1. INTRODUCTION

1.1 Background

The forest leopard (*Panthera pardus*) is a highly adaptable large carnivore mammalian predator species and found commonly in most part of Asia and Africa. In most of its range, the leopards are sole large mammalian predator.

The *Panthera pardus* has the widest distribution of all the big cats (Srivastava 1999). As a habitat generalist species (Maan and Chaudhary 2000) it can live and thrive almost all types of habitats including dense forest, open country, rocks and scrubs (Prater 1993); grasslands and even in the mountain cliffs, where sufficient hide out and preys are available and they feel just as secure (Nowak, 1997). It has been reported from tropical forests, deserts and even from the frozen mountains at an elevation of 5,630 meters on Kilimanjaro (Guggisberg, 1975; Nowak, 1997).

For a big cat the Leopard is remarkably persistent in the face of human settlement (Nowell and Jackson 1996) and can easily survive outskirts of densely populated urban areas such as Kathmandu (Shah *et al*.2004), Bombay (Jackson 1991), Islamabad (Jackson 1996) and most part of Java (Nowell and Jackson 1996).

The leopard occurs in a very wide geographical range. It has been reported from most part of Africa, Central Asia, Middle East, South Asia, South East Asia, Indo-China, and Manchuria to Korea and above the 50° latitude in eastern Siberia (Nowell and Jackson 1996). In South Asia, it is distributed in Pakistan, India, Nepal, Srilanka and Indochina (Prater 1993, Roberts 1997, Shrestha 1997). The leopards are found throughout the Indian subcontinents with exceptions of deserts and the Sundarban mangroves (Johnsingh *et al*. 1991). In The Himalayas, the leopards are sympatric with snow Leopard up to 5200m (Jackson 1984) although they more commonly live below the tree line (Roberts 1997, Green 1987).

Forest leopards are also common in the foothills of the Nepalese Himalayas, despite a dense human population (Nowell and Jackson1996). It has been reported from all the protected areas and occurs in almost all the districts of Nepal (Shah *et al.* 2004, Majupuria and Majupiria 2006).

The Leopards have a varied diet but show a preference for small to medium sized ungulates but it preys on a variety of animals that range in size from small birds to Samber. The food habits of leopards have been studied in various part of Asia and Africa such as Java (Santiapillai and Romono 1992), Thailand (Rabinowitz 1989), India (Johnsingh 1983, Karanth 1993); Sri Lanka (Muckenhirn and Eisenberg 1973); Nepal Terai (Seidensticker *et al*. 1990), Pakistan Himalaya (Schaller 1977), Ussuri region of Russia (Abramov and Pikunov 1994, Korkishko and Pikunov 1994), China (Schaller *et al.* 1985). The known prey of leopard ranges from dung beetle (Fey 1964) to adult male eland (Kingdon 1977), which can reach 900 kg (Stuart and Stuart 1989). Bailey (1993) documented over 92 prey species in the leopard's diet in sub-Saharan Africa. Seidensticker *et al.* (1990) identified *Cervus* sp., Sus sp., *Axis axis, Axis porcinus, Muntiacus sp.*, goat, sheep, cow, dog, and vulture from the scat of the leopard in Chitwan, Nepal.

The leopard maintains large home range. Rabinowitz (1989) found that male leopards in the Huai Kha Khaeng Wildlife Sanctuary, Thailand maintained slightly overlapping home range of 27-37 km^2, while female had range of 11-17 km^2 within the range of males. Seidensticker *et al*. (1990) found similar-sized female home ranges of between 7-13 km^2 in the Chitwan National Park in Nepal. The female's range is usually exclusive, although this may be slightly flexible. The young are transient until home ranges become available because of adult mortality. Urine spraying, scraping and tree scratching are methods used by leopards for territory marking and identification (Jackson 1990).

The forest leopards may be seen at any time of the day, but tend to be nocturnal and secretive. In protected areas, the leopards are more diurnal, even being

seen hunting in the bright sunlight, and very good climbers and swimmers, but do not lie in the water like a tiger and two thirds of the leopard's time is spent resting and surveying its pads, much of the time lying in a tree, on large boulders or in a vulture's nest (CST 1996).

The leopards are threatened by habitat loss, depletion of wild ungulate prey base, persecution and poaching (Korkishko and Pikunov 1994, Hanchel and Ray 2003, Shah *et al.*2004, Nowell and Jackson 1996). Its habitat is becoming more fragmented and disjoint as the human population increases (Nowell and Jackson 1996). The habitat loss results not only in physical area in which they live but also in a decrease in ungulate prey. Illegal commercial hunting for pelts and bones for traditional medical is widespread throughout its range. Because of its cattle lifting behaviour, the leopards are persecuted (Alderton 1998, Shah *et al*.2004).

The forest leopard is listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits trade in any body part of the animal in those countries that are members of the convention (Shah *et al.* 2004).

1.2. Statement of the Problem

Because of its wide distribution, the forest leopard is considered common species in Nepal. It is threatened by habitat loss, depletion of ungulate preys, poaching and persecution (Shah *et al*.2004). Although there are a few studies on the leopard are available (eg. Seidensticker *et al.* 1990, Shah *et al.* 2004, Poudel 2005), but detail information on ecology and behaviour is still lacking in Nepal. Several times, the resident leopard of Shivapuri National Park have created terror due to their unexpected activities within and around Kathmandu city. This study has been conducted to assess status, distribution, food habits and conservation threats to the leopards in ShNP.

1.3.Objectives

The main objective of this study was to collect detail ecological information on the leopard in the Shivapuri National Park. The specific objectives of this study were to

- determine status and distribution,
- analyze diet of the leopard, and
- examine the human – leopard conflicts and conservation threats on leopard in Shivapuri National Park.

1.4.Rationale

Present study has analysed status, distribution, diets and conservation threats of leopard in ShNP. It is hoped that these valuable ecological information can be used for further research and implementing conservation strategies for the leopards in the park.

1.5.Limitations

Time, security situation, literatures and financial resources are major limitations for this study. Because of land mines and other security constraints, I could not smoothly work throughout the park. The movement of people and vehicles on the road had completely damaged the tracks of the leopards inside the parks.

I had faced the most striking difficulty in the collection of reference hair samples of the potential prey species, identification of the hair samples present in the scats and photographing problems in the laboratory. It was very difficult to identify the bones, claws present in the leopard's scat, therefore this part has been excluded.

2. STUDY AREA

2.1 Locations and Physiography

Present study was carried out in the Shivapuri National Park ($27^0$45' – $27^0$52'N and $85^0$15' - $85^0$30' E), which is located at the northern side of Kathmandu Valley about 12 km from the centre of the city. The park covers a total area of 144km^2 (DNPWC 2004) and consists of 12 Village Development Committees (VDC) of Kathmandu districts, 9 VDCs of Nuwakot and two VDCs of Sindhupalchowk district. The altitude of the ShNP varies from 1360 m to 2732 m at the Shivapuri peak. It is only protected area of Nepal lying entirely within mid – hills.

2.2 Geology and Soils

Geologically, Shivapuri area occupies the inner Himalayan region. The dominant rocks are gneiss and magnetite with mica, schist and pegmatic granite (HMG/UNDP 1996). Eco-Cambrian bands of quartzite and limestone are also present in this area (Shrestha 1980). This is a tectonic zone extending nearly in the East-West direction along the Northern margin of the Kathmandu basin from Trisuli Ganga, the Shivapuri Lekh to the Manichur lekh and continues to the Sunkoshi tectonic zone in the east (Mohammad *et al*.1998). The soils of the area range from loamy sand on Northern side to sandy loam on the southern slope. Entire area is characterized by its steep topography. More than 50% of the area has greater than 30% slopes. Erosion hazard, stream bank erosion both natural and man- included is found all over the area (Shrestha 2005).

Soil Moisture content of ShNP in general increases with the increase in elevation from the altitude of 1670m to 2732 m and then decreases in altitude of 2732. Moisture content was higher in the natural forest than in barren area and the humus content increased with the altitude up to 2468m but soon decreased at 2734m (Karna1994). P^H of soil is acidic in disturbed as well as undisturbed forest but it is more acidic in disturbed site than in undisturbed natural site (Baniya 1998).

Map 1: Map showing the study area

2.3 Climates

Shivapuri National park lies in the central mid-hill region of Nepal and the climate ranges from sub-tropical to warm temperate, which is delimited in three climatic periods: a) Pre- Monsoon season (hot dry season) extending from mid February to mid June and is the hottest and driest season, b) Monsoon season occurring from June to September and c) Post monsoon season (Cold dry season) occurring from October to mid January.

Three climatological stations are there in Shivapuri range at Kakani, Sundarijal and Budhanilkantha. Analysis of Analysis of climatic data recorded in the meterological stations in Budhanilkantha and Kakani showed that the average monthly temperature ranged from less than 5^0 Celsius in January to over 25^0 Celsius in the months of May, June, July and August (Figure 1).

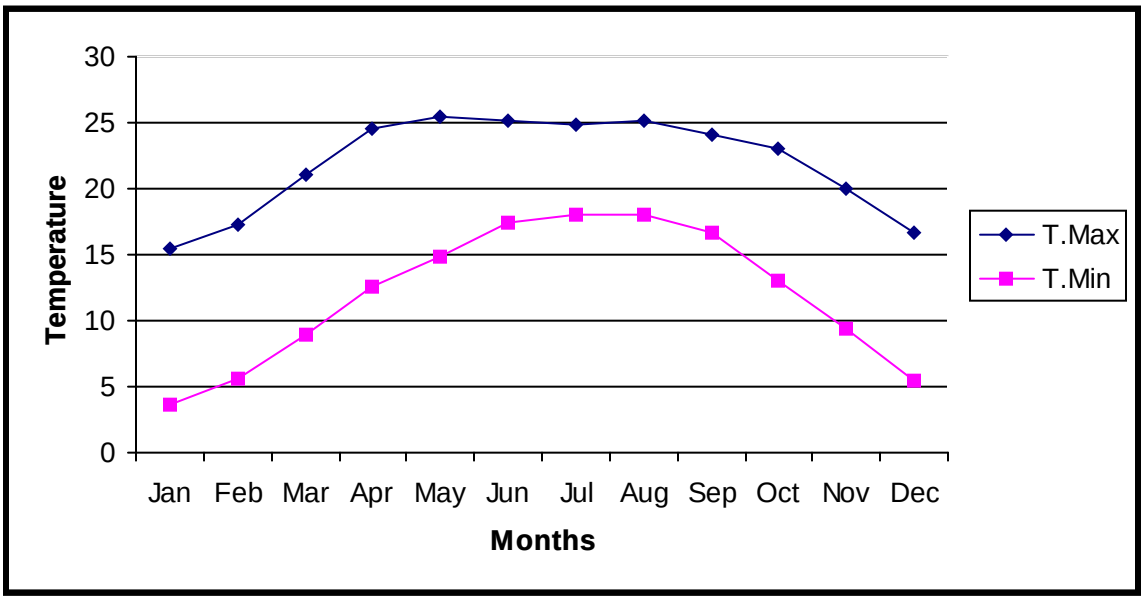


Figure 1: Average monthly mean maximum and minimum temperature of ShNP (1995-2004)

The average monthly rainfall ranged form 9.4 mm in December to 684 mm in July and more than 85% of precipitation occurs in the monsoon periods between June and September (Figure 2). Between the two stations, the Sundarijal Area received more rain than Budanilkantha.

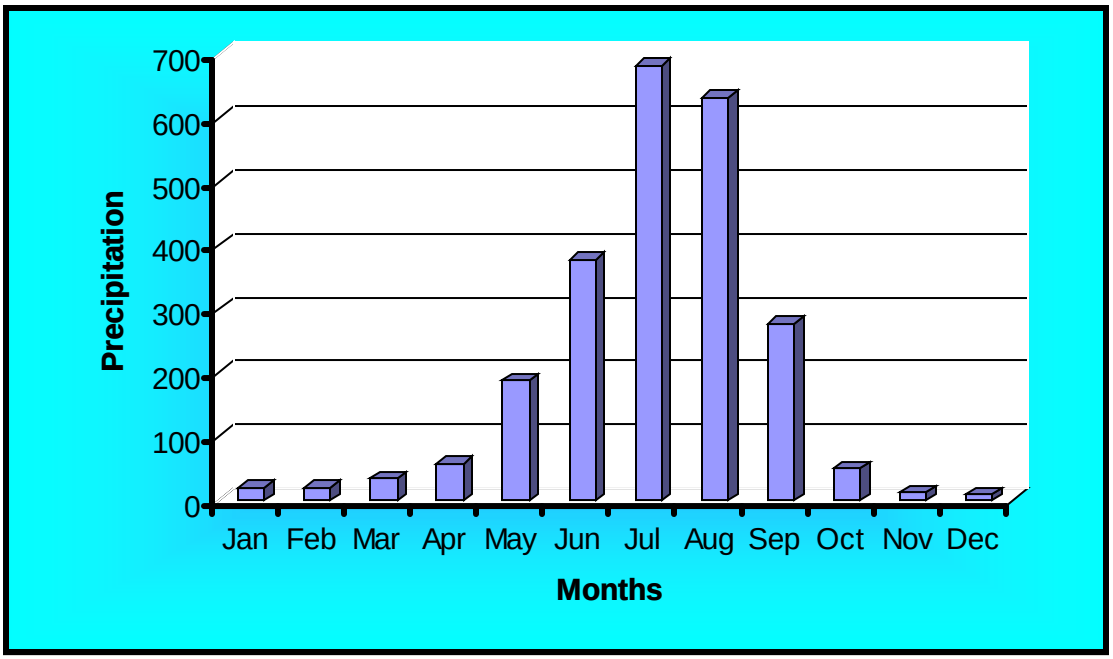


Figure 2: Average monthly Precipitation in ShNP (1995-2004)

Relative Humidity in ShNP shows the highest value in August (91.4%) but it is higher in the months from June to October (more than 89%). The lowest monthly relative humidity was in April (77.1%) (Figure3).

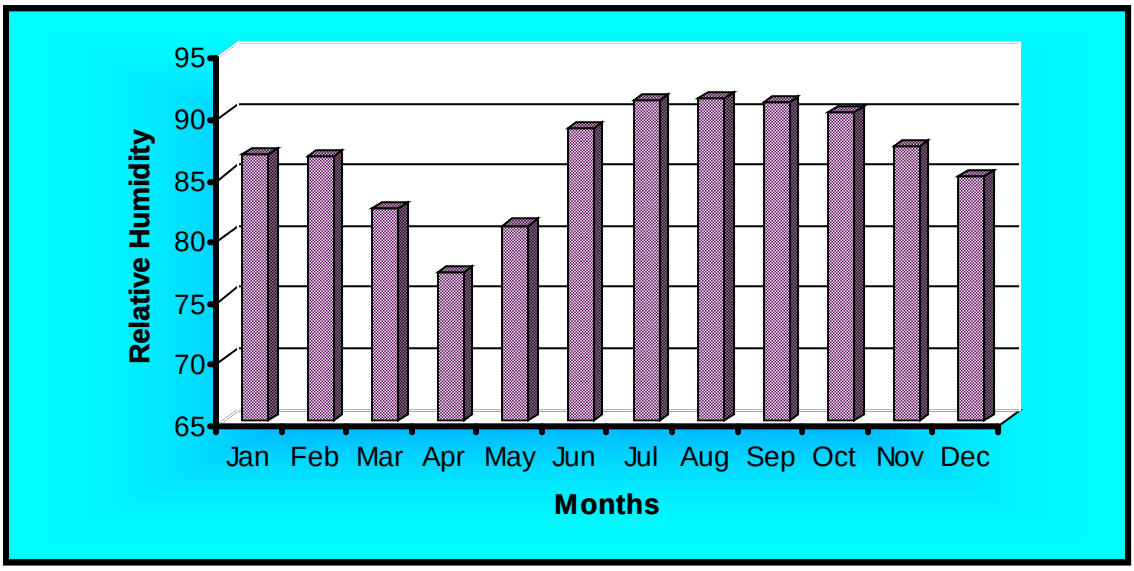


Figure 3: Average monthly relative humidity in ShNP (1995-2004)

2.4 River Systems

The park itself is the main watershed, which supplies water to the people of Kathmandu. It is drained by Bagmati and Bishnumati rivers, and their tributaries. Similarly, tributaries of the Likhu and Sindhu Khola, which drain the northern side, also originate from the park.

2.5. Vegetation

Because of the variation in altitude, topography and climates within a short distance a great diversity of flora exists in this area. The vegetation varies from the Sal forest in the North near Likhu Khola to the sub tropical vegetation in the southern hill, with *Alnus, Schima, Castonopsis* and *Pinus* species. Higher altitudes are characterized by temperate forests of *Quercus semicarpifolia* on the top of Shivapuri hill (Amatya 1993).

There are 98 tree species belonging to 37 families (Sotomayor 2002), 133 species of shrubs 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).

Amatya (1993) has divided forest of the park into four types. These are

i) Lower mixed hardwood forest: It extends from 1000m-1500m. *Schima wallichi* and *Castonopsis indica* forest and the others are *Alnus nepalensis*, *Anthosaphalus cadamba* and *Prunus ceracoides*.

ii) Chir-Pine forest: Chir pine forest lies from 1000m – 1600m. In this forest type Pinus roxburghii is dominant to other species; *Castonopsis indica*, *Merica esculata*, *Pyrus pashia*.

iii) Oak Forest: from 2300m to 2700 meter lies Oak forest. Species combination is *Quercus semecarpifolia*, *Eurya acuminata*, *Ilex dipyrens*, *Michelia champaca*, *Rhododendron arboreum*, *Symplocus* sp.

iv) Upper Mixed hardwood forest: Upper hardwood forest lies at 1500 – 2700 m. The species composition in this forest is *Acer* sp., *Aesculus* sp., *Juglans regi*a, *betula* sp., *Fraxinus* sp., *Alnus nepalensis*, *Salix* sp., *Celtis* sp.

2.6 Fauna

The fauna of the ShNP has been documented by Kattel (1993), Smith (1996), Shrestha (2005), Rimal (2006). Kattel (1993) recorded 19 species of mammals while Shrestha (2005) has recorded more than 22 species in ShNP. Common Leopard (*Panthera pardus),* Yellow throated marten (*Martes flavigula*) wild boar (*Sus scrofa*), barking deer (*Muntiacus muntjak*) and rhesus monkey (*Macaca mulatta*) are some common species of the park.

The park is the home to 177 species of birds (Inskipp 1989) including 9 endangered species. The park is a paradise for many resident as well as migratory birds. Many bird species including two restricted range species; Hoary throated Barwing (*Actinodura nipalensis)* and Spiny babbler (*Turdoides nipalensis*) are quite common here (Baral and Inskipp 2001).

More than 102 species of butterflies have been recorded from the park and its surrounding area (Smith1996). These include endangered Kaiser-hind (*Teinopalpus imperialis*) and the susceptible endemic sub species *Oreolyce vardhana nepalica*. Shivapuri is also important as one of the few sites where the rare relict Himalayan dragonfly (*Epipophlebia laidlawi*) was found (HMG/FAO 1996).

2.7 Socio-economic Condition

The total people living in and around the park are about 48,991 with about 9,432 households. Mixed ethnic groups inhabit the villages inside the park and its buffer zones.

About 75% of the people of the area are economically active and engaged in agriculture as primary occupation. The younger generation prefers off-farm employment opportunities rather than the traditional occupation of subsistence farming (Khatri – Chhetri 1993). Some people are involved as labour, driver and service at nursery, hotel and lodge, and government services besides the agriculture (Shrestha, 2005).

Recreational activities are increasing in the park at a rapid rate and more people are engaged in this profession. Being closest national park of Kathmandu, the ShNP attracts many visitors and tourists for Trekking. Trekking routes to Nagarkot, GosainKunda, Helambu and Langtang national park also go through the Shivapuri area (HMG/FAO 1996).

The tourists from foreign countries, SAARC countries and Nepal visit ShNP regularly. In the year 2003/2004 a total of 39094 visitors including 6087 non Nepali visited the park, which was 26670 in 2002/2003 and 301124 in 2001/2002 (Figure 4) which has been the major threats to the biodiversity.

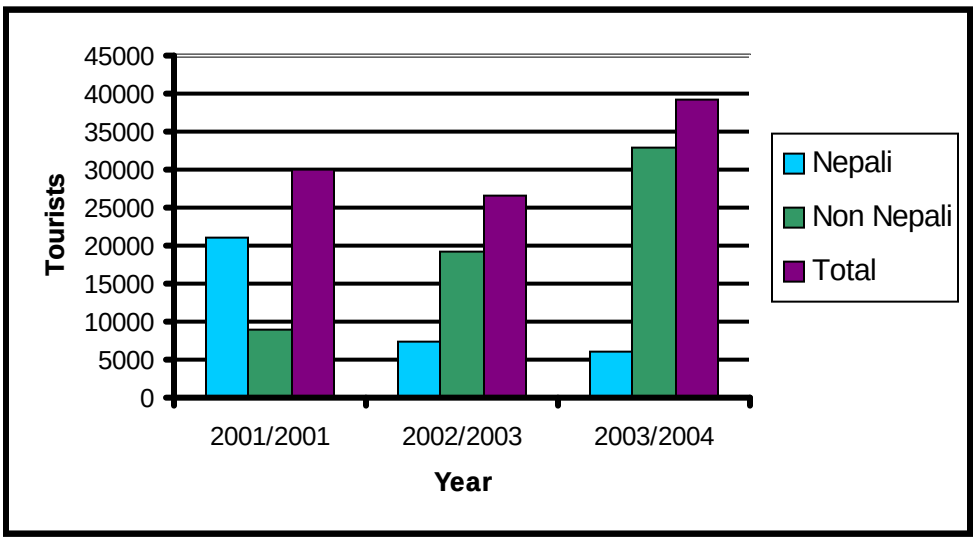


Figure 4: Number of Tourists visiting in ShNP from 2001/02 – 2003/2004.

Source: DNPWC, Annual Reports from 2001/02 – 2003/2004.

3. METHODOLOGY

3.1 Reconnaissance of the Area

Preliminary field reconnaissance was carried out in November and December 2004 to collect general information on leopard distribution and to select sampling sites. During the preliminary survey, interactions with the park staff and local people were made.

3.2 Field Surveys

The field surveys were carried out to determine distribution and population of the leopard from January 2005 to December 2005. Because of the highly secretive and nocturnal habit of the leopard, the indirect methods of animal presence were used. During the field surveys information on the distribution of scats, pugmarks, scratch, scent marks and predation records were collected to determine distribution and population of the leopard in the ShNP.

3.2.1. Block Design

The entire study area was divided into three blocks namely A, B and C for sampling purpose. The different sites were selected by using topo map (1:25000) of ShNP for the block design on the basis of natural barriers and manmade demarcation such as deep gullies, rivers and foot trails.

Block A: It includes the areas of the western part of the national park from Kakani including Gorje, Khole gaon, Gurung Gaon and Sikre. The western boundary is demarcated by western boundary of Park whereas the Panimuhan – Sikre foot trail, demarcates the eastern boundary. Vegetation in this blocks consists of the lower mixed hardwood forest in the lower elevation and Chir pine forest and and upper mixed hardwood forest dominated the higher elevation.

Block B: Middle portion of the park including Sinche, Mahadev danda, Budhanilkantha area, Shivapuri peak, Baghdwar, Nagi Gumba, and Mulkharka

area in the Block B. The western boundary is demarcated by the motorable road from panimuhan to Gumba followed by the foot trails to peak. Whereas the eastern boundary is demarcated by the foot trails to Okhreni from Sundarijal. Bagmati and Bishnumati Khola were also included in this block. The vegetation of this block is *Schima Castonopsis* forest, *Quercus semecarpifolia* and *Rhodedendron* and *Alnus nepalensis* forest.

Block C: It is located in the eastern part of the national park including Mulkharka, chisapani.,and manichur.. The western boundary was made by the foot trails from Mulkharka to Chisapani whereas the eastern boundary was demarcated by the park boundary. The vegetation was of mixed type including *Schima wallichiana, Quercus* species, *Prunus cerrasoides*, *Cinnamomum tamade* etc.

Map2. Map showing the study blocks and Transects

3.2.2 Leopard Sign Transects

Present study followed sign transect method developed by WWF (2001) for snow leopard survey and Hanchel and Ray (2003) for forest leopard surveys in African rain forest with some modification to collect data on the leopard signs (pugmarks, scats, scrapes and scent sprays). These signs give the relative abundance and distribution of leopards. A total of 11 transects, 3 were laid on Block A, 5 on Block B and 3 on Block C. The Length of the sign transect was from 500m to 4 km and breadth was 5 m left and 5 m right from the central line. The data on altitudes and habitat types were recorded from each sign location. Simultaneously all observed scats were collected and preserved for diet analysis and pugmarks were captured.

3.2.3 Identification of Leopard Signs

Leopard's signs were identified following Henchel and Ray (2003). Adult leopard often travel along the trails and roads and deposit their faeces for marking purpose and the signs are therefore the most frequently encountered leaving little chance for the confusion with other species (Hanchel and Ray, 2003).

3.2.3.1 Scats

Leopard's scats were identified by shape, size, length and diameter. The scat is elongated often tapering one end and generally in several pieces each measuring 6 – 13 cm in length and 2.5 – 4 cm in diameter with high calcium content turned white, particularly when bleached by the sun but usually they are dirty white (Henchel and Ray, 2003).

3.2.3.2 Pugmark

A full grown forest leopard will have a track that that measures 7.5 – 11 cm width and length with the main pad 4 – 7.5 cm with a male being a bit larger than female (Henchel and Ray, 2003).

3.2.3.3 Scrapes

Scrapes of the leopard were identified following WWF (2001). Scraping is the most common marking activity and among long lived signs, especially if made in gravelly and undisturbed areas (Shrestha 2005).

3.2. 4. Pugmarks Capture

Three separate techniques were also adopted for capturing the leopards pugmarks.

3.2.4.1. Tracing methods

Tracing of pugmarks were done following WWF (1998). For each tracing a transparent rectangular glass plate (20cmX25cm) was placed over the track and pressed down close to the relief edges of track without actually touching the edges. Tracing on the glass plate was then overlaid with a piece of tracing paper (held to the glass plate with four plastic clips) and copied.

After tracing, the total length (TL), total width (TW) and pad width (PW) of the pugmark were measured to differentiate individuals. I tried to identify sex on the basis of distinct differences of TL, TW and PW. In some cases, field circumstances (for example the clear occurrences of large and small leopard tracks deposited at the same time at a single location indicating a female with cubs) allowed for the high confidence interpretation and were also included in the reference data set.

3.2.4.2. Casting methods

Casting method was used to collect an impression of the pugmark to identify individual animal. This technique quickly provides information to identify the individual animal (WWF 1998). The impression was made with plaster of Paris. The pugmark was cleaned with the help of forceps after locating it. Fine dusts of talcum powder were blown and then the casting frame is positioned, gently pushing the edges of frame into the soil. The mixture of plaster of Paris, a little common salt and water immediately poured on the pugmark and was allowed to settle for about 30-45 minutes. Later the casting frame was taken out and cast was labelled.

3.2.4.3. Photography

Photographs of all the identified pugmarks were taken when encountered in the transects.

3.3. Distribution Patterns

Block wise and transact wise distribution of the leopards were determined according to the signs observed.

3.4. Diet Analysis

The diets of the leopard were assessed by scat analysis method. During the food habit studies of carnivores, scat analysis have been widely used for describing diet because it is non destructive and scats are easy to collect (Joslin 1973, Johnsingh 1983, Norton *et al.*, 1986, Palmer and Fairall 1989, Windberg and Mitchell 1990).

3.4.1. Potential Prey Survey

Potential wild and domestic prey species of the leopard and their presence in ShNP were determined through literature review. Determination of the presence

of potential preys in the study area has helped to identify actual preys by scat analysis method.

3.4.2. Scat collection

Leopard's scats were collected from the transects and stored in the polythene bags systematically recording the date, time, location and habitat of collection.

3.4.3. Laboratory Work

Laboratory works were done for the preparation of the slides and reference slides for the identification of the hair samples and photography of the prepared slides.

3.4.3.1 Scat Analysis

After washing the scats thoroughly with hot water, the hairs and other remains of preys were separated and dried. Hair remains in the scats was identified using reference hair samples of large mammals in Shivapuri National Park, which was collected from different local sources like villagers and friends and available hides. Several hair samples in the scat were examined microscopically and compared with the reference collection.

Hairs present in the scats were identified. The hair samples obtained from the collected scats were compared with the reference hair samples and during that gross morphological characteristics such as length, colour patterns were examined as described by Berwick and Shaharia (1995) using a powerful hand lens and compound microscope at 100X magnification.

3.5. Human- Leopard Conflict

Questionnaire surveys, interviews and direct observations of different signs from study area were used to assess the human–leopard conflict and to identify threats. Pre-structure but open-ended questionnaire was used to collect information to addressed aforesaid objectives. Altogether 117 questionnaires

were used, 32 respondents were from Block A, 57 from Block B and 28 from Block C and all the respondents were the villagers.

3.6. Data Analysis

3.6.1 Statistical Analysis

Collected data were analysed by using Microsoft excels. The chi-square contingency test was used for statistical test showing comparative abundance of leopard signs in different transacts, to show the distribution frequency in different types of transacts in different blocks taking $p<0.05$.

3.6.2 Spatial Analysis

The park boundary map was digitised, settlements area and agricultural land, road inside the park, from the geo referenced topographic scan map using the GIS software Arc View 3.2 in geographic projection. I tried to show the Blocks and transacts in the study area, distribution map of different sign marks according to the transects, using data recorded in the topomap.

4. RESULTS

4.1. Population Status

Pugmark analysis confirmed the presence of five forest leopards in Shivapuri National Park. Among them, two were males, two females and one cub (Table1). The pugmarks of female with cubs were recorded from Dhap area, whereas the pugmarks of male leopard were from Gurung Gaon and Jhule area and a female's pugmarks from Kakani area.

Table 1: Description of Pugmark signs

S.N	Measurement of Pugmarks			Sex	Location
	TL (cm)	TW (cm)	PW (cm)		
1	8.8	7.6	5.4	Female	Dhap
2	5	4.6	2.7	Cub	Dhap
3	10	9.4	5.8	Male	Gurung Gaon
4	9	8.7	6.4	Male	Jhule
5	8.3	7.5	5.5	Female	Kakani

4.2. Distribution

A total of 52 sign marks (pugmark, scat, scrape, scent and predation) were recorded from the 11 transects of 3 different blocks in ShNP during the study period. Among these, 18 were pugmarks, 12 were scats, 10 were scrapes, 11 were scent sprays, and 1 was predation sign. The highest number of the sign distribution was recorded from the transect C_3 (Dhap-Jhule). The Chi Square Contingency test shows that there was significant difference (χ^2=19.53, $p<0.05$, at10d.f.) of sign distribution among the transects.

Table: 2. Distribution of Leopard signs by transects and blocks.

SN	Block	Transects	Location	Types of signs					Total
				Pug marks	Scat	Scrape	Scent	Predation	
1	A	A_1	Kakani -Gorje	-	1	1	1	-	3
2		A_2	Gurung Gaon – Khole Gaon	3	3	-	1	1	8
3		A_3	Panimuhan - Sikre	1	1	2	1	-	2
4	B	B_1	Gumba-Tarebhir	2	-	-	1	-	3
5		B_2	Gumba to Peak	-	2	1	1	-	4
6		B_3	Sundarijal -Baluwa	4	1	2	1	-	8
7		B_4	Reservoir-Bagmati river upwards	-	-	-	1	-	1
8		B_5	Sundarimai-Nagmati river Upwards	-	-	-	1	-	1
9	C	C_1	Sundarijal – Chisapani Foot trail	-	2	2	1	-	5
10		C_2	Chisapani -Dhap	4	2	1	1	-	8
11		C_3	Dhap - Jhule	4	3	1	1	-	9
Total	3	11		18	12	10	11	1	52

4.2.1. Frequency of Sign Distribution

Among the three blocks, the highest frequency of sign distribution was recorded in the block C (2.2 signs per kilometre in length). Block B and Block C followed it respectively (Table 3). The χ^2 show no significant difference (χ^2=0.18, $p<0.05$, at 2d.f.) of distribution frequency among three Blocks.

Table: 3. Frequency of leopard sign distribution in different blocks

S.N.	Block	Total sign-marks	Total distance (km.)	Frequency
1	A	13	9	1.44/km.
2	B	17	8	2.12/km.
3	C	22	10	2.2/km.

4.2.2. Sign distribution by types of transect

Higher frequency of the signs were observed in the motorable roads transect (39) followed by human trails and riverbeds. There is significant difference (χ^2=42.95 $p<0.05$, at 2 d.f.) in sign distribution among the transect types.

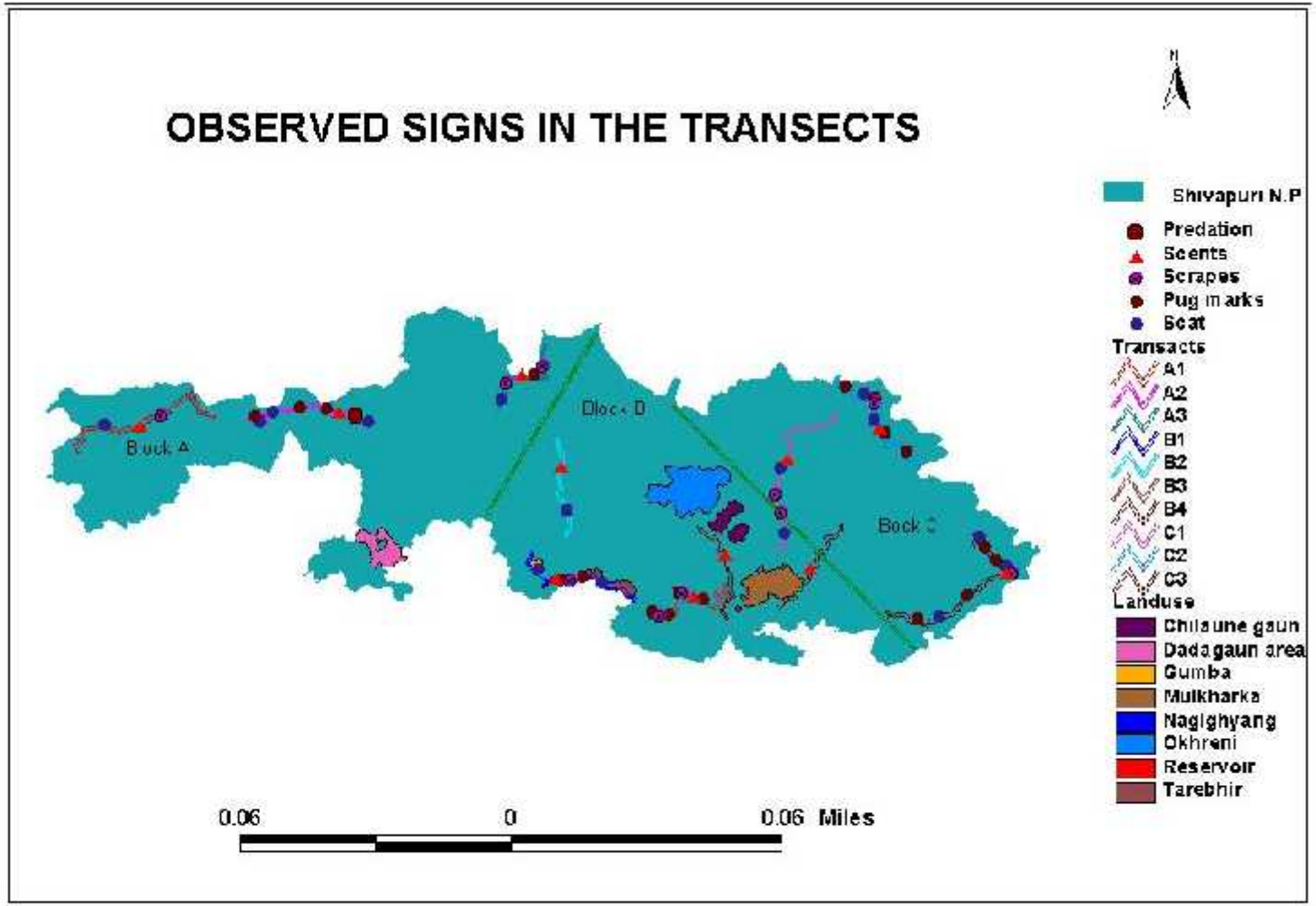
Table: 4. Distribution of sign marks by transect types

S.N	Divisions	Sign Marks	Total Length	Frequency
1	Human Trails	11	10 km	1.1/km
2	River Bed	2	1 km	2/km
3	Motorable Roads	39	16	2.43/km
Total		52		

4.2.3. Respondents report on the leopard and sign distribution

Out of the 117 respondents, 23 had never seen the leopard as well as signs within transects. But majority of respondents frequently sighted leopard or signs and heard calls in the ShNP. Altogether 84.37% of the total respondent informed presence of the leopard in Block A, 80.7% in Block B and 75% in Block C and others were unknown about the species (Figure 4).

Figure: 5. Respondent's response regarding the presence of leopard in the study area.



Map 3 : Map showing different signs in different transects

4.3. Food Habit

4.3.1. Potential Mammalian Prey species Survey

A total of 9 wild and 6 domestic potential prey species of forest leopard were recorded from the study area (Table 5).

Table: 5. Potential prey species of leopard in and around ShNP

Potential Mammalian Prey species		
S.N	**Wild**	**Domestic**
1	Barking Deer	Dog
2	Himalayan Ghoral	Goat
3	Wild Boar	Cow
4	Rhesus Monkey	Sheep
5	Squirrel	Buffalo
6	Indian Hare	Pig
7	Porcupine	
8	Royel's Pika	
9	Mouse	

4.3.2. Scat Analysis

Twelve scats of the forest leopard were collected and they are distinguished from those of other predators by their shape and size and ancillary evidences such as scrapes and tracks. In the lab, scats were soaked in hot water for a day and then washed it with cold water several times to separate the hair and bones present in the scat with other wastes. The bones and claws present in the scats were excluded from analysis because they could not be identified, thus only hair remains in the scats were used for analysis.

4.3.2.1. Diet Composition

A total of 14 types of hairs were collected from the 12 scat samples. Nine species of preys were confirmed from 14 types of hair and five hair samples could not be identified. Among 12 scats, two (16.66%) samples composed of single prey species while the remaining 10 (83.33%) samples composed of two or more prey species. In most of the scat samples, considerable amount of sand (10 out of 12 scat samples) and a grass *Imperata cylindrica* species in 4 different samples were observed.

Table: 6. Hair remains of prey species in the leopard scats

Scat No	Collected Transect	Prey species in the scat									
		Barking deer	Wild Boar	Hare	Porcupine	Cow	Sheep	Mouse	Goat	Dog	Not Identified
1	A1				√						√
2	A2	√							√		
3	A2							√		√	√
4	A3								√		
5	B2		√	√							
6	B2	√	√								√
7	B3			√					√	√	
8	C1					√					
9	C2	√				√					√
10	C2	√									
11	C3		√				√			√	
12	C3	√							√		√
Total	12	5	3	2	1	2	1	1	4	3	5

The major components of the leopard diet consists of barking deer (22%), goat (17%) whereas mouse, sheep and porcupine were found lowest in diet frequency as 5% each (Figure 6).

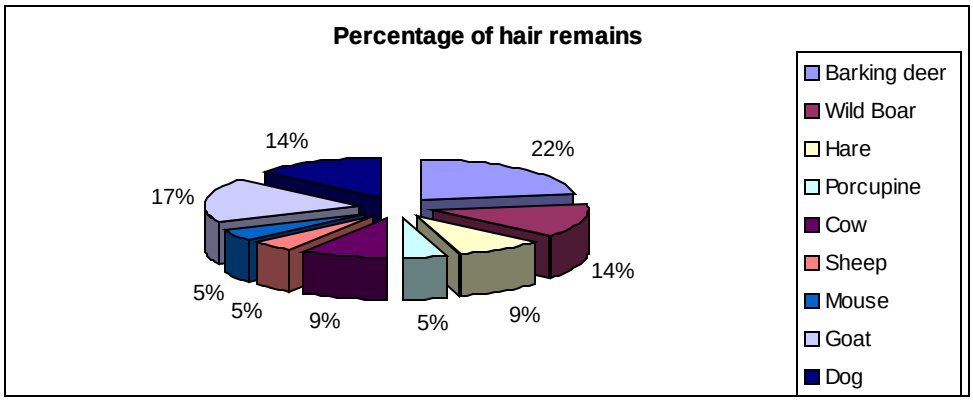


Figure 6. Diet Frequency of Leopard analyzed from present study

Table 7: Table showing the details of domestic and wild preys in the scats

S.N	Domestic Animals	Wild Animals
1	Cow (2)	Barking Deer (5)
2	Dog (3)	Wild Boar (3)
3	Sheep (1)	Hare (2)
4	Goat (4)	Porcupine (1)
5	-	Mouse (1)
Total	10	12

Wild prey species were found 55% of the total diet whereas domestic animals in and around the park contribute 45% of the total diet. (Figure7).

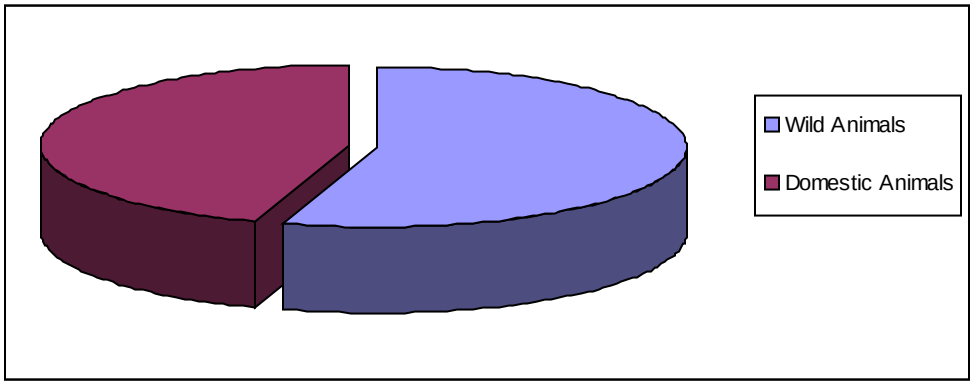
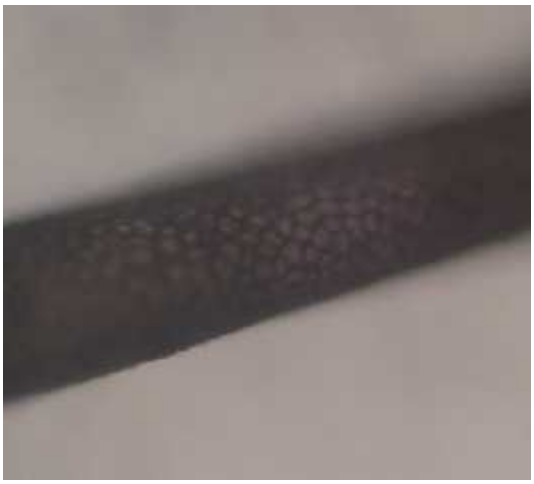


Figure7.Diet Composition of Leopard showing wild and domestic animals.

PLATE I

Photographs of Hairs in Scat **Photographs of Reference Hairs**



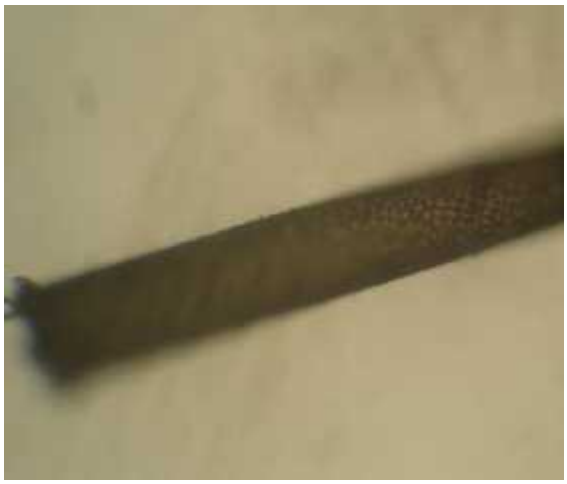


Photo 1: Hair of Barking Deer

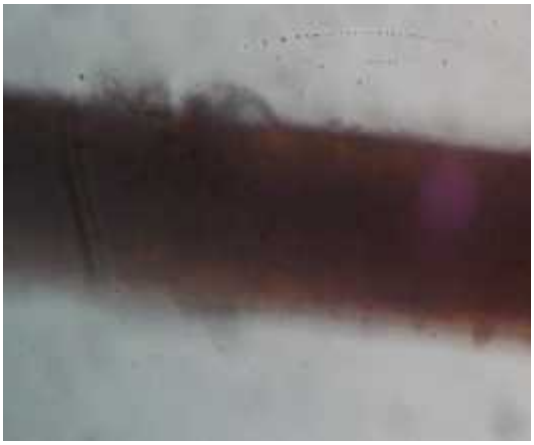


Photo 2: Hair of Cow

Photo 3: Hair of Dog

PLATE II

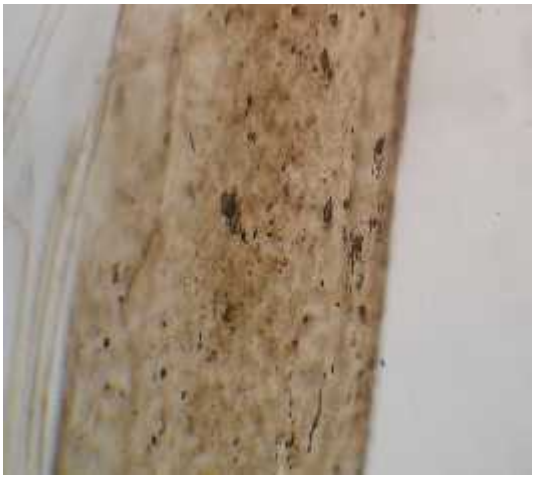
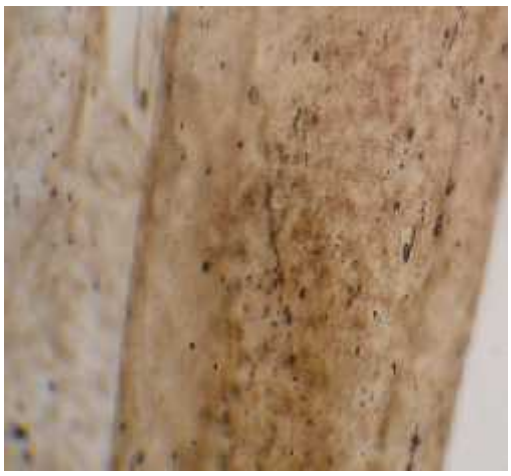



Photo 4: Hair of Mouse


Photo 5: Hair of Porcupine


Photo 6: Hair of Hare

PLATE III

Photo 7: Hair of Sheep

Photo 8: Hair of Wild Boar

Photo 9: Hair of Goat

4.4 Human – Leopard Conflicts and Threats to the Leopard

4.4.1 Livestock and Pet animal Loss

Livestock loss is a serious cause of conflicts between leopard and human in ShNP. A total of 11 livestock were killed by leopard including 7 goats, 2 calves and 2 dogs during the study period. Four Livestock killed from Block A and 3 and 4 from Block B and Block C respectively (Table 8).

Table: 8. Livestock and pet animal loss due to Leopard killing (2005)

S.No.	Domestic Animals	Blocks A	Block B	Block C	Total
1	Goat	3	2	2	7
2	Calf	-	1	1	2
3	Dog	1	-	1	2
Total		4	3	4	11

The estimated cost of livestock loss was NRs. 34,000. The highest economic loss was recorded from Block A and least amount from Block B (Table 9).

Table: 9. Economic Loss (Price in Nepalese Currency NRs.)

S.N	Domestic Animal	Block A	Block B	Block C	Total
1	Goat	12,000	8,000	8,000	28,000
2	Calf	-	2,000	2,000	4,000
3	Dog	1,000	-	1,000	2,000
Total		13,000	10,000	11,000	34,000

(Price of a goat = 4,000, A Calf = 2,000, A dog = 1,000)

4.4.2. Leopard Attack and threats to the humans

No observation was made related to the leopard attack to the human being during the study period. According to the questionnaire survey frequent

encounter occurs during their travel in motorbikes and on foot, which caused a lot of threats on them.

4.4.3.Impacts of the Location and small area of the National Park

Shivapuri National Park covers an area of only 144 km^2. Two VDCs namely Okhreni and Mulkharka are almost completely located inside the park. Similarly human activities inside the park area were also very high as it being one of the picnic spots and trekking routes. Frequent visiting of the leopard inside the Kathmandu was heard from ShNP and other forests due to small sizes of forests and depletion of prey species. A leopard was captured in Kirtipur and was released at the Dhap of ShNP.

4.4.4. Livestock grazing and forage collection

About 93% of the total 117 respondent reported that they have livestock. Out of 1288 heads of livestock, 59% were goats, 20% cow, 12% sheep and 9% of buffalos. Ownership varied widely, ranging from at least 3 livestock to 17 livestock.. Most of the villagers owned less than 12 cattle with an average of 11 in Block A, 12 in Block B and 9 in Block C (Table 9). This park is used for grazing of the livestock.

Table 10. Number of livestock form different blocks.

Block	Number of Respondents	Number of Livestock Holding	Average Livestock per respondent
A	32	352	11
B	57	684	12
C	28	252	9
	117	**1288**	

From the direct observation three different types of threats were observed. Among them grazing and forage and firewood collection were found high in each blocks whereas timber collection was recorded from block A and B as medium. The signs of illegal hunting and poaching were not observed during the study period (Table11).

Table: 11 Threats value from Direct Observation

S.N	Types of Threat	Blocks		
		A	B	C
1	Grazing	H	H	H
2	Forage and Firewood Collection	H	H	H
3	Timber Collection	M	M	-
4	Hunting / Poaching	-	-	-

Notes: H = High, M = Medium

4.4.5 Questionnaire Survey

Of the 117, 48 respondents claimed that there are no threats to the leopards from human activities, 33 identified forage and firewood collection as a threat, 25 have opined those cattle and 11 claimed poaching as threats to the leopard.

Table:12. Different threat activities identified from Questionnaire Survey

S.N.	Types of Activities for threats	Blocks			Total
		A	B	C	
1	Forage and Firewood Collection	11	14	8	33
2	Grazing	8	11	6	25
3	Hunting / Poaching	4	4	3	11
4	No activities	9	28	11	48
	Total Respondents	32	57	28	117

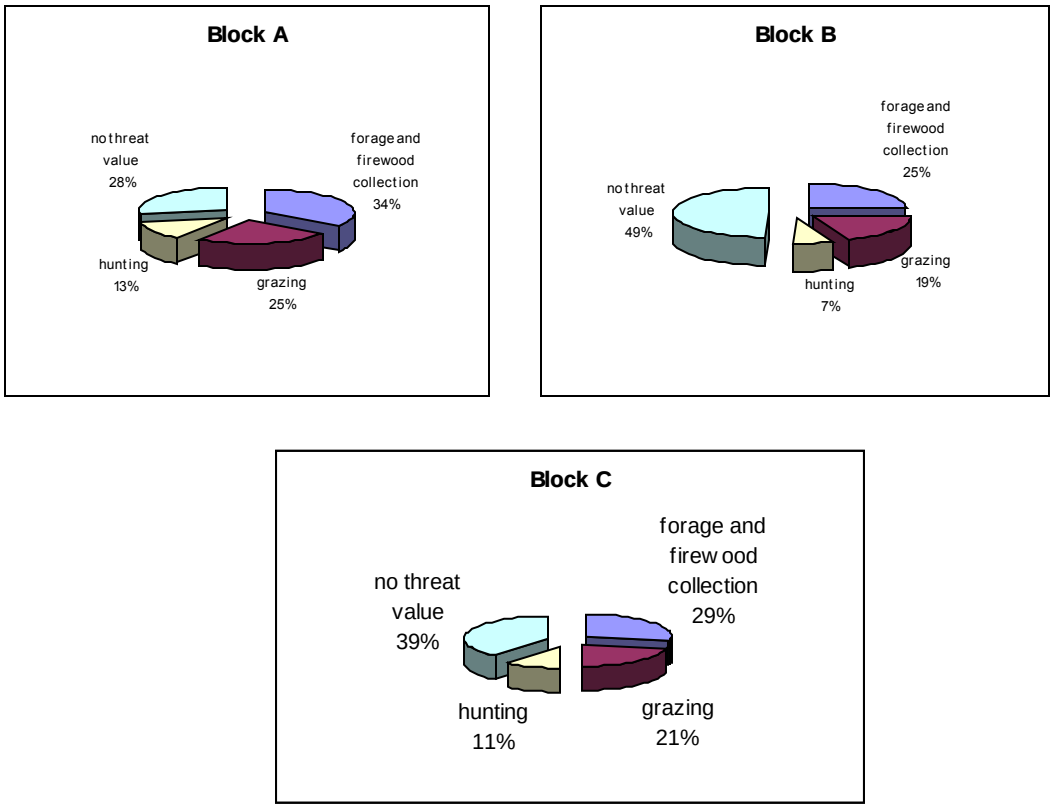


Figure 8. Threat activities in Different Blocks A, B and C.

4.4.5.1. Peoples Attitude towards Leopard

Out of 117 respondents, 78.63% showed negative attitude towards the leopard, 14.52% have no idea and remaining 6.83% were willing to conserve the leopard in the ShNP (Figure 9).

Figure 9. Attitude of local people towards the Leopard

4. DISCUSSION

5.1. Population Status and Distribution

Forest leopard is sparsely populated and secretive carnivore usually active in down or dusk time; thus, determination of population size and distribution patterns by direct survey method is very difficult. Present study used the sign transect method for determination of the species presence and abundance in ShNP. Many biologists including Choudhary (1971), Mc Douglal (1977), Tamang (1982), Sagar and Singh (1990) used the pugmark method to estimate the rough

figure of tiger population, Shrestha (2005) used this method to estimate leopard population and Adhikari (2004) and McCarthy and Munkhtog (1995) used this method to estimate the population of Snow leopard in Langtang National park and Mongolia respectively, which is reliable, easier, cheaper and most precise method.

Presence of five individuals of leopards including 2 females, 2 males and a cub has been determined in the ShNP. The estimated population is very small and may not represent for all individuals living in the park area, the security problem in the park area did not permit to cover the all area, the pugmarks recorded may be repeated or pugmark of some individual may not be observed.

Panwar (1979), Sale and Berkmuller (1988) described that the tracing of the pugmark shows that the difference between individual animals will be consistently detectable. While Karanth (1993), criticized the techniques by testing six experienced Indian wildlife managers in making 33 pugmarks of 4 captive tigers on two different soil substrates, because 75% of them correctly identify the sex but the worst result was in estimating the total number of tigers responsible for pugmarks whose estimates were 6,7,13, 23 and 24 tigers.

Forest leopard signs were distributed in all types of habitat from its lower boundary (1360 m) up to the upper elevation of the Shivapuri Peak (2732m) indicating they used all types of available habitat in the park. Shrestha (2005) reported leopard signs in the elevation between 1740 and 2600m in the ShNP. It is most widely distributed species in various altitudes of its geographical range (Jackson 1990, Ale and Gurung 1995, Roberts 1997, Green 1987, KMTNC 1998, Shah *et al.* 2004). The wide distribution of *Panthera pardus* suggests its ability to cope with a variety of environments (Anton and Turner 1997) and climates (Guggisberg 1975, Santiapillai and Romono 1992).

Among the fifty-two signs (scats, pugmarks, scrapes and scents) recorded, the highest frequency (42.30%) was observed in the Block C (Sundarijal to Chisapani, Chisapani to Dhap and Dhap to Jhule), because the block C is relatively safe and undisturbed site among the three blocks for movement. The distribution of the wildlife species is correlated with the availability of resources, undisturbed habitat and safe ways to movement.

The leopard in ShNP preferred to use motorable roads most frequently (2.43 signs/km) followed by dry riverbeds (2 signs/km) and human trails (1.1 signs/km). Such a distribution of sign can indicate leopard's preference to particular travel lane (for example road), frequency of human activities to them and detectability of signs. The leopard preferred to use open muddy road and dry riverbed to move and search the prey. The bushes on the side of such travel lane provide hiding cover. In addition, the dusty and muddy road is easy to detect the signs. On the other hand less frequency of sign distribution in the human trails indicates that the low preference due to human interference. Also, the steep foot trails made no deposition of soil particles, which made difficult to observe the pugmark signs. Hanchel and Ray (2003) described the roads muddy roads and trails are helpful to acquire good set of tracks and pugmarks.

5.2. Diet Analysis

The diet of leopard in ShNP consists of both domestic and wild preys. The wild prey remains were found in 55 % of scats while the remaining 45% scats consists of domestic animals. Singh *et al.* (1999) found 32.74% of leopard scat composed of livestock remains, 51.69% scats was composed of wild prey remains, and 2 scats were full of grass and 3 contained sand particles along with the prey remains. The leopards living in the periphery of the park depend on domestic preys. Domestic stock has been found to be a major component of leopard diet outside the protected areas (Schaller 1977, Seidensticker *et al.*1990). Joslin (1990) reported that 78% of the scat contained livestock in Iran. Similarly, Mukharjee (2001) found that remains of domestic and wild animals are

represented in almost equal numbers of scats (23 and 24) which indicated high predation of domestic animals despite there being seemingly abundant wild prey in Majhatal Harsang Wildlife sanctuary, India.

A total of nine species of preys (barking deer, wild boar, hare, porcupine, mouse, cow, sheep, dog and goat) has been identified from the scats of leopard living in the ShNP. The high frequency of barking deer (22%) and wild boar (14%) in the scat may be correlated with the frequency of availability of the preys in the park. Shrestha (2005) and Majupuria and Majupuria (2006) reported that barking deer, wild boar, Indian hare, and monkeys as abundant preys in the ShNP. Among the domestic animals, goat and dogs were major components in the scats. The highest frequency of goat in the scat may be correlated with small size and easy to lift during grazing too and that of dog may be due to free ranging of dogs outside the houses in the evening and nights and easy to lift. Srivastav (1999), reported that most of the leopard killed revealed they had empty viscera which may be due to non availability of food and wild animals as porcupines, wild boars are approached in the field for food and water which prompts the leopard to hunt them in the fields surrounding the forest and leads to encounters with humans. In ShNP also non-availability of the native prey may be the prominent cause for to kill the domestic preys by the leopard.

Srivastav (1999) described that wild goat, livestock, urial, chinkara, hare, porcupine are the preferred diet in the Himalayas. Hoogerwerf (1970) found that leopards preys on a variety of animals in Java that range in the size from bats and mice to barking deer, however its preferred prey appears to be the medium sized barking deer (*Muntiacus muntjak*), which is in abundance in almost all the protected areas in Java (Santiapillai and Romono 1982) 1982 found praying on the barking deer, on monkeys such as long–tailed macaque (*Macaca fasciculous*) and silver leaf-monkey (*Presbytis cristata*), Wild boar (*Sus scrofa*), lesser mouse deer (*Tragulus javanicus*) and at times even an occasional Javan

gibbon (*Hylobates moloch*) and in areas near human settlements and agriculture, the leopard is also known to prey dogs, goats and even chickens.

5.3. Conservation Threats

Leopards in ShNP are threatened by habitat degradation due to deforestation, grazing, forage collection. Occasional instances of livestock depredation and encounter with human are serious issues of conflicts between man and leopard. Similarly small size and irregular shape of the park, location of the villages inside the park and people's negative attitude towards this cat cause threats to leopard. Leopard attack on domestic livestock has made economic loss for the local communities and also creates negative attitude in wildlife conservation. Due to the depletion of prey species, habitat degradation and small size of the park and other forests areas, frequent visit of the leopard in the settlement area was seen and a leopard entered the Kirtipur area was captured and released in ShNP.

Johns (1989) also found forest loss a significant threat to the leopard in Malaysia. Shrestha (1997) mentioned that clearing of forest habitat for human habitation, deforestation and grazing have upset ecological balance in the ecosystem and man's presence in the forest and carcass poisoning by villagers appear to have reduced population of the leopards.

Similarly, Hanchel and Ray (2003), Schaller (1967), Seidensticker *et al.*(1990) mentioned that the forest leopard negatively affected by prey depletion, hunting, habitat conversion etc, which results killing the livestock and other domestic animals to fulfil their food requirements. Shah *et al.* (2004) found leopards take livestock, from buffalos and cattle to dogs and poultry and leopards usually kill grazing animals as well as living inside the fenced enclosures at night and caused surplus killing. Forest leopard has been identified common livestock

predator in RCNP (Sharma 1991, and Shrestha 1993), RBNP (Bhatta 1994 and Tamang 2002), Arun Valley (Giri and Shah 1992), ACAP (Shrestha *et al*. 1992) and MBNP and Conservation area (Thapa 1995).

In the Nepalese Himalaya, conflict with the rural communities are due to livestock predation to large carnivores like snow leopard, common leopard, wolf and wild dog has risen sharply in recent years which is attributed to a lot of factors as implementation and enforcement or wildlife protection law (which have permitted a recovery in carnivore numbers), the creation of protected areas (which serve as refuges from which predators can populate the surrounding areas), the depletion of natural prey due to poaching and loss of habitat and livestock herding practices (Jackson *et.al.*1996).

6. CONCLUSION AND RECOMMENDATIONS

Shivapuri National Park provides a good habitat for forest leopard. A population consisting of five individuals is well distributed throughout the national park. Altogether 52 different signs were observed in the different transects in which the pugmark were found to be maximum of 34.6% among the different signs. Block C, transect from Dhap to Jhule was found to have the signs of leopard to be distributed maximum of about 17.30%. The frequencies of distribution of leopard's signs were found maximum in motorable roads (2.43/km) and least in human trails (1.1/km). During the study period a leopard was released in ShNP, which was captured from Kirtipur area.

Nine wild and five domestic prey species of the leopard were surveyed. Food included barking deer (22%), goat (17%), wild boar (14%), hare (9%), cow (9%), mouse (5%), sheep (5%), porcupine (5%) when its hair samples present in the scats were observed and examined. The bones, hooves and feathers present in the scats were excluded. Considerable amount of sand and grasses were also found in the scat samples. Fifty five percent of the food included the wild prey species whereas forty five percent of it included the domestic prey species.

The location of the Park, as 21 Villages surround it and two villages lie within the park and livestock rearing and grazing was found to be the major economic activity in and around the households of ShNP. An average of 11.008 livestock were reared per household as surveyed within 117 households. Activities like firewood and fodder collection, timber collection and grazing within the park area were found and hunting or poaching of wild prey species only when they enter the cultivated area which were creating the food scarcity for Leopard and leads to prey upon livestock enhancing the conflicts. Among the predators in Shivapuri National Park, Forest Leopard was found to be the main livestock predator, which caused the high percentage of livestock depredation. Altogether 11

livestock including were found to be preyed by the leopard. Altogether the economic loss of about Rs.34, 000 was found for which no compensation was found to be made which had made the increase of negative attitude towards the leopard. Among the respondents, 78% found the leopard troublesome creature where as 11% were not clearly known and only 7% responded to have positive attitude towards the Leopard and think it to be conserved.

Present study concluded the following recommendations as a solution to the problem.

1. Status of leopard is still unknown because of the inadequate researches made in Leopard within the country. In this study, status of leopard was primarily based on the study of pugmark signs, which has given only the estimation of population size and no actual size can be presented. So regular monitoring and researches should be made using the modern techniques such as using camera-trapping method.

2. Hooves, bones and unidentified hair samples in the scats were excluded. And no actual result regarding the food habit can be provided. So proper study regarding the food habit should be made by using other modern techniques.

3. The economic losses caused by the leopard should be monitored and proper compensation should be provided to the villagers so as to develop the positive attitude towards the leopard. To save the leopard and its prey species in ShNP specific management plan are essential that will reduce the conflicts between forest leopard and local people.

4. Illegal firewood and fodder collection throughout the year from the national park area, grazing of livestock and killing of wild prey species should be stopped. Agroforestry system should be promoted in private lands and

stall-feeding system should be increased to reduce the grazing pressure. Suitable compensation should be made to the owners for the losses made by the leopard and other wild predator species.

5. Corridor should be maintained so as to connect ShNP with the adjoining forest areas as Nagarjuna forest up to the park of Terai regions, Gokarna forest and other forests around the valleys and Langtang National Park in the north to provide the sufficient space for this territorial animal to maintain its number.

6. Local people should be made aware of the importance of the predator leopard and other wildlife and encouraged to work for their conservation.

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ANNEX I

Leopard and Prey Species Survey Questionnaire

Would you like to participate in the survey? (If yes proceeded to ties #1)

1. Name of the interviewer: Interview date:
2. Name of the park:
3. Village location (or approximate location):_____. Elevation (m): _____
4. Respondents gender: _____ Age: _____. Occupation: _____
5. Total Village population:

Leopard sighting and status

6. Do leopard occur here or in nearby areas? Yes_____ No_____
   (If respondent answers "No" or to question #22)
7. If so, where? (List of name of place(s) where seen in past year).
8. Where was one (or evidence of one) last seen? (Month/Year)
9. How far from the village/location (km)? _____
10. Indicate sign of evidence found with tick below:
    Pugmark _____ Scrape____ Feces____ Sighting____ a livestock kill_____
11. Indicate the size of sign (pugmark, Scrape, feces)
12. Describe the place where sign was found (eg trail, base of cliff, stream bed, ridge, rocky area, other)
13. What habitat type? (Forest, grassland, rock, shrub):
14. If sighting, how many leopards were seen? And their age class?
    Male_____ Female_____ Young_____Unknown age_____
15. Describe the distinctive physical feature:
16. How big was it? (Indicate height as shoulder)
17. How many leopards do you think use in this area?
18. Do you see their sign? Very often, commonly, uncommonly, rarely
19. During which month are they or their sign seen? (List each month and circle the month where most are seen):
20. What is your opinion about leopard? Good, Bad or No opinion

21. Should they be protected or eliminated and why?

Threats and conservation Status

22. Do leopard kill livestock in your area? Yes, No, Don't know

(If don't Know, go to question #27)

23. If yes, which kinds of livestock are killed? (Please list in order from most to least commonly killed)

24. How many were killed in last 12 months (Specify type of livestock killed)?

25. List months of year with most losses.

26. How many in winter? _____. How many in summer? _____

27. Is there any poaching in your area?

28. If yes, which wildlife species?

29. Kind of weapons/methods used in poaching?

30. Have other person visited and inquired about leopard pelts or body parts?

Yes_____ No_____ Don't know (if No or don't know, go to question# 36

31. If yes, when and how many? (Mention day, month, year, and number of persons).

32. Were they interested in (circle all that applies)

Seeing a now leopard, buying a pelt, purchasing its bones.

33. How much will they willing to pay? (Price in Rs.)

34. Did they offer any incentive or money for the information about leopard parts?

35. If so were it cash? _____ or any kind? (eg. Cigarettes, or goods)____

Other Wild life present in this area

36. What other predators occur here? (Circle all that apply)

Tiger, Lynx, Wolf, Wild dog, others

Comments

0 1 2 3

Very unreliable Very reliable

ANNEX I I

Livestock Depredation Report data form

1. Name of interviewer
2. Name of park
3. Name of village (or approx. location)
4. Number of household:

Adult male_____ (b) Adult female_____ (c) Children_____

5. Primary Source(s) of livelihood _____
6. Livestock Ownership and Trend

Current livestock holdings

Type	Total number	Adult male	Adult female	Juvenile
Cattle				
Buffalo				
Sheep				
Goats				
Others				

Livestock holding last year

Type	Total number	Adult male	Adult female	Juvenile
Cattle				
Buffalo				
Sheep				
Goats				
Others				

7. Are you able to obtain enough winter and summer forage for your animals?
8. What is the source of forage? _____
9. Do you take your livestock grazing inside the park?

10. Is your livestock predated by any predators? Where?

11. What is the number of livestock losses by predation of leopard?

Type	Number of losses	Economic loss
Cow		
Goat		
Sheep		
Dog		
Others		

Plate IV

Photo10: Scat in Kakani Area

Photo 11: Pugmark Casted

Photo 12: Scrape in Sundarijal area

Photo 13: Pugmark in Dhap area (Muddy road)

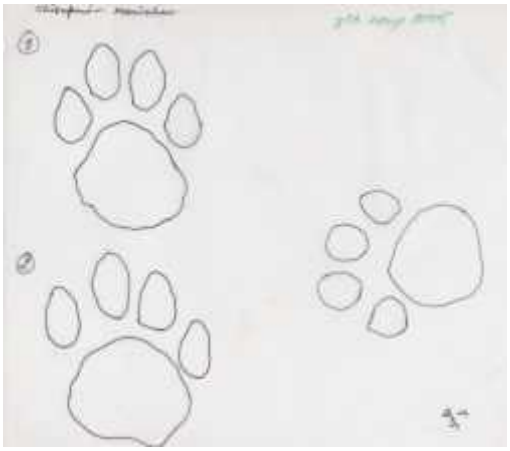

Photo 14: Pugmarks Traced

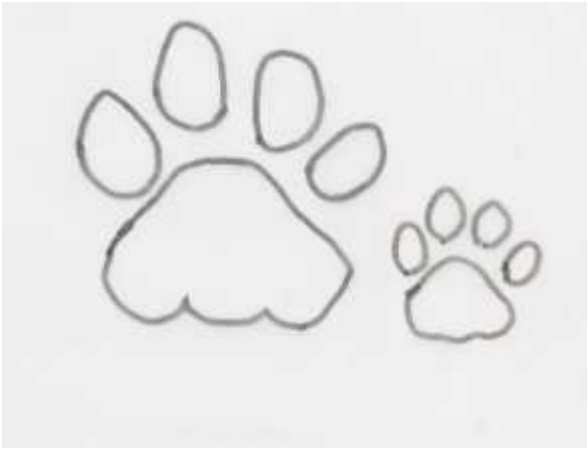

Photo 15: Pugmarks of Leopard with Cub

Plate V

Photo16:A herd of Goat inside the park

Photo 17: Grazing Cows and Buffaloes

Photo18: Fodder and Firewood Collection

Photo 19: Trees Cut down

Photo 20:Mining on the park area

Photo 21: Trekking Routes

Plate VI

Photo 22: Okhreni Village

Photo 23: Mulkharka Village

Photo24: Picnic inside park

Photo 25: Vehicles inside the park

Photo 26: A Goat attacked by the Leopard

Photo 27: Forest Leopard captured from Kirtipur area released inside the park