Final Report On

Demography and Causes of Mortality of Blue Sheep (*Pseudois nayaur*) in Dhorpatan Hunting Reserve in Nepal

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Abstract

A total of 206 individual Blue sheep *Pseudois nayaur* were estimated in Barse and Phagune blocks of Dhorpatan Hunting Reserve (DHR) and population density was 1.8 Blue sheep/sq.km. There was not significant change in population density from last 4 decades. An average 7 animals/herd (SD-5.5) were classified from twenty nine herds, sheep per herds varying from 1 to 37. Blue sheep has classified into sex ratio on an average 75 male/100females was recorded in study area. The sex ratio was slightly lower but not significantly different from the previous study. Population of Blue sheep was seen stable or not decrease even there was high poaching pressure, the reason may be reducing the number of predators by poison and poaching which has supported to increase blue sheep population. Because of reducing the predators Wolf *Canis lupus*, Wild boar population was increasing drastically in high rate and we can observed wild boar above the tree line of DHR.

The frequency of occurrence of different prey species in scats of different predators shows that, excluding zero values, the frequencies of different prey species were no significantly different (χ^2 = 10.3, df = 49, $p > 0.05$). Most of the scats samples (74%) of Snow leopard, Wolf, Common Leopard, Red fox's cover one prey species while two and three species were present in 18% and 8%, respectively. Barking deer *Muntiacus muntjak* was the most frequent (18%) of total diet composition of common leopards. Pika *Ochotona roylei* was the most frequent (28%), and Blue sheep was in second position for diet of snow leopards which cover 21% of total diet composition. 13% of diet covered non-food item such as soil, stones, and vegetable. Pika was most frequent on Wolf and Red fox diet which covered 32% and 30% respectively.

There was good positive relationship between the scat density and Blue sheep consumption rate, increasing the scat density, increasing the Blue sheep consumption rate. Blue sheep preference by different predators such as Snow leopard, Common leopard, Wolf and Red fox were 20%, 6%, 13% and 2% of total prey species respectively.

Abbreviation

CITES: Convention on International Trade of Endangered Species of Wild

DHR: Dhorpatan Hunting Reserves

DNPWC: Department of National Park and Wildlife Conservation

GIS: Geographical Information System

GN: Government of Nepal

GPS: Global Positioning System

Ha: Hectare

HMG/N: His Majesty's Government of Nepal

IOF: Institute of Forestry

IUCN: (World conservation Union) International Union for Conservation of

Km^2: Square kilometre (sq.km)

m: meters

NTFPs: Non-Timber Forest Products

pers. comm.: personal communication

VDC: Village Development Committee

Table of Contents

Figures:

Tables:

Introduction

Blue sheep are native to Asia, main prey species of snow leopard and hunting for trophy therefore, that conservation of blue sheep is a national concern. Government of Nepal is protecting endangered flora and fauna also allow the sustainable harvesting. Out of them the Blue sheep is one of the hunting animals found in Dhorpatan Hunting Reserve. It *is* the only hunting reserve in Nepal and is particularly important for its blue sheep population. It is regularly used by hunters from overseas (Wegge, 1976; FAO, 1980). The area was surveyed by Wegge (1976) in November 1974 and from March to June 1975. There was research on the population ecology of blue sheep (Wegge, 1979). Subsequently, Wilson (1981) studied blue sheep habitat use and population dynamics.

Determining Minimum Viable Population (MVP), population performance, management option of population and reserve size is a major objective in conservation biology (Shaffer, 1981; Belovsky, 1987; Ewens et al., 1987; Akcakaya et al., 1999).These estimates are considered most importance for Blue sheep because they are main prey species for threatened umbrella species of Himalayan 'Snow leopards' (Wegge & Oli, 1997).

Blue sheep are main prey species of snow leopards and its population in Nepal is expected to be 10000 animals in 15000km2 (Wegge & Oli, 1997). The crude densities of blue sheep in four areas (Dhorpatan, Manang, Lapche and Shey) in Nepal ranged from a low of 0.7 to high of 6.6-10.2/km2 (Schaller, 1977). In Nepal, Shackleton (1997) reports a "conservative estimate of 10,000 animals", although Schaller (1998) included a table suggesting 1,947-2,561 in areas counted within Nepal.

The herd size ranged from 1 to 162 (Sherpa & Oli, 1988, Wegge, 1976), and average group size of 11 (Wegge, 1976). Blue sheep is main prey species of snow leopards. So presence of blue sheep is indicators of presence of snow leopards. After 1976 (wegge, 1976). Wilson, 1981 estimated blue sheep *Pseudois nayaur* population from 700 to 740 animals within a 96,000ha survey area. There is not any detail research on Blue sheep in Dhorpatan area despite there were small research by DNPWC (Wegge & Oli, 1997, DNPWC, 2006).

Diet/scats analysis is important in forensic and biological science. Several investigator have described the hair structure of different animals' species which has found in predators' scats (Kotwal, et. al., 1993; Mathiak, 1988; Williams, 1938; Mayer, 1952; Adorjan and Kolenesky 1952). The prey species of predators is found out through the looking on hairs structure which is found in the scats of predators. The hair structure is of paramount importance for wildlife management in two ways, viz. (1). In the study of food habits of carnivores from scat analysis, where the hairs of prey animals are passed in faeces of the predator. Large number of faecal samples of the predator is collected in different seasons of the year. The hairs of the prey species are identified in each sample and thus the percentage predation on different prey species in various seasons in the area can be worked out. (2). In the identification of animals species killed by poachers where some fallen hairs of the dead animal are only spot evidence. In several such instances, the identity of the poached animal has been established on the basis of hair structure. The hair structure study is also useful in textile technology (Appleyard 1978). Koppikar and sabnis (1976) have detailed the hair structure of some wild animal. However, hair structures of several wild animals species are yet to be standardized. the present study depicts the diet analysis of different blue sheep

predators of Dhorpatan Hunting Reserve through the remaining hair in the predators' scats.

Blue sheep is the primary prey species of snow leopard in Nepal. Often, presence of blue sheep provides indicator of presence of snow leopard in that area. Therefore, understanding the demography characters and causes of mortality of blues sheep is most important for it proper management and help understand the status of predators species.

IUCN Red List status of Blue Sheep

Blue Sheep is placed in the IUCN Red list status as "Lower Risk/near threatened" (Harris, 2006; IUCN, 2006)Where as snow leopards as listed as endangered.

Aim and Specific Objectives

The main aim of the study was to estimate demography and diet composition of different predators in Dhorpatan Hunting Reserves (DHR), Nepal.

Specific Objectives

1. To estimate the population size and demographic parameters of Blue sheep.
2. To analysis diet composition of large carnivores of the area (predators of Blue sheep).
3. To analysis prey predator relation and prey (Blue sheep) selection pattern by different predators.

Methods and Materials

Study Area

Study was carried out in Phagune and Barse blocks of Dhorpatan Hunting Reserve of Nepal . It lies in Baglung District in the Dhaulagiri Himalaya of Western Nepal with coordinate of 23°30'N-28°50'N, 82°50'E-83°15'E . It covered area of 132,500ha with the altitude ranges from 2,850m to 5,500m. (Wegge, 1979). Reserve has divided in Seven blocks out of them Phagune and Barse were our main study area.

Phagune: In west along the trail up north from Uttar Gang at Taka across the Phagune ridge at approx, 12,500 ft.; down to Pelma khola, there turning east upstream along Pelma & Gustung kholas to an about 3.2-4.0km east sheep ridge east of tributary, along east side of the ridge to the Dhorpatan trail intersection than following trail south to Dhorpatan & back down along Uttar Ganga.

Barse: Along the eastern part of Phagune block, up from gusting southwards along the Kharka trail to Dhorpatan, eastwards along Uttar Ganga to Barse Mount trail take-off, following trail along the ridge northwards across pass to eastern tributary of Gustung Khola, along the tributary and Gustung down back to Phagune block boundary.

Climate The reserve is located in front of an only moderately high saddle connecting the high Dhaulagiri and Hiuchuli. It is also shielded by several lekhs South of Utter Ganga. The Sheep area therefore receives less precipitation than others ares of the Nepal Midlands (Stainton 1972). Wegge (1976) extrapolates the annual precipitation to somewhat less than 1000m.

During winter or dry season, which lasts from mid-September to early June, there is very little human activity in the hills above the timberline. The weather is dry and cold, with light snow during midwinter, and unpredictable heavier snowstorms into late spring (Wegge 1976).

Vegetation The area is characterized by many plant species of the drier climatic belt to the north, but remnants of the more humid zone are also present, giving the area a mixed vegetation cover. Falling in a transition zone, the dry northern elements are more pronounced at higher altitudes and on south-easterly aspects. In more moist and shaded habitats mixed hardwoods form well-developed strands at lower elevation, yielding first to fir *Abies spectabilis* and then to birch/rhododendron at higher altitudes. The upper northern slopes are densely covered with birch *Betula utilis* and rhododendron *Rhododendron campanulatum* to the tree line, between 3,050m and 3,660m; below is a belt of fir and hemlock Tsuga dumosa, which gives way to a rich mixed-hardwood forest next to the river. The southern slopes, on the contrary, in a wide belt from approximately 3,500m to 2,440m, consist of a very sparse scrub forest of oak Quercus semecarpifolia, interspersed with isolated blue pine Pinus excelsa trees and occasionally rhododendron Rhododendron arboreum.

Fauna Dhorpatan is noted for its blue sheep *Pseudois nayaur* population. Other **ungulates** include Goral *Nemorhaedus goral*, Himalayan tahr *Hemitragus jemlahicus*, and wild boar *Sus scrofa* (particularly common in the upper coniferous zone, especially in the Gurbad and Uttar Ganga catchments), Himalayan musk deer *Moschus chrysogaster* (widely distributed), Serow *Capricornis sumatraensis* and Indian muntjac *Muntiacus muntjak*. Common leopard *Panthera pardus* is common and widely distributed up to altitudes of 4,420m. Other predators include lynx *Felis*

lynx (known to occur in the Upper Seng Valley). Wild dog *Cuon alpinus* (V), red fox *Vulpes vulpes*, wolf *Canis lupus* (V) and snow leopard *Uncia uncia* (E) are occasional visitors to the area. Himalayan black bear *Selenarctos thibetanus* is common in forested areas. Red panda *Ailurus fulgens* is reported to be fairly common in the upper forests of the Lower Seng and Upper Bakre valleys (Wegge, 1976; Fox, 1985).

Methods

Population Survey and Parameters

Population estimate of Blue sheep was done by 'Fixed-Point Count Method' and visiting potential habitats of two blocks of the reserve (Barse and Phagune) (Jackson et.al 1996, DNPWC, 2006,Schaller 1973, 1977 and Wegge 1976). Population count was done in March-April-May 2008 which is peak breeding season April/June (Wegge, 1976).

Preliminary field visit was done each possible blue sheep habitat, undertaking searches from high vantage points and possible low site to locate animals within given sighting distances. Powerful binoculars (8-42x) and a spotting scope (15–45 X) were use to count the blue sheep. Survey was undertaken early in the morning when animals were more likely to be feeding, before haze has developed, and with the sun behind the observer's back and late afternoons. They were blend remarkably well into the background, especially if the ground is rocky or similar in coloration, and can be seen only when they move. Try to climb onto high ridgelines and look downward into adjacent valleys. Team has divided into two groups for reducing double count in same area. We viewed a valley slope from the opposite slope, with the keeping in mind that animals may detect the observer first and leave the area before they are counted. We were aware of their well–developed sense of smell; it is better to approach the observation site from downwind and view the area to be sampled from a distance that minimally threatens any animals present.

Whenever an individual or groups were conformed, They were classify in to sex and age class, using standard criteria and age classes (Table 1). After the sighting of group, Appendix-1 Form was fill up in each sighting site.

Table 1: Blue sheep classification

Total group	Adult Females	Lambs	Yearlings	Adult males	Class I	Class II	Class III
					Horn size between 15-35cm & 2,3 year old small size males.	Males with horn longer than 30-35cm but curving backward slightly, presumably consisting 7, 4, 5&6 year olds.	Fully grown male with an estimated horn length of at least 45-50cm, horns curving noticeably backwards, animals mostly older than 7 yrs.

Snow Leopard, Wolf, Common Leopard, Red Foxs' Scats survey

Sign (scats, pugmarks, scraping, and scent spray) survey were also carried out in study area to distinguishing different predators' scats and to estimate scat density. Different predators' signs were identified on basis of their size, colour, pugmarks and other features (Table 1). Confusion with dogs, lynx scats were avoid because herders and livestock were in downhill and we did not find lynx, wild dog, in Barse and Phagune blocks. I used existing trail as transect line for collecting different predators' scats. Additional transect were laid out in snow leopards potential area, such as ridgeline, stream beds, and accessible cliffs. It was also assumed that scats found above 4500m altitude are snow leopards and or wolf. I used the techniques of the

Snow leopard Information Management System (SLIMS) (Jackson and Hunter 1996), a standardized approach widely used in snow leopard research.

Table 2: Distinguish characters of different predators use for confirmation of their scats.

Feature	*Common Leopard*	*Snow Leopard*	*Wolf*	*Red Fox*	*Civate cat*
Scats		Scats are deposited alone or in association with other sign. Scats are short and segmented	Canid scats tend to be long with tapered ends, compared to felid scats. Scats deposit in group. Wolf tends to make scratches rather than scrapes.	Smaller size, long and final tips pointed. Scats cover grasses, fruits materials.	Smaller than red fox and amount will be lesser than red fox
Scrapes	Orientation of scrapes to the trail is any orientation to trail and on or beside the trail. Scrapes are cluster linear as a long string of scrapes Rescraping is uncommon. Scrape clusters appear ephemeral rather than sculptured. Small pile of soil behind the scrape depression Toe or claw indentations are frequently found in scrapes depression. Scrapes appear to be hastily made. Scrapes appear to be longer, narrower, and	Orientation of scrapes to the trail is parallel to trail and beside the trail Scrapes are cluster circular as a tight group of scrapes. Rescraping of the same scrape or cluster of scrapes is very common. Scrape clusters acquire a sculptured appearance. Large pile of soil behind the scrapes depression. Toe or claw indentations are not frequently found in scrape depression. Pugmark not frequently found at front of the scrape depression. Scrapes appear to have been			

	more linear in shape	made with care.		
	Scrape depression shallow	Scrapes appear to be broader, shorter, and more heart shaped Scrape depression deeper.		
Urine		Snow leopards may urinate on the top of their scrapes.		
Scent spraying		Both sexes may scent mark upright rock faces by spraying them with urine.		
Claw –raking		Snow leopards may leave claw marks on tree trunks or rock faces.		
Altitude		Generally Scats found above 4000m -4500m care found identification while it is assumed that above the 4500m altitude scats were snow leopards.	Above the 3000m	2500m to 4000m.

Source: Jackson, et.al.,1996 and field information

Scats Collection and Analysis Methods

Standard micro-histological method was used to identify prey through the scats hair sample with compare to reference of hair samples of each potential preys. Different predators' scats including snow leopards were collected from the field to know blue sheep depended predators of study area. Different predator species such as, Snow leopards, Common Leopard, Red fox, Wolf 's scats were collected from field in the transect line. Diet composition of different predators represented only for summer season March-June by this study. Scats of different predators were identified on the basis of size, colour, location, local knowledge and microscopic structure of medulla and cuticular structure of hairs. Scats were prepared according to Johnson and Aldred (1982), and Korschgen (1980) for identification of prey items, it was done by

comparing hair surface scale patterns of guard hairs with those of a reference hair collection comprising potential prey species from area (Weingart 1973).

The hair sample from the scats was first washed in hot water. Subsequently, it was thoroughly air dried and cleared in Ether for 1 hour to remove the wax deposition and traces of the moisture. Finally the hairs were passed through Xylol for 24 hour and mounted with DPX for permanent slides to see to medulla structure of the hair. Gelatin solution was used to prepare slides for seeing the cuticular structure of hairs and cuticular scales were observed by the impression techniques. The Slides were observed under a light microscope (400x) and digital photos were taken to see the cuticular and medulla pattern. The main emphasize was given to Blue sheep hair for identify predator of blue sheep. At least 20 hair samples were taken from the each sample scats for analysis and detect multiple prey species Mukherjee et al. (1994). The prey residue composition of the predator scats were extrapolated in term of the prey frequency of occurrence in scats (Fi) calculated by equation-I (Karanth and Sunquist, 1995; Mizutani, 1999; Pikunov and korkishko, 1992; Ramakrishan et. at., 1999).

Fi= ni100% /N equation (I)

Where ni is the number of scats where a given i-th prey species residues occur and N is the number of all scats samples.

Blue sheep selection or preference was analysis on the basis of Blue sheep hair presence in different predators' scats. Blue sheep consumed % of different predator were taken out and compare blue sheep predation by different predator for analyzing Blue sheep preference/selection pattern by predators.

Table 3: collected scats of different predators (N-334)

Name of species	Number of scats sample collection
Common leopard	147
Wolf	78
Snow leopards	23
Red fox	85

I removed others predators scats from analysis without blue sheep hairs, that means at least one scats sample should covered by blue sheep hair. I collected around 50 scats samples of Civet cat but there were not any scats with blue sheep hairs so I removed these scats from diet analysis.

Data Analysis

Computer base SPSS 13.1 and Excel software were used to data analysis. Mean population of blue sheep, standard deviation, and error, correlation between blue sheep and its depends predators were analysis. Population pattern were showed through the graph. Age, sex, sex ration, population density and its relation were calculated through the statistical program (SPSS13.1) through chi-square test. Scates of predator and Blue sheep relation were analysis through Chi-square test**.**

Result

Population Size & Demographic Parameters of Blue Sheep.

Population of Blue Sheep

The survey covered all potential habitats of blue sheep of the study area. A total of 283 individual blue sheep were observed from the two study blocks (Barse-174 and phagune-109). After reducing the double counts numbers of the blue sheep, it has estimated that total 206 population of blue sheep occurred in the study area. One hundred twenty eight populations of blue sheep estimated in Barse block while 78 estimated in Phagune block. If we compare the present population with Austegard & Hangland (1993) study, the population has decreased by 25.5% in the study area. Overall the blue sheep population has not significantly changed within 4 decades (χ^2=0001, P>0.5, df= 3) .

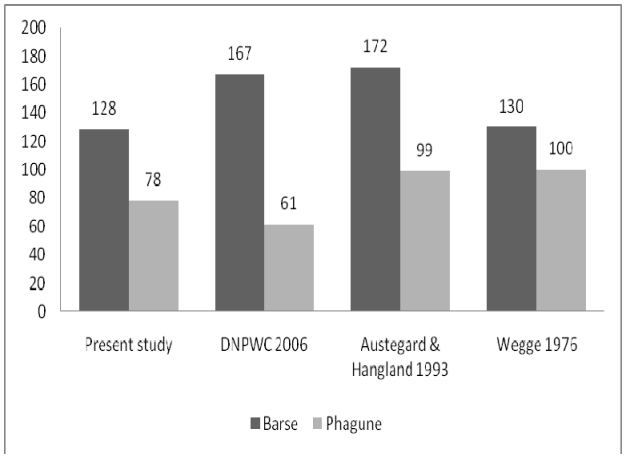

Figure 1: Population trend of blue sheep

Density

Phagune and Barse block cover 465 km^2, out of them one half of the area of the reserve is covered by the forest and ¼ is uninhabitated by sheep due to extreme altitude or ruggedness (wegge 1979), therefore potential habitat for blue sheep in these two blocks covered 115 km^2. Present population density in these two blocks is 1.8 blue sheep/sq.km (206 blue sheep/115km2). There was not significant change in population density from last 4 decades (χ^2=0001, P>0.5, df=3).

Herds Size

An average 7 animals (SD-5.5) per herds were classified from twenty nine herds, sheep per herds varying from 1 to 37. There was not significantly different in herds composition in both blocks (Barse χ^2=2.06, P>0.5, df=11; Phagune χ^2=4.31, P>0.5, df=8).

Population Composition and Sex Ratio

A total of 283 blue sheep observed in the study area. It has classified into sex ratio 64 males/100females and 85 males/females respectively and in an average 75 male/100females were recorded in both blocks (figure 2). The sex ratio was slightly lower but sex ratio was not significantly different from the previous study (Table1) (*χ^2=0001, P>0.5, df=8).* Ewes' population composition was 67% lower than previous study. Rams has also decreasing pattern within last 4 decades. Rams and ewes population composition in Barse block was higher than Phagune blocks but there was not significant different in different age composition of animals (figure 2) (phagune *χ^2=0.667, P>0.9, df=4; Barse χ^2=0001, P>0.9, df=5 and Barse and phagune χ^2=3, P>0.9, df=8)*

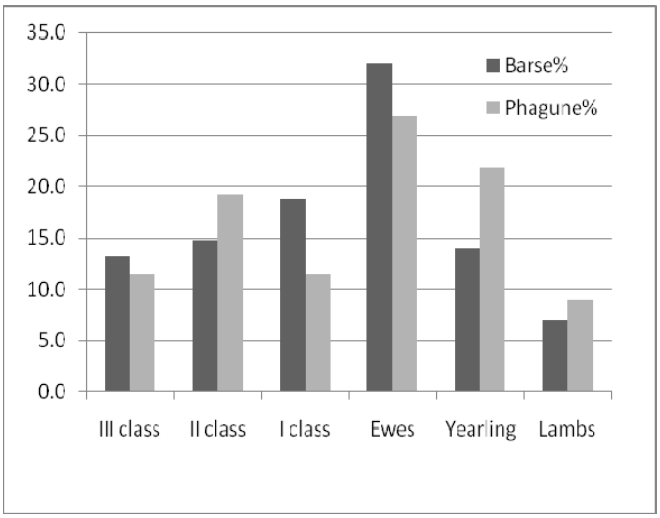

Figure 2: Present population composition in study area

Table 4: Sex ratios (Males per 100 female) of Blue sheep

Area	Phagune 1976	Barse 1976	Total	Phagune 1993	Barse 1993	Total	Phagune 2006	Barse 2006	Total	Phagune Present study	Barse Present study	Total
Rams	55	88	143	34	67	101	46	152	198	54	101	155
Ewes	69	115	184	49	69	118	15	15	30	24	27	51
Sex Ratio	80	77	78	69	97	86				64	85	75

Population Trends

A total 155 rams population were observed in the study area where as Ewes population was 51. Class II and I animals were higher than previous study but the III class animals were lower than 2006 study but higher than others study data. Rams population was slightly lower than 2006 study. Class III rams were more in Barse block than Phague blocks. Proportion of ewes was more or less same while there were fewer yearling and lambs. There was weak relation among the population composition of blue sheep ($R^2 = 0.0039$).

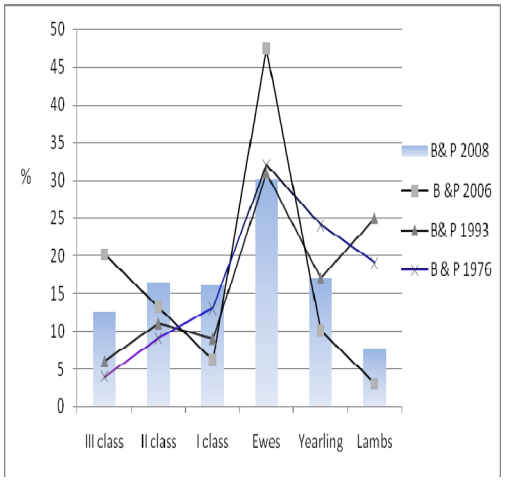

Figure 3: Population composition trends in different years (B= Barse, P= Phagune) $R^2 = 0.0039$

Overall populations were more in Barse block than Phagune. Population trend seems changing every years from last 4 decades (figure 3). There was not change blue sheep population drastically even there was very high pressure of poaching (χ^2=6, P>0.9, df=17).

Diet Composition of Large Carnivores (Predators Of Blue Sheep)

The frequency of occurrence of different prey species in scats of different predators shows that, excluding zero values, the frequencies of different prey species were no significantly different (χ^2 = 10.3, df = 49, $p > 0.05$). Most of the scats samples (74%) of Snow leopard, Wolf, Common Leopard, Red fox's cover one prey species while two and three species were present in 18% and 8%, respectively.

Diet Composition of Common Leopard *Panthera pardus*

The Frequency of occurrence of different prey species in scats of common leopard (*Panthera pardus)* (Table 3), excluding zero values, the frequencies of different prey species were no significant different and there was close relation with each preys species for diet of common leopard (χ^2 = 0.889, df = 16, $p > 0.05$; R^2- 0.84). On average, Barking deer *Muntiacus muntjak* was the most frequent (18%), and Blue sheep consume only 6% of total diet composition of common leopards. Beside that common leopards also consumed wild boar (*Sus scrofa*), Himalayan Serow *Capricornis sumatraensis*, Pika *Ochotona roylei*, Musk deer *Moschus chrysogaster* and about 4% livestock which together form the rest of the frequency percentage (Table 3). Non food item of common leopards covered 9% of total diet composition which covers vegetation, soils and stones.

Table 5: Occurrences of prey species in scats (n-147) of Common Leopards

Prey species	Frequency	%
Barking Deer	521	17.72
Wild boar	430	14.63
Pika	287	9.76
non food item	264	8.98
Himalayan Serow	236	8.03
Himalayan Musk deer	211	7.18
Blue Sheep	176	5.99
Monkey	109	3.71
vegetation	109	3.71

Goat	83	2.82
Birds	75	2.55
Goral	69	2.35
Cow	44	1.50
unknown	286	9.36
Himalayan tahr	34	1.16
Horse	6	0.20

Diet Composition of Snow Leopard *Uncia uncia*

The Frequency of occurrence of different prey species in scats of snow leopard (Table 4), excluding zero values, the frequencies of different prey species were no significant different and there was close relation with each preys species for diet of snow leopard (χ^2 = 0.0001, df = 13, $p > 0.05$; R^2- 0.74). On average, Pika *Ochotona roylei* was the most frequent (28%), and Blue sheep second position for diet of snow leopards which cover 21% of total diet composition. Beside that snow leopards also consumed wild boar (*Sus scrofa*) 16%, Himalyan tahr *Hemitragus jemlahicus* 11%, Goral *Nemorhaedus goral*, Birds and about 3% livestock which together form the rest of the frequency percentage (Table 4). 13% of diet covered non-food item such as soil, stones, and vegetable.

Table 6: Occurrences of prey species on scats **(n-23)** of Snow leopards

Prey species	**Frequency**	**%**
Pika	127	27.56
Blue Sheep	93	20.12
Wild boar	74	16.05
Himalayan tahr	52	11.40
non food item	42	9.19
Goral	12	2.67
Goat	10	2.21
Himalayan Musk deer	6	1.28
Horse	5	1.16
Vegetation	11	2.44
Unknown	24	5.93
Birds	3	0.58

Diet Composition of Wolf *Canis lupus* **and Red fox** *Vulpes vulpes*

The Frequency of occurrence of different prey species in scats of Wolf and Red Fox (Table 5, 6), excluding zero values, the frequencies of different prey species were no significant different and there was close relation with each preys species for diet of wolf and Red fox (Wolf $\chi 2 = 0.857$, df = 12, $p > 0.05$; R2- 0.66; Red fox $\chi 2 = 0.86$, df = 12, $p > 0.05$; R2- 0.64). Pika *Ochotona roylei* was most frequent on Wolf and Red fox diet which covered 32% and 30% respectively. Wild boar was second (21%) and third (25%) position for the diet of wolf and red fox respectively. Beside that wolf consumed 12% Blue sheep, 3% Himalyan tahr *Hemitragus jemlahicus* 2%, Goral *Nemorhaedus goral*, Birds and about 2% livestock which together form the rest of the frequency percentage (Table 5). 19% of diet covered non-food item such as soil, stones, and vegetable. Red fox consumed 24% vegetation and 13% non-food item and followed by Serow, Musk deer and only 2 % blue sheep (table 6).

Table 7: Occurrence of prey frequency on scats(n-78) **of Wolves**

Prey species	**Frequency**	**%**
Pika	465	31.85
Wild boar	302	20.68
non food item	237	16.23
Blue Sheep	184	12.60
Himalayan tahr	56	3.84
Goat	34	2.33
Himalayan Musk deer	21	1.44
vegetation	42	2.88
Goral	18	1.23
Horse	10	0.68
Unknown	10	5.68
Birds	5	0.34
Monkey	2	0.14

Table 8: Occurrence of prey frequency on scats(n-85) **Red Fox**

Prey species	**Frequency**	**%**

Pika	508	29.88
Vegetation	421	24.76
non food item	221	13.00
Wild boar	192	11.29
Himalayan Serow	62	3.65
Monkey	45	2.65
Himalayan Musk deer	41	2.41
Blue Sheep	29	1.71
Goral	26	1.53
Birds	25	1.47
Goat	23	1.35
unknown	176	5.41
Himalayan tahr	15	0.88

Prey (Blue Sheep) Predator Relation and Preference

There was good positive relationship between the scat density and Blue sheep consumption rate, increasing the scat density, increasing the Blue sheep consumption rate (R^2-0.49; r-0.7, figure 4).

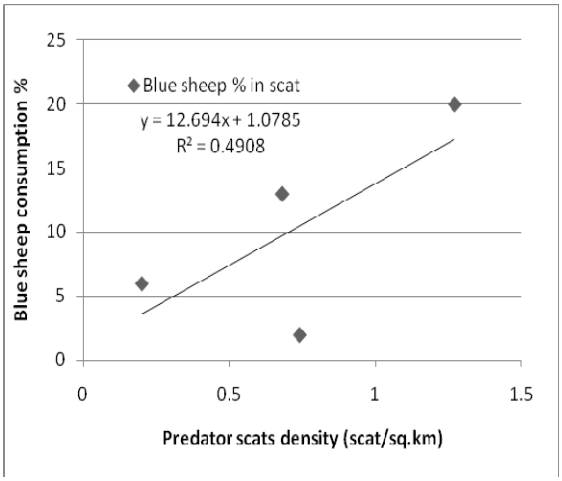

Figure 4: Blue sheep predators relationship

Blue sheep preference by different predators such as Snow leopard, Common leopard, Wolf and Red fox were 20%, 6%, 13% and 2% respectively. There was no significant different in Blue sheep consumption by different predators and there was close relation among the predators for Blue sheep predation ($\chi 2$ = 0.0001, df = 3 p > 0.05; R^2- 0.58) (Table 9). Among the different predators snow leopards and wolves were select/prefer more Blue sheep then common leopards and Red fox.

Table 9: Prey (Blue sheep) predator relation

Name of species	Number of scats sample collection	Scat density (Number of scat/potential area 115 sq.km) scat/sq.km	% of Blue sheep in Predator scats(Blue sheep preference)
Snow leopard	147	1.27	20
Wolf	78	0.68	13
Common leopard	23	0.2	6
Red fox	85	0.74	2
Blue sheep density 1.8 Blue sheep/sq.km			

Discussion

Discussion on Population of Blue Sheep

Wegge (1976) estimated 120 and 100 population in Barse and Phagune Blocks respectively. It seems that only 1.5% population decreased in Barse block and 23% of population has decreased in Phagune block. Austegard & Hangland 1993 estimated 172 and 99 blue sheep population in Barse and Phagune blocks respectively. This study show that Blue sheep population has decrease with compare to Austegard & Hangland (1993) study while there were not significantly change on population when we compared this study data with Wegge (1976) study. Although, the poaching was main problem, the population of blue sheep has changing significantly, it may due to decrease in wolf and other predator by poison (detail discussion has given below paragraphs).

Discussion on Blue sheep density

Sherpa and Oli (1988) found mean population density of 7.6 blue sheep/km2 in Nar and Phu valley but overall population density in Annapurna conservation area was estimated ranging from 16.8 to 25.8 blue sheep/km2 (Oli and Rogers, 1991). Austegard & Hangland (1993) reported 2.3 blue sheep/Km^2 in Barse and Phagune block while Wegge (1976) reported 2 blue sheep/km2 and DNPWC (2006) reported 1.4 blue sheep/km2 in the reserve. Present population density in the study area was lower than previous study and other parts of country except DNPWC (2006).

Discussion on Herds Size

This study found mean group size was 7 blue sheep which was lower than previous study. Wegge (1976) and Austegard & Hangland (1993) found mean group size 11.1 and 9.7 animals respectively in same blocks. The herd size of blue seep was

determined by quality and distribution of forage, and life threatening disturbance. Patchily distributed and poor quality forage cannot support a big herd, and the larger herds may break up in to smaller herds and forage separately. When the blue sheep detect a predator, they tend to flee in all possible directions to escape the danger. While fleeing the herds break up, and only a few individuals may re-establish contact with others, thereby resulting in smaller herds (Oli and Rogers 1991),

Discussion on Population Composition and Sex Ratio

In wild sheep populations subjected to harsh winter conditions and heavy predation, a skewed ratio favouring females prevails (Geist,1971; Murphy and Whitten 1976). Non-hunted population may have a slight preponderances of male (Woodgerd 1964)or a unity ratio (Wegge 1979).The low ratio of males to females in Phagune and Barse by selective hunting (Wegge1979). Local people hunted selectively the large males because of the amount of meat, and because behavioural characteristics made them easier to hunt (Wegge, 1979). Poaching was major problem in both Barse and Phagune blocks, because of absence of local reserve authorities in different filed station of DHR and there was increase in poaching activities. Although, there were presence of local reserve authorities in DHR head quarter, meat of different games including the blue sheep still found in illegally on the way to Dhorpatan and surrounding the reserve. Local people blamed that more illegal hunting was occurred last 7 years after the reserve authority shift into district head quarter. Same time they also blamed that during insurgency period, Reserves specially Barse and Phagune block were main shelter for MAOIST, it was supposed that at that time high poaching pressure. Therefore, the population of lower than 1993 study. Hunting methods used by the local people in Namlang valley in north-western Nepal tended to be selective

on older males (Jackson,1978). In DHR trophy hunting has been going on since the early seventies. This means that the legal harvesting of older males may also have influenced the sex ratio. During the summer some of livestock herder was main agents for illegal hunting while winter poacher have good opportunity to hunting near the village because of heavy snow fall in high altitude.

Discussion on Population Trends

Present population trend showed that there was not significant change in population composition even there is high pressure of poaching which is still continue. Population composition show that there was more rate of mortality between yearling and lambs but not statistically significant ($\chi 2=0.75$, $P>0.9$, $df=6$). Similarly Wegge ,1976 also found there was not significant different in ewe/lambs ratio while Austegard & Hangland (1993) found higher than others study. The proportion of trophy rams was found to be higher than the earlier studies (Wegge 1976, Austegard & Hangland, 1993), lesser than DNPWC (2006) studied but overall population was lower than previous study. This may be because the trophy hunting was suspended for more than 7 years in DHR and poachers hunted more ewes and class I animals. The proportion of young rams were more compared to earlier studies & one of the possible explanations for this could be that many young females with smaller horn size may have been classified as adult male. Overall population was lower than the previous study, but similar to Wegge 1976 survey.

Population of Blue sheep was seen stable or not decrease even there was high poaching pressure, that another reason may be reducing the number of wolves. Because of livestock depredation by wolves and other carnivores, last year herder killed many wolves and leopards by poisoning, that's direct effect can be seen by

number of wild boars which population is maximum because of low number of predators. So that, blue sheep are the one of the prey species of wolves so that reducing of number of wolves support to increase the population of blue sheep, this is another existing situation of the reserve. Wild boar was main problem in DHR, and I observed wild boar above the tree line of Dhorpatan region. So less number of natural predators and herders/livestock owners killed large predators to a greater extent which has also help to good performance of blue sheep population.

Others reason of good performance of blue sheep in Dhorpatan may be quality and or the quantity of the food resources have not decreased, despite the high increase in domestic stock only in summer. A certain amount of domestic grazing may even have increased the quality of the food resource for wild sheep (Wegge 1976), and range deterioration has not yet been reached.

Discussion on Diet of Wolf and Red fox

As it has been demonstrated, dominating Pika, Wild boar and Blue sheep for DHR tend to dominate in Wolf diet. In Alam-Pedja NR, Wild boar and moose are dominant ungulate species, which is reflected in the local Wolf diet, differing from generalised results from some part of Estonian areas (Valdmann et al. 1998). Because of livestock depredation by wolves and other carnivores, last year herder killed many wolves and leopards by poisoning, so there wild boars population has increased and seen above the tree line of Barse and Phagune blocks. Although the wild boar population was high, only 20% diet of wolf covered by wild boar so that, higher the number of wild boar, reducing the pressure of predation on Blue sheep. One hand increasing the population of wild boars supporting to the Blue sheep population by reducing

predation pressure and other hand, reducing the predators has created problem of crop damage by wild boar.

The predation rate of Wolves on Pika and Wild boars can be influenced by several factors: the mean wolf pack size, preys density and physiological condition of Pika and Wild boars. Kubarsepp, 2003, suggested, that, relatively large (7.9 specimens) pack is able to hunt moose and wild boar more effectively, probably enhancing selection of larger prey. Besides the domination in biomass, Pikas have also higher frequency of occurrence in the diet of wolves (32%). Wolves limit Pika and wild boars numbers and, potentially, they may even regulate populations at low densities but now population of wild boars increasing drastically which was also the evidence for reducing the wolves population. Most European locations where wild boar is avoided by wolves (Belyanin 1979; Nesterenko 1988; Jædrzejewska et al. 1994; Okarma et al. 1995), in this study area wild boars were the dominant prey species (by 21%).

Discussion on Diet of Snow Leopards and Common Leopards

Wegge (1976) originally reported snow leopard as a possible permanent resident in the northern reaches of the DHR (Wegge 1979; Wilson 1977). Within last 4 years snow leopards are frequently visit in northern part of the DHR i.e. Barse (Mansun area and NE site of Barse duri), Gustung, Seng and Dhogadi Blocks, It is also visit border of Phagune and Barse also, I found very old(>5 week) and some fresh scats of snow leopard there. There were very low density of snow leopards therefore I was unable to collect very low number of the snow leopards scats, it is also confirmed that snow leopards is not permanent residential in Barse and Phagune Block of DHR, but come regularly in March-October in those two blocks, there may be permanent

resident of snow leopard in Gustung, Seng, and Dhogadi blocks of DHR but detail study should be carried out in these blocks. The Snow leopard has very varied diet and did not exclusively feed on the wild prey (Chundawat, 1993). Blue sheep remained the major prey throughout the year. In our study Pika was major prey species follow by Blue sheep and Wild boar. Various explanations have been giving for the presence of plant matter in carnivore diet (Robinette, et. al. 1959; Khan, 2004).

Smaller mammals are important in the diet of a predator (Zhirjakov, 1990) and more so when it's major or preferred prey is not readily available. It was evident that in the diet of the snow leopards small mammals were very important, the study show that 27% of snow leopards diet covered by Pika and 16% wild boar in DHR. While common leopards covered about 10% of Pika and 16% of wild boars in their diet in DHR. Summer diet of common leopards covered highest percentage by Barking deer (large mammals) while snow leopards main diet was Pika it may due to availability of alternative prey species, although the main diet of snow leopard is blue sheep. Very little information is available on the importance of alternative prey in a predator's diet (Shaw, 1977). The role of alternate prey becomes very important when its major prey is not readily available. In such a situation alternate prey in the form of smaller animals become very important in the snow leopard and common leopards diet. This is obvious from snow leopard and common leopard food habitat in summer. Blue sheep the major prey species of snow leopards moved to higher open pastures and formed large groups as an anti-predatory strategy. Pikas which were abundant during the summer become the major prey species in DHR. This shift in diet in summer considerably reduced predation pressure on the blue sheep population. Similarly in common leopards, large mammals (barking deer, Musk deer, Serow) are the major

prey species of common leopards which are more active in summer and hard to find so the smalls mammals like Pika, Wild boars abundant was high in summer. Another reason to increase population of smalls mammals was decreasing the population of wolf which was assumed major predator for these mammals. So predation strategy of common leopards and snow leopards shifting towards the smalls mammals in DHR.

Snow leopards, common leopards, diet covered by 21%, and 6%, of blue sheep respectively. Common leopard occasion kills the blue sheep, generally high in winter as compare to summer. In continued predation pattern of above predators in the study area, if all the domestic prey is to be removed then the role of the alternate prey in the form of smaller animals will be greater importance. The predation on smaller animals, especially on Pika and Wild boars were so heavy that from some site of Barse and Phagune blocks they were exterminated. Snow leopards, Wolf, and somehow Common leopard and Red fox are competitor and depend on almost same types of preys in the DHR. Therefore, the DHR management has to consider managing these species more scientifically and same time blue sheep hunting quota should be determine through the scientific basis. Abundance and availability of alternate prey will help in maintaining the blue sheep population on a sustainable basis.

Discussion on Vegetation and Non-Food item in Predators

However, the significance of the occurrence of vegetable and non-food item in the snow leopards, wolf and common leopards' diet at such high frequency, remains unknown. Snow leopards, Wolf and Common leopards may be eating vegetation to fill the stomach during the starvation period between two major kills. This can be further explaining by the fact that the occurrence of vegetable matter was much less in summer, when smaller animals were in abundant as food, than in winter. This study

also carried out in summer and represents less percentage around 10% non food item including vegetation in both leopards and more than 15% in wolf an red fox. It is also interesting to note that most of the scats on common leopards, wolf having vegetable matter than snow leopards scats. It is extremely difficult to arrive at any conclusion unless a detailed chemical analysis of the plants and the remains of the plant matter and soils in the scats are conducted.

Discussion on Prey Predator Relation and Prey (Blue sheep) Preference

There was good positive correlation between the scat density and Blue sheep consumption rate, increasing the scat density, increasing the Blue sheep consumption rate (R^2-0.49; r- 0.7; figure 4), but it is depend on the available alternative preys species, and depend on predators. Most of the predators are more opportunistic, so they consumes those prey when they encounters, and it is easy to kill small animal rather than big and predators have used low energy for small animals rather than big one. Small animals like red fox consumed low % of blue sheep as compare to big predators, it seems that red fox eats remaining blue sheep part which kills by other big animals wolf or common leopards or snow leopards. So that its scats density high but Blue sheep consumption rate was low (figure 4).

While studying prey (Blue sheep) selection by predators (Common Leopard, snow leopard, wolf and Red fox), more emphasis was given to scat data, because scat samples portray predator diets more accurately, whereas the kill samples underestimate proportions of smaller prey and young individuals (Karanth and Sunquist 1995, Miquelle *et al.* 1996). Even in the scats, the smaller prey are believed to be under-represented, because these are consumed completely without leaving a trace in the faecal material, which causes the underestimation of the role of these prey

in a predator's diet (Bothma and le Riche 1984, Karanth and Sunquist 1995, Khorozyan and Malkhasyan 2002). Floyd *et al.* (1978) and Oli *et al.* (1993), however, think that smaller prey contains a relatively high proportion of indigestible matter, and their remains are over-represented in scats.

The findings of scat analysis during this study fully agree with Schaller's (1967) statement that most scats contain the remains of only one prey species, but a few contain two different items.

The preference for large prey species (Barking deer, Wild boars by Common leopards; Blue sheep by Snow leopards; etc), as found in this study, supports the hypotheses related to foraging theory (Stephens and Krebs 1987), which suggest that predators may select species containing the most 'profitable' prey, as measured by the ratio of energy gain to handling time (MacArthur and Pianka 1966, Schoener 1971, Pulliam 1974, Werner and Hall 1974, Charnov 1976, Scheel 1993, Karanth and Sunquist 1995). For large felids the most profitable prey type would seem to be the largest available prey that could be safely killed, but the importance of search time, encounter rates, and the energetic costs of capture for various prey types also need to be considered (Sunquist and Sunquist 1989). Large carnivore species must rely upon the energy sources that occur in large food items, unless they can collect smaller prey with great efficiency (McNab 1963); carnivores usually prey upon herbivores of about their own size and weight (Bourliere 1963). Common leopard (*Panthera pardus*) usually catches the kill when it is large enough to afford more than one meal (Johnsingh 1983). The vertebrate predators would be selective 'energy maximisers' in prey-rich habitats, but would be non-selective 'number maximisers' in habitats where large prey are scarce (Griffiths 1975).

While only consideration of blue sheep predation by different predators highest percentage of Blue sheep diet cover by Snow leopard followed by Wolf, Common leopards and Red fox respectively. Because of habitat preference of Snow leopards, Wolves were on Blue sheep habitat and they consumed highest percentage of Blue sheep as compare to others predators of the area (table 9).

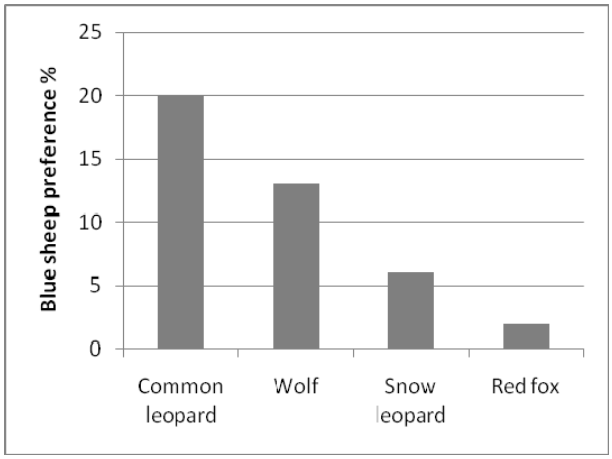

Figure 5: Blue sheep preference by different predators

In the DHR different predators prey heavily on Pika after that others Blue sheep, Wild boars etc population, hence it might play the key role in shaping the such prey population and perhaps even their average body size (since larger individuals are hunted more often than others). Predator-prey interactions affect population dynamics of individual species and community structure (Gasaway *et al.* 1992, McLaren and Peterson 1994, Estes and Duggins 1995, Macdonald *et al.* 1999, Baker *et al.* 2001). Other researchers have observed that increased predation risk leads to decreased body mass (hence fecundity), and decreased food levels lead to increased mortality of the prey (McNamar and Houston 1987, Ludwig and Rowe 1990, Brown 1992). The survival rate of blue sheep and others depends mainly on the predation by Snow leopards, Common leopards, Wolves. Studies in North America revealed that predation by even a small number of puma can affect bighorn sheep (*Ovis canadensis*) survival rates (Wehausen 1996, Ross *et al.* 1997), and population-level effects may be exacerbated if female bighorn sheep are preyed upon heavily (Hayes *et al.* 2000).

Conclusion

A total of 283 individual blue sheep were observed from the two study blocks (Barse-174 and phagune-109), One hundred twenty eight populations of blue sheep estimated in Barse block while 78 estimated in Phagune block, Present population density in these two blocks was 1.8 blue sheep/sq.km (206 blue sheep/115km2). There was not significant change in population density from last 4 decades (χ^2=0001, P>0.5, df=3). An average 7 animals/herd (SD-5.5) were classified from twenty nine herds, sheep per herds varying from 1 to 37. A total 155 rams population were observed in the study area where as Ewes population was 51. It has classified into sex ratio 64 males/100females and 85 males/females respectively and in an average 75 male/100females were recorded in both blocks. The sex ratio was slightly lower but sex ratio was not significantly different from the previous study. Poaching was major problem in both Barse and Phagune blocks. Meat of different games including the Blue sheep still found in illegally on the way to Dhorpatan and surrounding the reserve. Local people blamed that more illegal hunting was occurred last 7 years after the reserve authority shift into district head quarter. Same time they also blamed that during insurgency period Dhorpantan specially Barse and Phagune block were main shelter for MAOIST, it was supposed that at that time high poaching pressure. Population of Blue sheep was seen stable or not decrease even there was high poaching pressure, that another reason may be reducing the number of Wolves. Because of livestock depredation by Wolves and other carnivores, last year herder killed many wolves and leopards by poisoning, resulting the increasing Wild boar population and reducing predators population. So that, Blue sheep are the one of the

prey species of wolves so that reducing of number of wolves support to increase the population of blue sheep. Wild boar was seen as problematic animal by crop damage Dhorpatan area because of its high population they were distributed in above the tree line. So less number of natural predators and herders/livestock owners killed large predators to a greater extent which has also help to good performance of blue sheep population.

The frequency of occurrence of different prey species in scats of different predators shows that, excluding zero values, the frequencies of different prey species were no significantly different (χ^2 = 10.3, df = 49, $p > 0.05$). Most of the scats samples (74%) of Snow leopard, Wolf, Common Leopard, Red fox's cover one prey species while two and three species were present in 18% and 8%, respectively.

On average, Barking deer *Muntiacus muntjak* was the most frequent (18%), and Blue sheep covered only 6% of total diet composition of common leopards. Pika was the most frequent (28%), and Blue sheep second position for diet of snow leopards which cover 21% of its total diet. Beside that snow leopards also consumed wild boar *Sus scrofa* 16%, Himalyan tahr *Hemitragus jemlahicus* 11%, Goral *Nemorhaedus goral*, Birds and about 3% livestock which together form the rest of the frequency percentage (Table 4). 13% of diet covered non-food item such as soil, stones, and vegetable. There were very low density of snow leopards therefore there was very low number of the snow leopards scats, it is also confirmed that snow leopards is not permanent residential of DHR, it may be permanent resident in Gustung, Seng and Dhogadi blocks of DHR

The Frequency of occurrence of different prey species in scats of Wolf and Red Fox (Table 5, 6), excluding zero values, the frequencies of different prey species were no significant different and there are close relation with each preys species for diet of

wolf and Red fox. Pika was most frequent on Wolf and Red fox diet which covered 32% and 30% respectively.

There was good positive relationship between the scat density and Blue sheep consumption rate, increasing the scat density, increasing the Blue sheep consumption rate. Blue sheep preference by different predators such as Snow leopard, Common leopard, Wolf and Red fox were 20%,6%,13% and 2% respectively. There were no significant different in Blue sheep consumption by different predators and there was close relation among the predators for Blue sheep predation ($\chi 2 = 0.001$, df = 3 $p > 0.05$; R^2- 0.58).

Snow leopards, Wolf, and somehow Common leopard and Red fox are competitor and depend on almost same types of preys in the DHR, Therefore, the DHR management has to consider managing these species more scientifically and same time blue sheep hunting quota should be determine through the scientific basis. Abundance and availability of alternate prey will help in maintaining the blue sheep population on a sustainable basis.

Recommendation:

Detail survey on Snow leopards should be carried out in Sundaha, Dhogadi, Seng, and Gustung Block of Dhorpatan Hunting Reserve.

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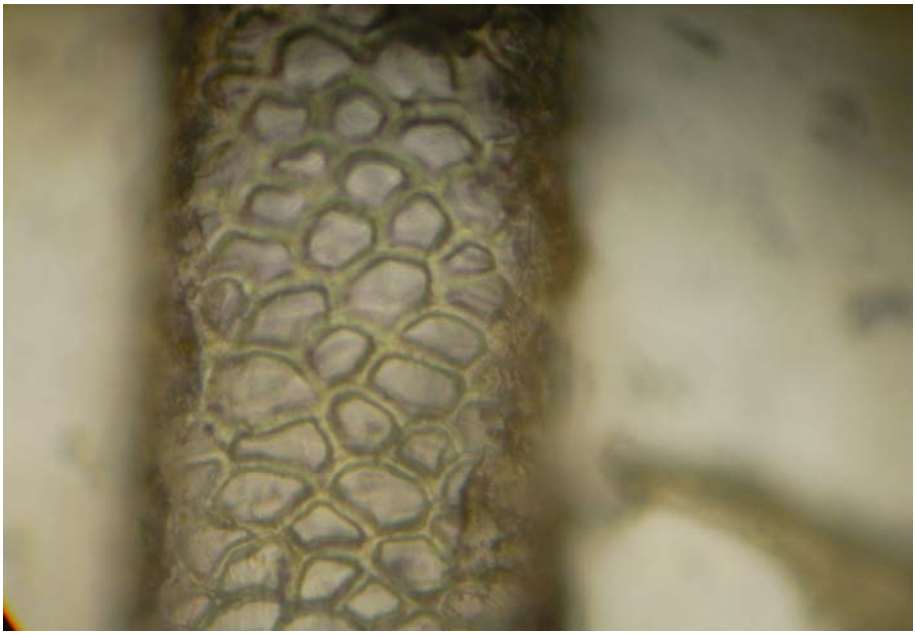
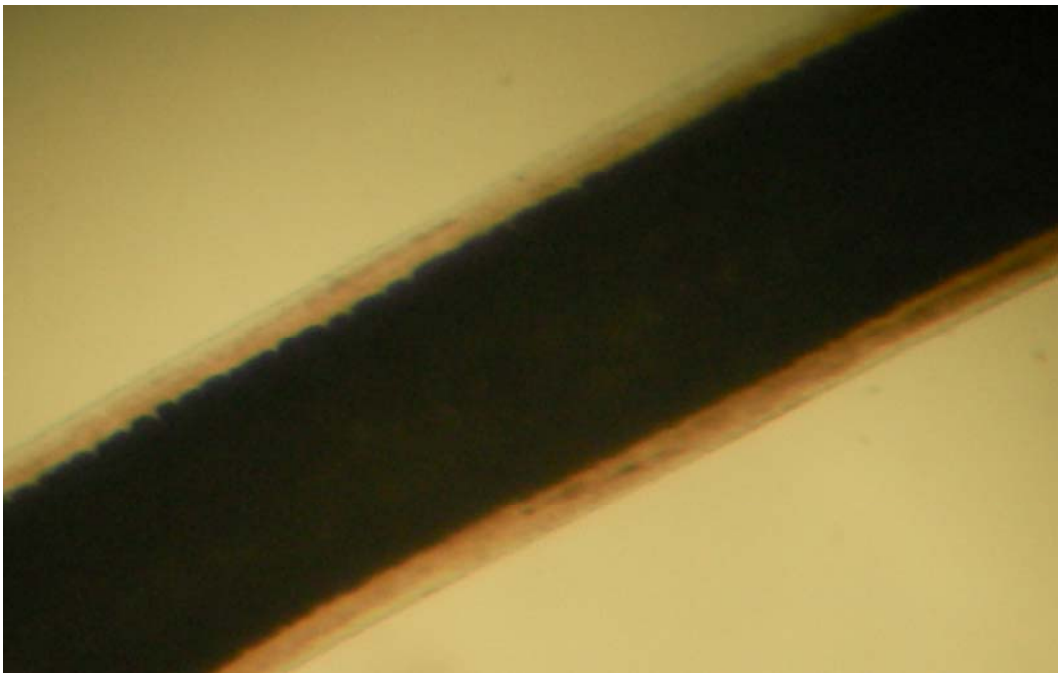
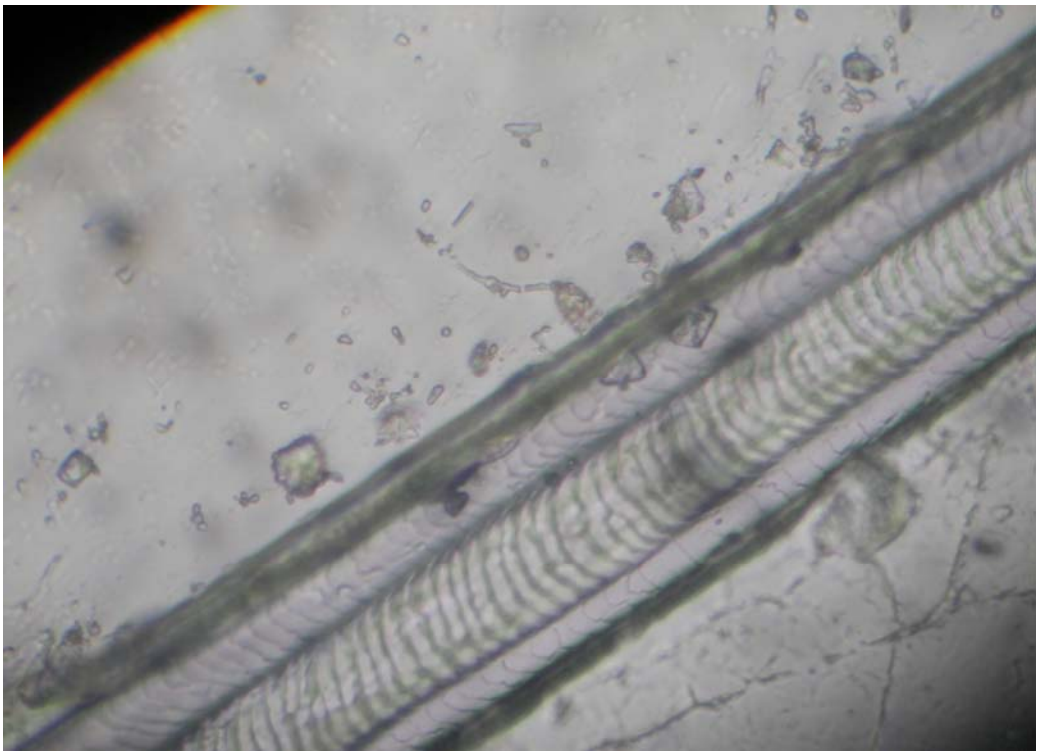
Project Photos: Some identified microscopic hairs (400x) structure



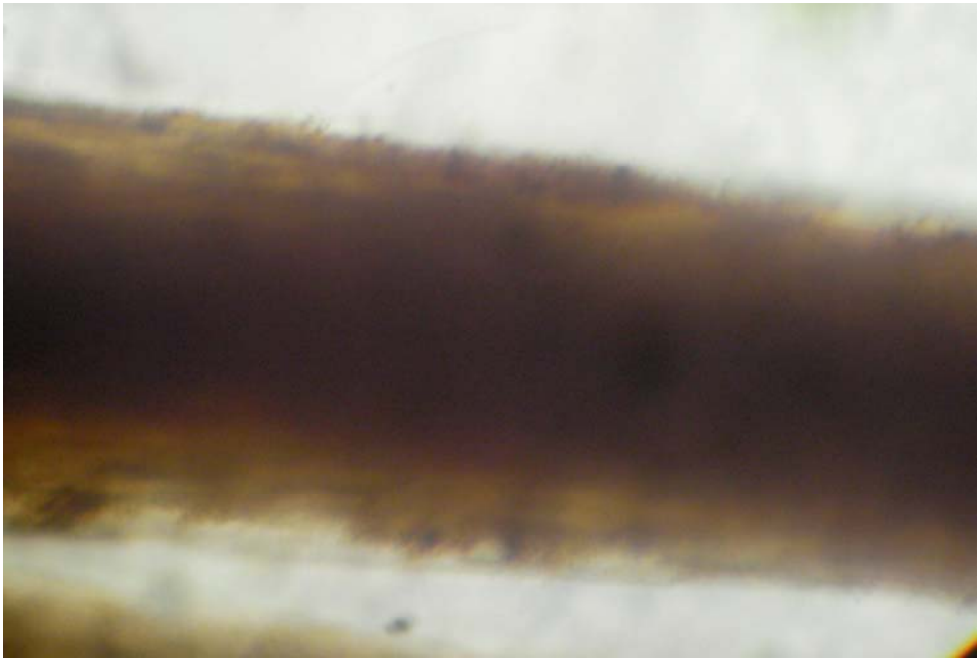
Blue sheep medullary hair structure



Himalayan tahr medullary structure



Pika medullary hair structure



Wild boar medullary hair structure

Snow leopard medullary hair structure

Photo: study team

Blue sheep herd