Summer diet composition of the Common Leopard *Panthera pardus* (Carnivora: Felidae) in Nepal

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Abstract: The Common Leopard *Panthera pardus* is one of the most widely distributed of all big cats. It is a threatened species throughout its range due to the degradation of natural habitat, poaching and persecution as a killer of humans and livestock. The purpose of this study was to determine the composition of the Common Leopard diet in the Dhorpatan Hunting Reserve (DHR) of Nepal. Among prey species Barking Deer (*Muntiacus muntjak*) were observed most frequently (18%) in leopard scats, while Blue Sheep (*Pseudois nayaur*) were observed less frequently (6%).

Keywords: Dhorpatan Hunting Reserve, diet composition, leopard, predators, prey.

Introduction

The Common Leopard *Panthera pardus* is one of the most widely distributed of all big cats (Bailey 1993), occupying an array of habitats in Asia and Africa. In south Asia, it is found in Pakistan, India, Nepal, Sri Lanka and Indochina (Prater 1993; Shrestha 1997). As a habitat generalist species (Bailey 1993; Maan & Chaudary 2000), the leopard can live and thrive in almost all types of habitats including dense forest, rock and scrub (Prater 1993), grasslands and even on mountain cliffs, where sufficient hideouts and prey species are available (Bailey 1993). Its behaviour varies according to the habitat it occupies (Seidensticker et al. 1990; Bailey 1993; Daniel 1996). These leopards have such a diverse and wide distribution due to their highly adaptable hunting and feeding practices, and their solitary nature. They can easily survive in human dominated areas by changing their dietary habits to include livestock, dogs and humans (Gugginsberg 1975; Sedeinsticker et al. 1990; Daniel 1996; Chauhan & Goyal 2001). The Leopard is categorised as a Near Threatened species by the IUCN Red List of Threatened Species (Henschel et al. 2008). It is threatened throughout its range due to habitat degradation, poaching for its valuable skin and bone, and persecution as a killer of humans and livestock. The ecology of the leopard in south Asia is not fully understood. However, some studies have been carried out in the region (Eisenber & Lokhart 1972; Sunquiist 1983; Seidensticker et al. 1990). The ecology and behaviour of this elusive species cannot be fully understood without knowing how leopards respond to various ecological resources and disturbance scenarios. Therefore, this study was carried out to understand the dietary composition of Common Leopards in the Dhorpatan Hunting Reserve of Nepal. Scat samples were collected during the summer season (March to June) of 2008. Blue Sheep *Pseudois nayaur* is the main legally hunted species in the reserve and is also assumed to be the main prey species of Common Leopards and other predator species as well, such as the Snow Leopard. Blue Sheep are assumed as the main prey species of Snow Leopards and other predators within the high altitude biomes of Eurasia. They are a species that are trophy hunted in DHR and the conservation of Blue Sheep is of international and national concern given its keystone prey status. Therefore, the main objective of this study was to determine the proportion of the Common Leopard diet that consists of Blue Sheep during the summer.

Methods and Materials

Study Area: This study was carried out in the Phagune and Barse blocks of the Dhorpatan Hunting Reserve of Nepal (Fig. 1). This reserve, which is divided into seven blocks, lies in the Baglung District in the Dhaulagiri Himalaya of western Nepal (23°30'-28°50'N & 82°50'-83°15'E). It covers an area of 1325km^{2}with altitude ranging from 2,850m to 5,500m. (Wegge 1979).

Phagune: In the west along the trail north from Uttar Ganga at Taka across the Phagune ridge at approximately 3800m; down to Pelma khola, there turning east

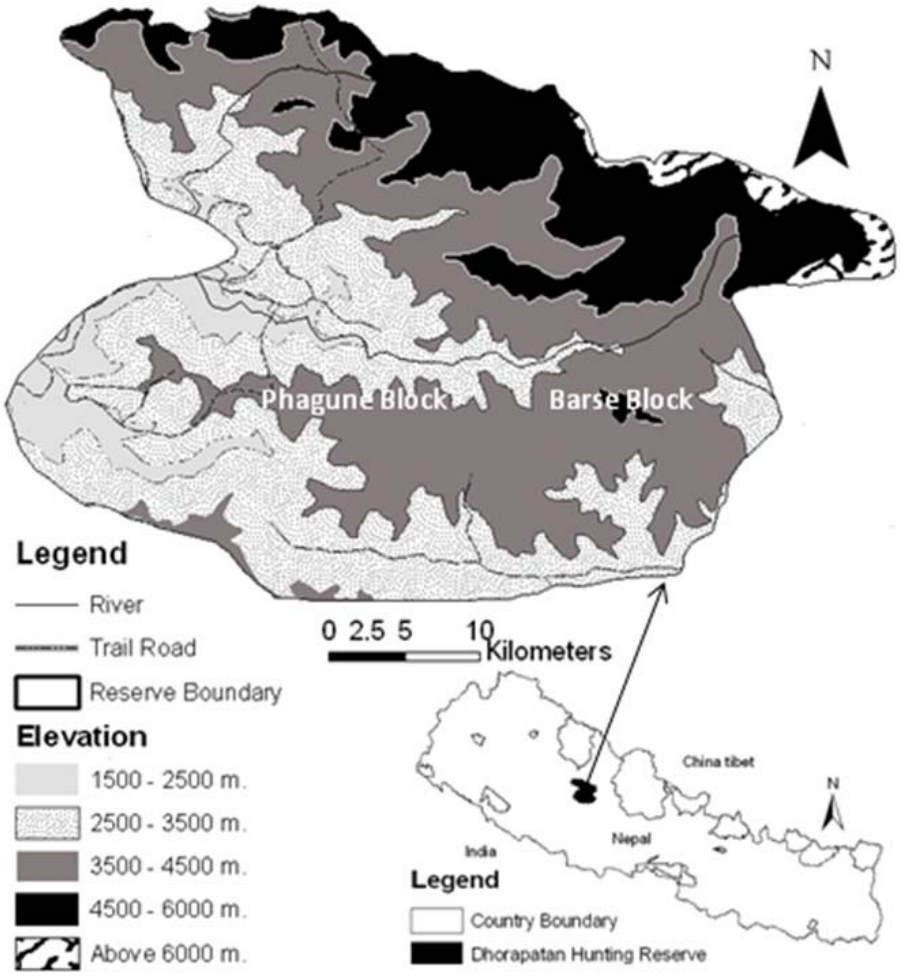

Figure 1. Study area (with Phagune and Barse blocks)

upstream along Pelma and 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 and back down along Uttar Ganga.

Barse: Along the eastern part of Phagune block, 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 (Wegge 1979).

Climate: The reserve is located in front of a moderately high saddle connecting the high Dhaulagiri and Hiuchuli. It is also shielded by several lekhs (high altitude grassland) South of Uttar Ganga. The sheep area therefore receives less precipitation than others areas of the Nepal midlands (Stainton 1972). Wegge (1976) extrapolates the annual precipitation to somewhat less than 1000m.

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 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*. The Leopard 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*, Red Fox *Vulpes vulpes*, Wolf *Canis lupus* and Snow Leopard *Uncia uncia* 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).

Common Leopard scat survey: Sign (scats, pugmarks, scraping and scent spray) surveys were carried out in the study area to distinguish different predators' scats and to estimate scat density. The signs of different predator species were identified on basis of their size, colour, pugmarks and other features (Table 1). Wild Dog and Lynx scats were avoided because herders and livestock were downhill, and we did not find evidence of Lynx or Wild Dogs in the Barse and Phagune blocks. Furthermore, it was assumed that scats found above 4500m in altitude were left by Snow Leopards and/or Wolves. Common Leopard scats were collected below 4500m. All together, 147 Common Leopard scats were collected from the field for diet analysis. The survey covered 265km^2 of Barse and Phagune block of study area.

Scat collection and analysis methods: Eighty-one existing human and livestock trails, each 1.5km in length, were used as transect lines for the collection of the faecal material of various predators. A total of 121km was sampled with the highest elevation reached being 4,500m. Following scats collection, a standard micro-histological method was used to identify prey species through the hair samples found in the Common Leopard scat. Species identification was accomplished by comparing the hairs

Table 1. The distinguishing characteristics of different predator signs that were used to confirm the presence of various species

Feature	Common Leopard	Snow Leopard	Wolf	Red Fox	Civet
Scats	(i) Scats are deposited alone or in association with other signs.	(i) Scats are deposited alone or in association with other signs.	(i) Canid scats tend to be long with tapered ends, compared to felid scats.	(i) Scats are smaller in size, long and final tips pointed.	(i) Civet scats are smaller than red fox scats in both size and quantity
	(ii) Single scraping.	(ii) Scats are short and segmented.	(ii) Scats are deposited in a group.	(ii) Scats are found on grasses and fruit material.	
			(iii) Wolves tend to make scratches rather than scrapes.		
Scrapes	(i) Scrapes can be oriented to trail in any manner and can be found either on or next to the trail.	(i) Scrapes are oriented parallel to and beside the trail.			
	(ii) Scrapes are clustered linearly as long strings.	(ii) Scrapes are clustered circular in a tight group.			
	(iii) Re-scraping is uncommon.	(iii) Re-scraping of the same scrape or cluster of scrapes is very common.			
	(iv) Scrape clusters appear ephemeral rather than sculptured.	(iv) Scrape clusters acquire a sculptured appearance.			
	(v) A small pile of soil found behind the scrape depression.	(v) A large pile of soil found behind the scrape depression.			
	(vi) Toe or claw indentations are frequently found in scrape depressions.	(vi) Toe or claw indentations are rarely found in the scrape depression Pugmarks are rarely found at the front of the scrape depression.			
	(vii) Scrapes appear to be hastily made.	(vii) Scrapes appear to have been made with care.			
	(viii) Scrapes are longer, narrower, and more linear in shape.	(viii) Scrapes are broader, shorter, and more heart shaped.			
	(ix) Scrape depressions are shallow	(ix) The scrape depressions are deeper than the scrape of the Common Leopard.			
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	< 4500m	Generally scats found above 4000m - 4500m. It is assumed that scats found above 4500m are of Snow Leopards.	> 3000m	2500m-4000m.	

Source: Jackson & Hunter 1996

from the faecal samples to reference hair samples for each of the potential prey species in the area. Specifically, the surface scale patterns of the guard hairs were compared. Scats of different predators were identified based on size, colour, location, local knowledge and microscopic structure of the medulla and cuticle structure of the hairs.

Scat samples were prepared according to the methods described by Mukherjee et al. (1994). The hair samples were first washed in hot water and then thoroughly air dried. They were subsequently cleared in ether for one hour to remove wax deposits and any remaining moisture. Finally, the hairs were passed through Xylol for 24 hours and mounted on permanent slides with DPX to allow for the analysis of the medulla structure of the hairs. A gelatine solution was used to prepare slides for the analysis of the cuticle structure of hairs and cuticle scales were observed using impression techniques. The slides were observed under a light microscope (400x) and digital photos were taken so that the cuticle and medulla patterns could be observed. The main emphasis was placed on blue sheep hair so that the predators of this species could be identified. At least 20 hair samples were taken from each faecal sample for analysis and to allow for the detection of multiple prey species (Mukherjee et al. 1994). The prey residue composition of the predator scats was extrapolated in terms of the prey frequency of occurrence in the scat samples (Fi), calculated by equation-I (Pikunov & Korkishko 1992; Karanth & Sunquist 1995; Mizutani 1999; Ramakrishan et at. 1999).

$$Fi = (ni/N)100 \qquad \text{equation (I)}$$

Where ni is the number of scats where a given ith prey species residue occurs and N is the total number of all scat

Table 2. Occurrences of prey species (based on hair and other food) in Common Leopard scat (n-147)

Prey species	Frequency	%
Barking Deer	521	17.72
Wild Boar	430	14.63
Pika	287	9.76
Other food item including vegetation, soil & stones	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

samples.

Results

Dietary composition of Common Leopard: The frequency of occurrence of different prey species in the scat of common leopards in this region of Nepal is found in Table 2. There was no significant difference between the frequency of occurrence of different prey species and there was a positive correlation between each prey species and the Common Leopard diet ($\chi 2 = 0.889$, df = 16, $p > 0.05$; $R^2 = 0.84$). Barking Deer was the most frequently occurring species (18%) while only 6% of their diet consisted of Blue Sheep. The Common Leopards in this region also consumed Wild Boar, Himalayan Serow, Pika (*Ochotona roylei*), Musk Deer, and livestock, which made up approximately 4% of the collected faecal material (Table 2). Other food items, such as vegetation, soil, and stones, made up 9% of the total diet composition.

Discussion

Wegge (1976) originally reported Snow Leopards as a possible permanent resident in the northern reaches of the DHR (Wegge 1979; Wilson 1981). Local people reported that within the last 4 years snow leopards have been frequently visiting the northern part of the DHR, i.e. the Barse (Mansun area and northeastern site of Barse Duri), Gustung, Seng and Dhogadi blocks. These cats also visit the border of that lies between the Phagune and Barse blocks, which has been confirmed by both old (>5 week) and fresh Snow Leopard scats found in this area. We were able to collect very low number of Snow Leopard scats in Mansun area and in Barse Duri. It is confirmed that snow leopards are not permanent residents in the Barse and Phagune blocks of DHR. However, there may be permanent snow leopard residents in the Gustung, Seng, and Dhogadi blocks of DHR but detailed studies should be carried out to confirm this. Common Leopards frequently visited areas up to 4500m altitude. Therefore, it there may be food competition between Common Leopards, Snow Leopards and Wolves, which also inhabit these areas of high altitude.

It is evident that small mammals are very important in the Common Leopard diet as this study shows that about 10% of the diet of these Common Leopards consisted of Pika and 16% consisted of Wild Boars. Smaller mammals are an important component of predator diets (Zhirjakov 1990) and even more so when it's major or preferred prey is not readily available. The summer scats of Common Leopards mainly consisted of barking deer. 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 the predator's major prey species is not readily available. In such a situation, alternate prey, in the form of smaller animals (e.g. Pika and Wild Boars), become a very important component in the Common Leopard's diet. This is obvious from Common Leopard food habitat, in the summer the Barking Deer was the major prey species of Common Leopards. However, Barking Deer move to dense forest area and may form groups as an anti-predatory strategy. Pikas, which were abundant during the summer, then become the major prey species for various predators in the DHR. This dietary shift during the summer considerably reduces predation pressure on the other prey species. Another possible explanation for the increase in small mammal population was the decreasing the population of Wolves, which was assumed to be the major predator of these mammals. Therefore, the predation strategy of the Common Leopards shifts towards smaller mammals in the DHR.

Six percent of the Common Leopards' diet consisted of Blue Sheep. It thus seems that Common Leopards occasionally kill Blue Sheep during summer. In the 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 of greater importance. The predation on smaller animals, especially Pika and Wild Boar, were so heavy that they were exterminated from some sites of Barse and Phagune blocks. Snow Leopards, Wolves, Common Leopards and Red Foxes are competitors and depend on almost the same type of prey species in the DHR. Therefore, the DHR management has to consider managing these species more scientifically and at the same time the Blue Sheep hunting quota should be determined through the scientific evaluation. The abundance and availability of alternate prey species will help maintain the Blue Sheep population on a sustainable basis.

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