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# Diet selection of snow leopard (*Panthera uncia*) in Chitral, Pakistan

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**Abstract:** Snow leopard (*Panthera uncia*) is an elusive endangered carnivore found in remote mountain regions of Central Asia, with sparse distribution in northern Pakistan, including Chitral and Baltistan. The present study determined the food habits of snow leopard, including preferred prey species and seasonal variation in diet. Fifty-six scat samples were collected and analyzed to determine the diet composition in two different seasons, i.e. summer and winter. Hair characteristics such as cuticular scale patterns and medullary structure were used to identify the prey. This evidence was further substantiated from the remains of bones, claws, feathers, and other undigested remains found in the scats. A total of 17 prey species were identified; 5 of them were large mammals, 6 were mesomammals, and the remaining 6 were small mammals. The occurrence of wild ungulates (10.4%) in the diet was low, while livestock constituted a substantial part (26.4%) of the diet, which was higher in summer and lower in winter. Mesomammals altogether comprised 33.4% of the diet, with palm civet (*Paguma larvata*) as a dominant (16.8%) species, followed by golden marmot (*Marmota caudate*) (8.8%), which was higher in winter. There was a significant difference in seasonal variation in domestic livestock and small mammals. The livestock contribution of 26.4% observed in the present study indicates a significant dependence of the population on livestock and suggests that the study area is expected to be a high-conflict area for snow leopards. The results of the current study would help improve the conservation efforts for snow leopards, contributing to conflict resolution and effective management of this endangered cat.

**Key words:** Snow leopard, conservation, seasonal variation, diet composition, Chitral, Pakistan

## 1. Introduction

The snow leopard is categorized as endangered in the 2009 IUCN Red List (IUCN, 2009). In Chitral Gol National Park, the status of snow leopard had changed from Tenuous Security to Seriously Threatened by 1974 as a result of hunting (Schaller, 1976). According to Ahmed (1994), the snow leopard faces problems of survival caused by the fur trade, conflicts with grazer communities, and the reduction of natural prey.

Snow leopard inhabits high mountainous regions of Central and South Asia. Generally, it is found at altitudes ranging from 3000 m to 4000 m. However, it may descend to as low as 1500 m during winter (Schaller, 1977).

In Pakistan, the snow leopard has a wide distribution in the northern mountainous region. It occurs sparsely in the northern Chitral, Dir, Swat, and Kohistan districts of Khyber-Pakhtunkhwa; the Gilgit-Baltistan districts of the Northern Areas (NA); and the Muzaffarabad district in Azad Jammu and Kashmir (Ahmad, 1994).

The total estimated wild population of the snow leopard is between 4500 and 7500 individuals in the world (Jackson et al., 2010). The number of snow leopards in Pakistan has been estimated to be 200–300 (Snow Leopard Network, 2014), while the total estimated population of snow leopard in Chitral was reported by Schellar (1977) as fewer than 250 individuals.

Snow leopard has a critical role in the ecosystem and serves as an indicator species for Asia's high mountain ecosystems, as it resides at the top of the food chain, requires large home ranges, moves over vast areas, and flourishes under pristine conditions. It is also a flagship species around which people rally in support of far-reaching conservation initiatives. By protecting snow leopards, one also protects the habitat for a host of other plant and animal species. Where the snow leopard occurs in good numbers, the environment is considered to be more productive and healthy. Snow leopards keep other species' numbers down and also improve their own genes with survival adaptations (Jackson and Hunter, 1996).

An adult snow leopard requires approximately 3000–4000 kcal per kilgram of its body weight per day as determined by the mass–energy equation developed by Kleiber (1975). In a similar study, Emmons (1987) reported this requirement to be 40–45 g of food per

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kilogram of body weight per day. Jackson and Ahlborn (1984) calculated the daily requirement for snow leopard as approximately 1.5 to 2.5 kg of meat. The snow leopard is an opportunistic predator capable of killing prey up to three times its own body weight.

Its main prey are blue sheep (*Pseudois nayaur*), Asiatic ibex (*Capra ibex sibirica*), argali (*Ovis ammon*), other domestic stock like sheep and goats, marmots (*Marmota* spp.), pikas (*Ochotona* spp.), hares (*Lepus* spp.), small rodents, and game birds such as snowcocks (*Tetraogallus himalayensis*) and chukar partridge (*Alectoris chukar*) (Jackson et al., 2008).

Knowledge of a predator's diet is very important in understanding its ecology, and for predicting its influence on the dynamics of prey populations. The food habits of mammalian predators are difficult to analyze because of the problems faced by researchers in observing the feeding behavior of solitary and elusive species like the snow leopard (Oli et al., 1993). A common problem in fecal analysis of mammalian predators is that the more obvious characteristics of the prey consumed are lost in the processes of mastication and digestion. Therefore, hard parts in the prey remains, such as bones, teeth, and hairs, are usually considered for study. Large bones and teeth are generally fragmented and are of little importance, but the hair suffers little in the process of digestion and retains many identifiable features. Thus, the identification of remains, in particular hairs, has been reliably used in the dietary studies of a wide range of mammalian carnivores (Oli, 1991).

The present study indicates the dependence of snow leopard on wild prey versus domestic livestock as its food. This study also estimates the livestock loss trend in the study area, due to which conflict arises between humans and snow leopards. As food selection varies according to the environment and availability of prey species, a diet study in the local context helps to improve the understanding of feeding ecology and also provides a scientific basis for effective conservation measures.

## 2. Materials and methods

### 2.1. Study area

The present study was conducted on scat samples collected from the Chitral area (35°51′N, 71°50′E), the northernmost district of Khyber Pakhtunkhwa (KPK) Province, as shown in Figure 1. The area spreads over 14,850 $km^2$ (http://www.pmd.gov.pk/). Potentially important habitats of snow leopard in Chitral were surveyed for scat collections. The survey areas included Zewar Gol, Chitral Gol National Park, Tooshi Game Reserve, and Girat Gol. The climate of Chitral is distinctly continental. It is hot in summer, ranging from very hot in the lowlands to warm in the uplands and cool at the higher elevations (Aga Khan Education Service, 2008).

Chitral is a land of three precipitous mountain ranges: the Hindukush, with towering Terichmir (7700 m) in the west; Hindu Raj to the east, with numerous peaks over 6096 m; and the Karakorum range, crossed by the famous Shandur Pass at 3725 m. Since Chitral is surrounded by mountains, it does not receive monsoon rains. Average

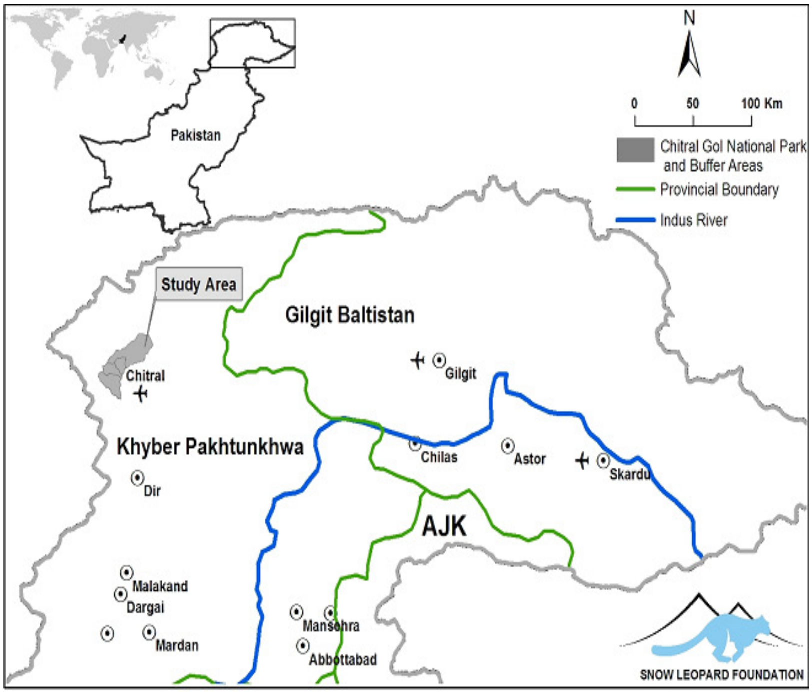


**Figure 1**. Location of study area in Chitral District, Pakistan.

rainfall in the year 2009 was recorded as approximately 650 mm. Summer and autumn are dry, with the area receiving barely 10–25 mm of rain per month. Chitral's flora is similar to that of Central Asia and comprises forest types like moist alpine pastures (*Astragalus*, *Corydalis*, *Oxytropis*, *Polygonum*, *Potentilla*, *Primula*, *Saxifraga*), subalpine birch (birch, willow, juniper), moist deciduous alpine scrub (birch, honeysuckle, juniper, wild rose, *Berberis*, *Ephedra*), dry temperate coniferous scrub (*Artemisia*, *Delphinium*, *Fraxinus xanthoxyloides*, *Haloxylon*, *Hyoscyamus niger*, *Rheum*, *Tamararix*), and dry oak (*Artemisia*, *Caragana*, *Capparis*, *Cotoneaster*, *Cymbopogon*, *Daphne*, *Ephedra*, *Heteropogon*, *Lonicera*, *Periploca*, *Plectranthus*, *Rumex*, *Sophora*, and *Spiraea*).

**2.2. Scat sampling**

A total of 56 snow leopard scats were collected whenever found from the various study areas (Zewar Gol, Chitral Gol National Park, Tooshi Game Reserve, and Girat Gol) from January 2008 to December 2009.

Scats were collected by an experienced team from the Snow Leopard Foundation of Pakistan. The samples were divided into two seasons, summer and winter. Summer samples were collected in April–August, while winter samples were collected from September through December. These scats were collected by using the guidelines defined by Jackson and Hunter (1996) that maximize the likelihood of them in fact coming from snow leopard (e.g., close association with one or more scrapes or fresh pugmarks; placement in steep terrain, especially at the base of a cliff or along its crest or at a known hill). Major travel routes and marking sites of snow leopard in the study area were particularly targeted in surveys in order to collect only fresh snow leopard scats.

**2.2.1. Storage and handling of samples**

Initially, samples were sun-dried and stored in polythene bags until further analysis. The scat was then washed with tap water in a fine cotton cloth. Each sample was further cleaned with 3 mL of carbon tetrachloride and dried between absorbent papers for detailed examination. For making slides, hairs were randomly selected from each of the scats for examination of the cuticle scale patterns. The remaining samples were kept in case more hairs were required later.

**2.2.2. Reference collection**

Reference hair samples were collected from both wild (markhor, ibex, marmot, pika, etc.) and domestic (sheep and goat) mammals that are known to occur in and around the study area. Hairs were collected in complete tufts from different body parts, which included a representative sample of all hair types. Hairs of some species, particularly of small mammals, were provided by the Pakistan Museum of Natural History, Islamabad (PMNH). A photographic reference key was developed for all potential prey species inhabiting the area, which was used to identify the prey species recovered in scats of snow leopard, as shown in Figures 2–4.

**2.3. Scat analysis**

Scat analysis using a hair-mounting technique is commonly used to determine diet in a wide variety of carnivore species (Joslin, 1973; Floyd et al., 1978; Johnsingh, 1983; Ackerman et al., 1984; Reynolds and Aebischer, 1991). The procedure is described below.

**2.3.1. Segregation of scat samples**

The scats were placed in a warm, dry place so that they could dry as quickly as possible. These samples were washed by using slightly warm water in order to dissolve the mucus. After washing, the sample was dried by placing it on blotting paper and then all the remains, such as hairs, bones, nails, feathers, and dentitions, were segregated by using forceps. From the undigested remains in the scats, hairs were used for making slides, which were then used as a key for identification.

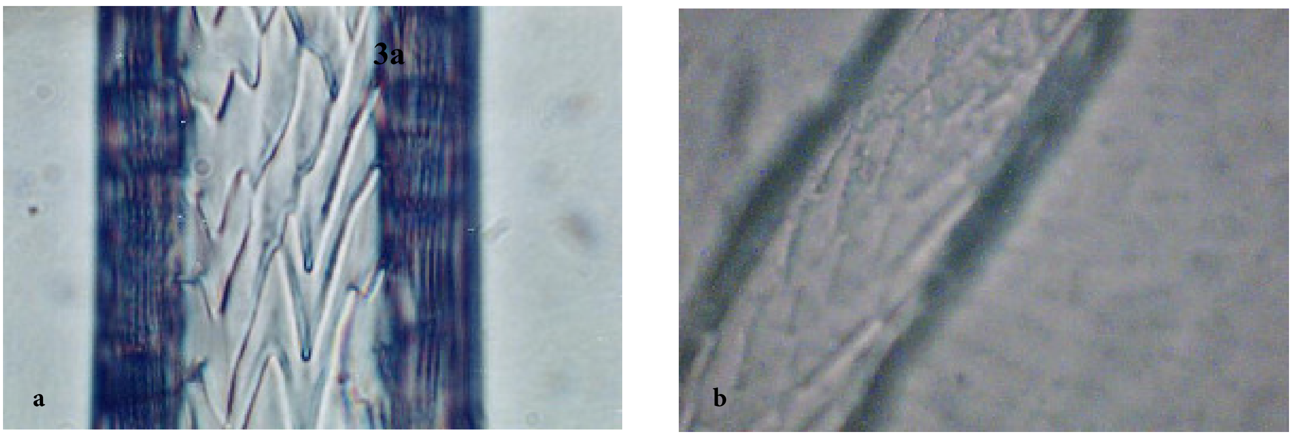


**Figure 2.** Microphotographs of hair scale pattern of Cape hare (*Lepus capensis*): a) reference hair (10 × 100×); b) hair found in scat sample (10 × 100×).

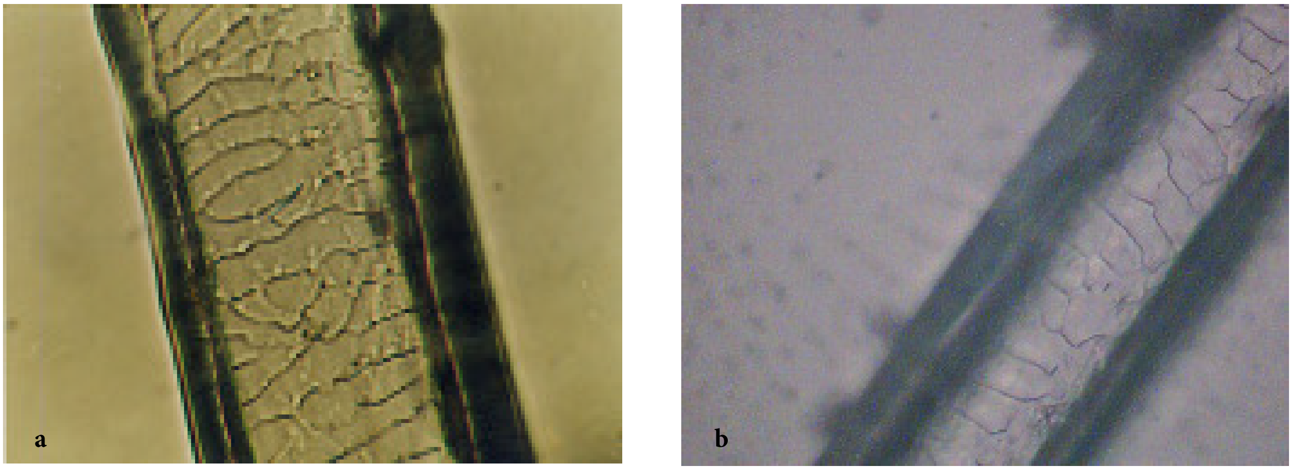


**Figure 3.** Microphotographs of hair scale pattern of markhor (*Capra falconeri*): a) reference hair (10 × 40×); b) hair found in scat sample (10 × 40×).

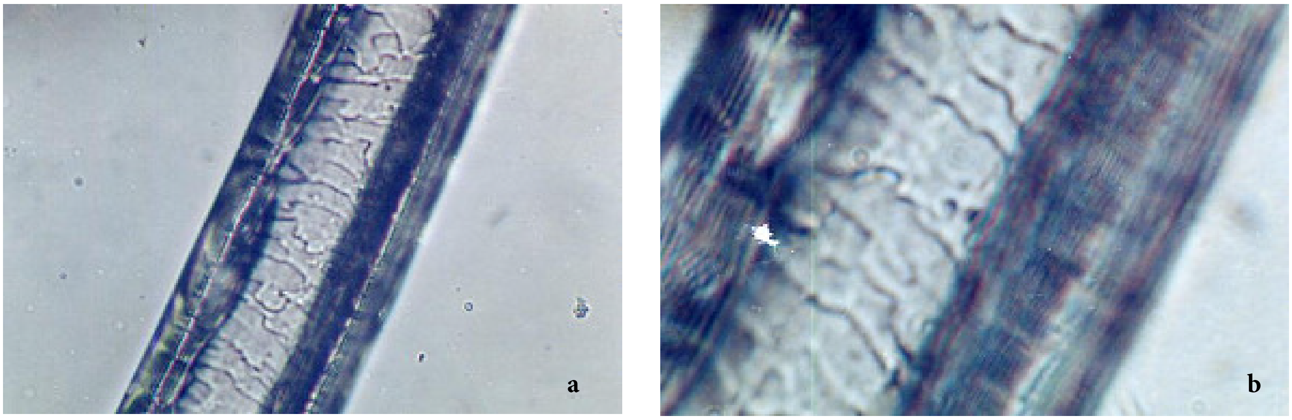


**Figure 4.** Microphotographs of hair scale pattern of palm civet (*Paguma larvata*): a) reference hair (10 × 100×); b) hair found in scat sample (10 × 100×).

Hair remains of prey were used for species identification following the methodology described by Mukherjee et al. (1994). Food items were identified mainly from the macro- and microscopic structure of hairs. For this purpose, cuticular scale patterns of hairs and medullary structure were used to identify the prey (Joslin, 1973). This evidence was further substantiated from the remains of bones, claws, hooves, feathers, and other undigested remains found in the scats.

### 2.3.2. Whole mount of hairs

A tuft of hairs cleaned in carbon tetrachloride was placed on a clean microscope slide. Individual hairs were separated from each other to avoid an untidy jumble of hairs on the slide. Long hairs were cut into 2 or more pieces before they were placed on the glass slide. Distyrene plasticizer xylene (DPX) was used as the mounting medium for preparing permanent reference slides.

### 2.3.3. Scale replication of hairs

The medium used for making semipermanent casts of cuticular scales of mammal hair was a 3% solution of glycerin jelly, which is a gel when cool and fluid when warm. Glycerin (3 mL) was mixed with 94 mL of warm water and 3 g of gelatin was added. After stirring, 0.1 g of carbolic acid was added as a preservative. Repeated heating of the gel or heating at too high a temperature may prevent the medium from jelling; heating the jar with the medium in a pan of water prevents overheating. The medium was stored in a refrigerator. Two to three drops of medium were placed on a glass slide and spread using another slide. Clean hair was then placed vertically to the long axis of the slide, with one end of the hair projecting over the edge of the slide so it could be easily grasped for removal.

The slide was then allowed to set for some time, until the medium had become fairly solid. Using forceps, the hair was removed from the solution when it had stuck to the solution so that the cast appeared under the microscope, which was almost an exact duplicate of the scales of the hair.

**2.3.4. Analysis of reference material**

Reference hairs were provided by the Pakistan Museum of Natural History. These hairs were taken from different parts of the body of the animal, i.e. from the belly, neck, and tail regions. The hairs were selected randomly and then reference slides were made by following the procedures for whole mount and scale replication (see Sections 2.3.2 and 2.3.3). These slides were then stored in a refrigerator. A photographic reference key was developed from these, as shown in Figures 2–4.

**2.4. Microphotography**

**2.4.1. Photography**

Before being photographed, the slides were thoroughly cleaned with tissue paper. The photographic film was exposed with a 35-mm camera fitted with automatic film advance onto an Olympus BH-12 microscope with an automatic exposure system with built-in microcomputer. Each slide was exposed to 100× and 40× objectives with an eyepiece with 3.3× magnification. A photographic reference key of 19 species was developed for identification (Figures 2–4).

**2.4.2. Magnification calculation**

**2.4.2.1. Magnification of the negative**

Following the Olympus photomicrographic system instruction manual, the magnification of the negative was calculated as follows:

Magnification = objective magnification × photo eyepiece magnification.

As the photographic films were exposed under both 100× objective and 40× objective and the photo eye piece was 3.3×, the magnifications of the negatives were as follows:

Magnification of negative at 100× objective = 100 × 3.3 = 330×.

Magnification of negative at 40× objective = 40 × 3.3 = 132×.

**2.4.2.2. Magnification of the positive**

Hair slides with the best cuticular scale patterns were developed at the two different magnifications. Enlargement of the 36-mm negative at which positives were developed was found to be 30 cm (300 mm).

The magnification of the positive was calculated as:

Length of the negative = 36 mm. Enlargement of the negative at which positive was developed = 300 mm.

Magnification factor of the positive = 300/36 = 8.33.

**2.4.2.3. Total magnification**

Total magnification of the positive at 100× objective = magnification of the negative × magnification factor of the positive = 330 × 8.33 = 2739×.

Total magnification of the positive at 40× objective = magnification of the negative × magnification factor of the positive = 132 × 8.33 = 1095×.

**2.5. Identification**

Prey species were identified by comparing the cuticular scale pattern of hairs recovered in scats with the photographic reference key. Scale patterns were often confusing, as they varied considerably along the length of hair and overlapped between species, but there is no doubt that the study of hair in fecal remains is the most useful aid in the identification of mammalian prey consumed. The most important feature in hair identification was the shape and arrangement of cuticular scales in the hair, which were compared with the reference key (Figures 2–4). Prey items in the scats were identified after a detailed analysis of hair, including scale pattern, with the photographic key. The food items identified in the scats were pooled into 3 main categories: large mammals, including ungulates; mesomammals (marmot, hare, civet); and small mammals, including rodents (Table 1). Assumed weights of domestic sheep, goat, marmot, pika, and yak were taken from Chundawat and Rawat (1994), while weights of other species including ibex, markhor, and other small animals were taken from Roberts (1997) and Anwar (2008). The biomass consumption was estimated by using the linear relationship developed by Ackerman et al. (1984). This equation is as follows:

$Y = 1.98 + 0.035X$;

where Y = weight of prey consumed per scat, and X = average body weight of the prey.

Another aspect of identification in this study was based on the bones, nails, and dentition recovered from scat remains.

**2.6. Statistical analysis**

**2.6.1. Chi-square test ($\chi^2$)**

A chi-square test was carried out to test the null hypothesis that the snow leopard prefers similar prey species in both summer and winter.

**3. Results**

**3.1. Diet composition**

In the present study, 125 prey items (17 species) were identified. Single prey species constituted 21% of the scats, while 79% of the scats had remains of more than one prey species. The present study indicated that the snow leopard had a varied diet, and domestic animals formed a significant part of it.

A total of 17 species were identified; 5 of them were large mammals, 6 were mesomammals, and the remaining 6 were small mammals (Table 1). The occurrence of wild ungulates in the diet was only 7.2% (2.4% ibex and 4.8% markhor). Livestock constituted a substantial part (26.4%)

**Table 1.** Composition (%) of the snow leopard's diet in Chitral, Pakistan (n = 56).

| Prey Item | Scientific names | Frequency | % Occurrence |
|---|---|---|---|
| LARGE MAMMALS | | | |
| Domestic sheep | *Ovis aries* | 15 | 12 |
| Domestic goat | *Capra hircus domesticus* | 11 | 8.8 |
| Ibex | *Capra ibex sibirica* | 6 | 2.4 |
| Yak | *Bos grumniens* | 3 | 5.6 |
| Markhor | *Capra falconeri* | 7 | 4.8 |
| MESOMAMMALS | | | |
| Marmot | *Marmota caudate* | 11 | 8.8 |
| Palm civet | *Paguma larvata* | 21 | 16.8 |
| Common red fox | *Vulpes vulpes* | 3 | 2.4 |
| Cape hare | *Lepus capensis* | 5 | 4 |
| Flying squirrel | *Eupetaurus cinereus* | 2 | 1.6 |
| Monkey | *Macaca mulatta* | 3 | 2.4 |
| SMALL MAMMALS | | | |
| Pika | *Ochotona roylei* | 4 | 3.2 |
| House mouse | *Mus musculus* | 3 | 2.4 |
| Wood mouse | *Apodemus rusiges* | 6 | 4.8 |
| Hamster | *Cricetulus migratorius* | 9 | 7.2 |
| Turkistan rat | *Rattus turkistanicus* | 3 | 2.4 |
| Mountain vole | *Alticola roylei* | 2 | 1.6 |
| Unidentified | | 11 | 8.8 |
| Total | | 125 | |

of the diet. Among livestock, domestic sheep dominated over domestic goat. Mesomammals altogether constituted 33.4% of the diet, with palm civet (*Paguma larvata*) as the dominant (16.8%) species, followed by golden marmot (*Marmota caudata*) (8.8%).

Similarly, small mammals, i.e. rodents (house mouse, wood mouse, Turkistan rat, and mountain vole), constituted 28.8% of the diet, and among this group hamster (*Cricetulus migratorius*) dominated over other species (7.2%); 8.8% of the scats remained unidentified in the diet of the snow leopard (Table 1).

### 3.2. Biomass consumption

In terms of biomass consumed, livestock dominated by contributing 32.9%. Wild ungulates constituted 17.5%, mesomammals 28.1%, and small mammals 13%. Among mesomammals, palm civet had the greatest contribution (12.9%), and hamster was the dominant contributor among small mammals (Table 2).

### 3.3. Seasonal variation

Frequency of occurrence of domestic livestock in the diet of snow leopard was higher in summer compared to winter. The frequency of wild ungulates was also higher in summer than in winter.

Among wild prey species, civet (*Paguma larvata*) was the most frequently occurring item in both seasons, but its frequency was greater in summer compared to winter, while marmot was ranked second; it accounted for 16.2% in winter and 24% in summer (Figure 5). Ibex was more frequently eaten in winter than in summer, while markhor was eaten more frequently in summer than in winter.

Similarly, mesomammals were higher in winter and lower in summer, while rodents (house mouse, wood mouse, Turkistan rat, and mountain vole) varied significantly in both seasons ($\chi^2 = 13.9$, $P < 0.05$, df = 5), as shown in Table 3.

**Table 2.** Calculation of biomass consumption (kg) by snow leopard in Chitral, Pakistan.

| Prey species | Assumed weight (A) | Biomass per scat (B) | No. of scats (C) | Biomass consumed (D) | Percentage (%) biomass consumption (E) |
|---|---|---|---|---|---|
| Domestic sheep | 30 | 3.03 | 15 | 45.4 | 13 |
| Domestic goat | 25 | 2.89 | 11 | 31.7 | 9.3 |
| Ibex | 70 | 4.4 | 6 | 26.4 | 7.7 |
| Yak | 300 | 12.5 | 3 | 37.5 | 11 |
| Markhor | 80 | 4.8 | 7 | 33.6 | 9.8 |
| Marmot | 4.5 | 2.2 | 11 | 24.2 | 7 |
| Palm civet | 3.6 | 2.1 | 21 | 44.1 | 12.9 |
| Common red fox | 3.8 | 2.1 | 3 | 6.3 | 1.9 |
| Cape hare | 3.5 | 2.1 | 5 | 10.5 | 3 |
| Flying squirrel | 1.7 | 2 | 2 | 4 | 1.2 |
| Monkey | 10.9 | 2.3 | 3 | 6.9 | 2.1 |
| Pika | 0.007 | 2 | 4 | 8 | 2.4 |
| Rodents | 0.02 | 2 | 23 | 46 | 13 |

A = Assumed weight (kg) of the prey species.
B = Estimated weight of prey consumed per scat (B = 1.98 + 0.035 × A) (Ackerman et al., 1984).
C = Number of scats in which prey species were identified.
D = Biomass consumed (B × C).
E = Percentage consumption (B × C/ S [B × C] × 100).

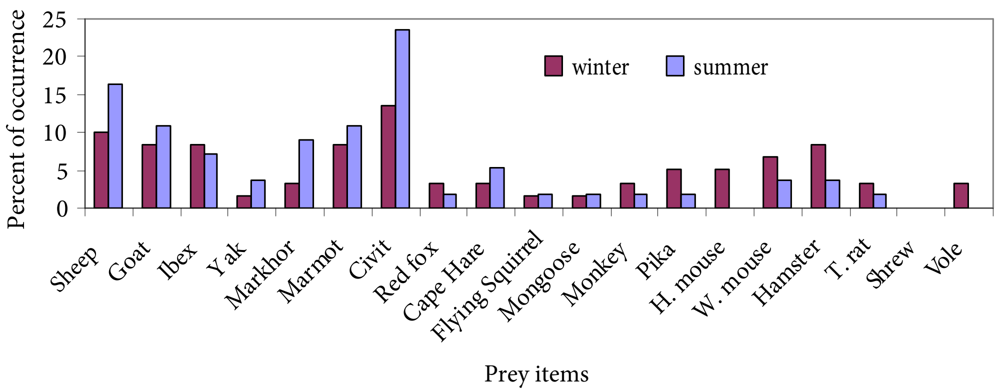


**Figure 5.** Seasonal variations in the diet of snow leopard (*Panthera uncia*). Squirrel.

### 3.4. Identification of bones

Bones were recovered from 44% of the scats, and categorized as being from rodents, lagomorphs, and ungulates. In the identified bones, rodents dominated (61%), followed by lagomorphs (20%). Bones of ungulates were rare, while other groups included birds (Table 4).

## 4. Discussion

Due to extensive hunting, the wild fauna of Pakistan has declined considerably. Decline in populations of prey species has a direct impact on the feeding habits of snow leopards, leading to predation on domestic livestock, resulting in increased conflicts between snow leopard and

**Table 3.** Statistical analysis of the seasonal variation in the diet of snow leopard.

| Group | Summer | Winter | $\chi^2$ | P-value |
|---|---|---|---|---|
| | % | % | | |
| Livestock | 30.86 | 20.1 | 5.7 | P < 0.05, df = 1 |
| Wild ungulates | 10.89 | 11.7 | 0.05 | P > 0.05, df = 1 |
| Mesomammals | 45.3 | 33.4 | 4.2 | P > 0.05, df = 5 |
| Small mammals | 10.8 | 31.86 | 13.9 | P < 0.05, df = 5 |

**Table 4.** Percentage of occurrence of bones in snow leopard scats in Chitral, Pakistan.

| Group of species | Frequency of occurrence | % of occurrence |
|---|---|---|
| Aves | 2 | 4.5 |
| Lagomarpha | 9 | 20 |
| Rodentia | 27 | 61 |
| Ungulata | 6 | 13 |
| Total | 44 | |

local people. Reliable information on diet is required to assess the magnitude of human–cat conflicts related to livestock predation. However, with the exception of one study undertaken in Gilgit-Baltistan (Anwar, 2008), no information on the food habits of the snow leopard exists in Pakistan. The current study attempted to explore the prey selection of snow leopard in Chitral and is expected to contribute to conflict resolution and effective management of this endangered cat.

Snow leopard is known to consume a wide range of prey species, from wild ungulates (ibex, markhor, blue sheep, argali sheep, etc.) to domestic livestock (sheep, goat, and yak) and small animals (rodents, marmot, civet, common red fox, etc.) (Jackson et al., 2008). Hence, it is known as an opportunistic predator that consumes any prey available (Chundawat and Rawat, 1984).

The current study in Chitral was compared with those from other parts of Asia, such as the Manang region of the Annupurna conservation area in Nepal (Oli, 1993), the Yashu and Shula Nanshan regions of Qinghai Province in China (Schaller et al., 1988), the Hemis region of Ladakh (Chundawat and Rawat, 1994), and the Spiti region in India (Bagchi and Mishra, 2006), as shown in Table 5.

Wild ungulates are considered primary prey for the snow leopard, and past studies have reported a substantial contribution of wild ungulates to the diet of the snow leopard. In the 10 studies summarized in Table 5, the average proportion of wild ungulates as prey is 43.4% in a particular environment. In the context of previous reports, the proportion of wild ungulates (10.4%) observed in the present study is very low, which is against expectations, because Chitral Gol National Park and the surrounding areas host a large population of markhor (1000 individuals) (KPK Wildlife Department, 2009).

A majority of Pakistan's protected areas where snow leopard exists have livestock-related conflicts (Din, 2005). Livestock predation is a major challenge for management and conservation of this species, and the magnitude of this issue depends on the availability of prey species in an environment.

The contribution of livestock in the snow leopard diet as reported in the 10 previous studies and shown in Table 5 is 28% on average (range: 2.4%–47.1%). The livestock contribution of 26.4% observed in the present study indicates a significant dependence of the population on livestock and suggests that the study area is expected to be a high-conflict area for snow leopards.

It is also important to note that livestock predation could be greater than calculated from fecal analysis, because snow leopards kill many more animals than they consume once they have entered a livestock enclosure. Jackson and Wangchuk (2004) reported that the most devastating livestock losses occurred after one or more leopards entered and killed all of the sheep and goats contained within an enclosure. They reported mass attacks by snow leopards in India, in which as many as 100 sheep

**Table 5.** Comparison of percentage of frequency of occurrence of different prey items in snow leopard *(Panthera uncia)* scats from Chitral, Pakistan against reports from other regions.

| Study sites | Wild ungulates | Domestic livestock | Meso-mammals | Small mammals | References |
|---|---|---|---|---|---|
| | % | % | % | % | |
| Yushu Qinghai, China (n = 46) | 70.9 | 47.1 | 89.8 | | Schaller et al., 1988 |
| Shule Nanshan, China (n = 91) | 44.4 | 2.4 | 46.1 | 2.4 | Schaller et al., 1988 |
| Zailisky-Alatan, USSR (n = 105) | 78.1 | | 11.9 | 1.8 | Zhiijakov, 1990 |
| Manang, Nepal (n = 213) | 51.6 | 17.9 | 20.7 | 23.5 | Oli et al., 1993 |
| Manang, Nepal (n = 213) | 49.74 | 34 | 13 | 2.65 | Oli, 1994 |
| Hemis Ladakh, India (n = 173) | 23.4 | 14.8 | 12.9 | 4.3 | Chundawat and Rawat, 1994 |
| Kibber, Spiti, India (n = 44) | 29.6 | 38.5 | 6.8 | | Bagchi and Mishra, 2006 |
| Pin Valley, Spiti, India (n = 51) | 56.9 | 23.6 | 3.9 | | |
| Himalya and Karakoram, Baltistan (n = 90) | 11.4 | 38.1 | 3.2 | 1.3 | Anwar, 2008 |
| Uttarakhand and Himachal Pradesh, India (n = 9) | 18.2 | 36 | | 18.2 | Maheswari and Sharma, 2010 |
| Chitral Gol National Park and adjacent areas (n = 56) | 10.4 | 26.4 | 33.6 | 28.8 | Present study |

and goats were killed in a single incident, but not all of the victims were consumed. A similar incident was reported in Chitral, in which 14 goats were killed by the snow leopard in a single attack (http://slf.org.pk/).

Although in the current study the occurrence of livestock was found in higher proportions of the scats, wild prey also made up a significant proportion of the diet of the snow leopard in Chitral compared to previous studies, i.e. in Manang, Nepal (Oli et al., 1993); Shule Nanshan, China (Schaller et al., 1988); Hemis Ladakh, India (Chundawat and Rawat, 1994); and Pin Valley, India (Bagchi and Mishra, 2006).

In the present study, rodents and mesomammals constituted 62% of the diet of the snow leopard, as shown in Table 5, which shows the relative importance of small animals in the diet of the snow leopard. Smaller animals play an important role as alternate prey in the diet of the snow leopard when its major prey is not readily available (Chundawat and Rawat, 1994).

Seasonal variation exists in the diet of the snow leopard. The proportion of wild prey species was higher in winter than in summer. This might be due to increased vulnerability of ungulates in winter.

Similarly, the occurrence of small mammals and livestock varies significantly in both seasons in the diet of the snow leopard (Table 3). The reason for higher occurrence of small rodents (31.86% in winter) might be due to the unavailability of marmots and reduced access to livestock during these months.

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## References

Ackerman BB, Lindzey FG, Hemker TP (1984). Cougar food habits in southern Utah. J Wildl Manage 48: 147-155.

Aga Khan Education Service (2008). Community Involvement: A Sustainable Approach to Quality Education in High Mountainous Areas. Karachi, Pakistan: Aga Khan Education Service, Pakistan Education Office.

Ahmed A (1994). Protection of snow leopards through grazier communities: some example from WWF-Pakistan's project in the Northern Areas. In: Fox JL, Jizeng D, editors. Proceedings of the Seventh International Snow Leopard Symposium. Seattle, WA, USA: International Snow Leopard Trust, pp. 265-272.

Anwar MB (2008). Food preferences of snow leopard (*Panthera uncia*) in Himalayas, Northern Pakistan. MPhil, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.

Bagchi S, Mishra C (2006). Living with large carnivores: predation on livestock by the snow leopard (*Panthera uncia*). J Zool London 268: 217-224.

Chundawat RS, Rawat GS (1994). Food habits of snow leopard in Ladakh, India. In: Fox JL, Jizeng D, editors. Proceedings of the Seventh International Snow Leopard Symposium. Seattle, WA, USA: International Snow Leopard Trust, pp. 127-132.

Din J (2005). Assessing the Status of Snow Leopard in Torkhow Valley, District Chitral, Pakistan. Final Technical Project Report. Seattle, WA, USA: Snow Leopard Trust.

Emmons L (1987). Comparative feeding ecology of felids in a neotropical rainforest. Behav Ecol Sociobiol 20: 271-283.

Floyd TJ, Mech LD, Jordan PA (1978). Relating wolf scat content to prey consumed. J Wildl Manage 42: 528-532.

IUCN (2009). Red List of Threatened Species. Gland, Switzerland: IUCN.

Jackson R, Ahlborn G (1984). A preliminary habitat suitability model for the snow leopard, *Panthera uncia*, in West Nepal. International Pedigree Book of Snow Leopards 4: 21-27.

Jackson R, Hunter DO (1996). Snow Leopard Survey and Conservation Handbook. Seattle, WA, USA: International Snow Leopard Trust.

Jackson R, Mallon D, McCarthy T, Chundaway RA, Habib B (2008). *Panthera uncia*. IUCN Red List of Threatened Species. Gland, Switzerland: IUCN.

Jackson R, Wangchuk R (2004). A community-based approach to mitigating livestock depredation by snow leopards (Sonoma, CA, USA: Snow Leopard Conservancy). Human Dimensions of Wildlife 9: 307-315.

Jackson RM, Mishra C, McCarthy TM, Ale SB (2010). Snow Leopards: Conflict and Conservation. In: Macdonald DW, Loveridge AJ, editors. Biology and Conservation of Wild Felids. Oxford, UK: Oxford University Press, pp. 417-430.

Johnsingh AJT (1983). Large mammalian prey–predator in Bandipur. J Bombay Nat Hist Soc 80: 1-53.

Joslin P (1973). The Asiatic lion: a study of ecology and behaviour. PhD, University of Edinburgh, Edinburgh, UK.

KPK Wildlife Department (2009). Distribution and Status of Wildlife in Khyber Pakhtunkhwa. Annual Report. Peshawar, Pakistan: KPK Wildlife Department.

Kleiber M (1975). An Introduction to Animal Energetics. Huntington, NY, USA: R. E. Kreiger Pub. Co.

Maheshwari A, Sharma D (2010). Snow Leopard Conservation in Uttarakhand and Himachal Pradesh. New Delhi, India: WWF India.

Mukherjee S, Goyal SP, Chelam R (1994). Standardisation of scat analysis techniques for leopard (*Panthera pardus*) in Gir National Park, Western India. Mammalia 58: 139-143.

Oli MK (1991). The ecology and conservation of the snow leopard (*Panthera uncia*) in the Annapurna conservation area, Nepal. MPhil, University of Edinburgh, Edinburgh, UK.

Oli MK, Taylor IR, Rogers ME (1993). Diet of the snow leopard (*Panthera uncia*) in the Annapurna conservation area. Nepal J Zool London 231: 365-370.

Reynolds JC Aebischer NJ (1991). Comparison and quantification of carnivore diet by faecal analysis: a critique, with recommendations based on a study of the fox *Vulpes vulpes*. Mammal Rev 21: 97-122.

Robert TJ (1997). The Mammals of Pakistan. Revised Edition. Oxford, UK: Oxford University Press.

Schaller G (1976). Mountain mammals in Pakistan. Oryx 13: 351-356.

Schaller GB (1977). Mountain Monarchs. Chicago, IL, USA: University of Chicago Press.

Schaller GB, Junrang R, Jiang MQ (1988). Status of the snow leopard *Panthera uncia* in Qinghai and Gansu Provinces, China. Biol Conserv 45: 179-190.

Snow Leopard Network (2014). Snow Leopard Survival Strategy. Revised 2014 Version. Seattle, WA, USA: Snow Leopard Network.

Zhiijakov VA (1990). The ecology of the snow leopard in the Zailisky-Alatau (northern Tien Shan). International Pedigree Book of Snow Leopards 6: 25-30.