martin	*Martes flavugula*	Carnivora