

Full Length Research Paper

## Snow leopard (*Panthera uncia*) surveys in the Western Himalayas, India

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We conducted surveys above 3000 m elevation in eight protected areas of Uttarakhand and Himachal Pradesh. These surveys provide new information on snow leopard in Uttarakhand on the basis of indirect evidence such as pugmark and scat. Snow leopard evidence (n = 13) were found between 3190 and 4115 m elevation. On an average, scats (n = 09) of snow leopard were found for every 56 km walked and pugmarks (n = 04) for every 126 km walked. Altogether, about 39% of the evidence were found on the hill-slope followed by valley floor (30%), cliff (15%) and 8% from both stream bed and scree slope. Genetic analysis of the scats identified three different individuals by using snow leopard specific primers. Snow leopard-human conflicts were assessed through questionnaire based interviews of shepherds from Govind Pashu Vihar Wildlife Sanctuary, Askot Wildlife Sanctuary and Nanda Devi Biosphere Reserve areas of Uttarakhand. Surveys revealed that livestock depredation (mule, goat and sheep) is the only cause of snow leopard-human conflicts and contributed 36% of the diet of snow leopard. Blue sheep and rodents together comprised 36.4% of the total diet. We found that 68.1% of the surveyed area was used for pastoral activities in Uttarakhand and Himachal Pradesh and 12.3% area was under tourism, defence and developmental activities.

**Key words:** Conflict, Himalayas, livestock depredation, prey, snow leopard, habitat, Uttarakhand.

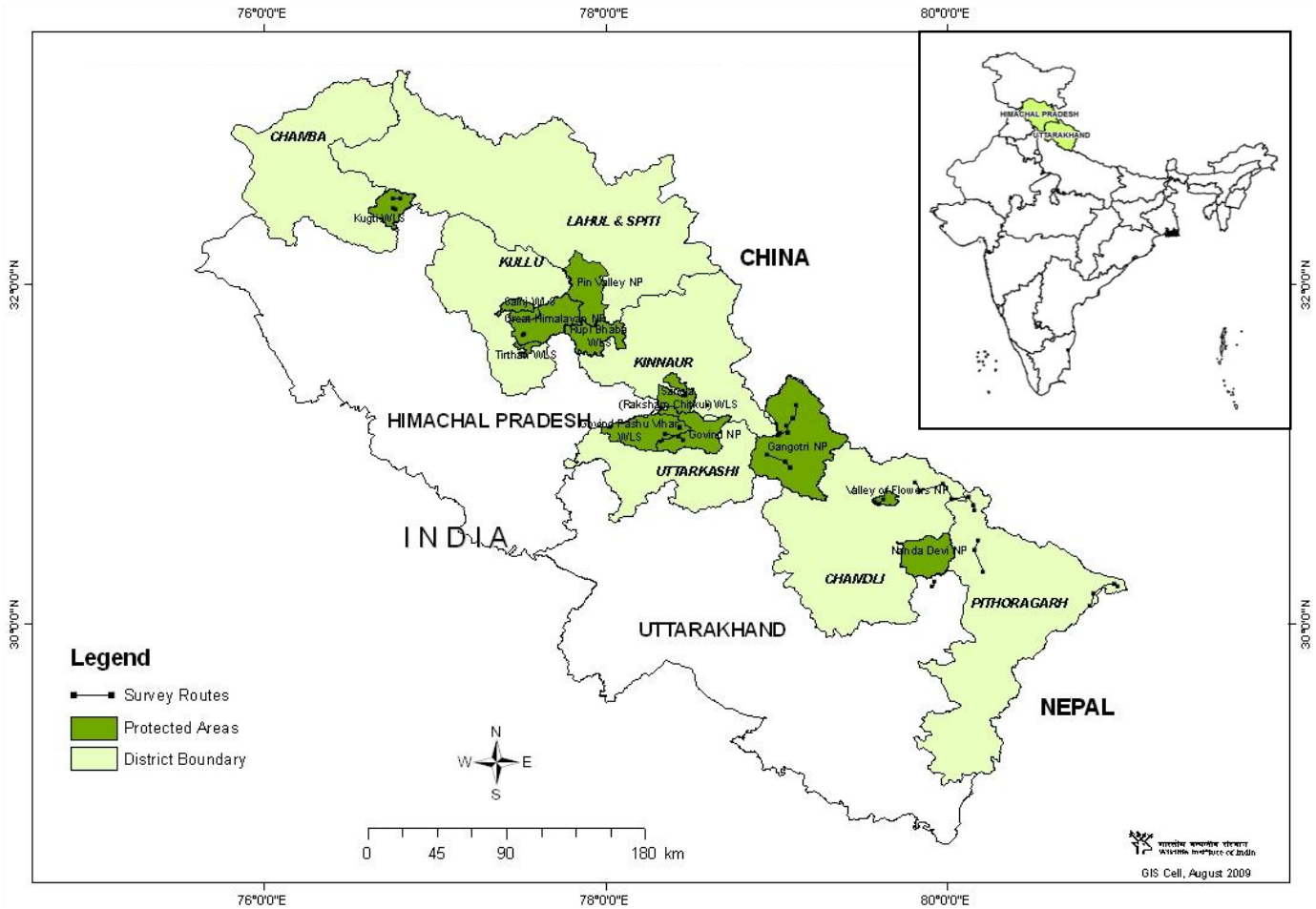
### INTRODUCTION

The snow leopard (*Panthera uncia*) is a large cat native to the mountain ranges of Central and Southern Asia. It is widely but scantily distributed over an area of 3.02 million km<sup>2</sup> (Hunter and Jackson, 1997) and highly threatened throughout its range. The total snow leopard population is estimated to be between 4,500 and 7,500 across 12 countries, viz., Afghanistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Nepal, Pakistan, Russia, Tajikistan and Uzbekistan (Fox, 1994; Jackson and Hunter, 1996).

Snow leopard serves as an indicator species for Asia's high mountain ecosystems. In India, the snow leopard has been identified by the Federal Government as a flagship species for the high altitude Himalayas and a

"Project Snow Leopard" has been launched (Anon, 2008) for the conservation of the snow leopard and its habitats.

Ecological studies on snow leopard have produced valuable information such as movement pattern, home range, behaviour and habitat use (Chundawat, 1992; Jackson and Hunter, 1996; McCarthy, 2000; McCarthy et al., 2010). Similarly, efforts have been made at community level to minimize snow leopard-human conflicts and threats to the habitat of snow leopard and associated species (Bhatnagar et al., 1999; Maheshwari et al. 2012; Mishra, 2000). These studies are on only a part of the snow leopard range. There are still some snow leopard range areas from where there is little or negligible information available on this elusive cat. Therefore, regions



**Figure 1.** Areas and routes of snow leopard habitats surveyed in Uttarakhand and Himachal Pradesh.

of Uttarakhand and Himachal Pradesh from where little information was available on snow leopard distribution and populations were selected for this survey.

Previous studies in the high altitude areas of Uttarakhand region of the western Himalaya include those on the mountain ungulates (Sathyakumar, 1993, 2004; Green 1985; Kandpal, 2010), Zoological Survey of India (1995) and Bhattacharya et al. (2007), on the causes of degradation and fragmentation of alpine habitats (Rawat, 2005; Kala and Rawat, 1999) and tourism and mountaineering in certain areas (Sathyakumar, 1993). Sub-alpine habitats have also undergone heavy degradation and fragmentation owing to anthropogenic activities such as collection of non-timber forest products, poaching, live-stock grazing and camping by the herders (Awasthi, 2001; Sathyakumar et al., 1993). In Himachal Pradesh, Lahaul-Spiti and Pangi Valley were studied for snow leopard and wildlife values by Bhatnagar (1996, 1997), Bhatnagar et al. (2002) and Saberwal (1996).

The surveys were designed to document the occurrence and distribution of snow leopard, conflicts with human and biotic pressures on snow leopard habitat.

### Study area

The surveys were conducted in the States of Uttarakhand and Himachal Pradesh based on information available on altitudinal range of snow leopard (3000 - 5000 m), availability of prey and continuity with the other similar snow leopard habitats. This survey covered four Protected Areas (PAs) and buffer zones of a Biosphere Reserve (BR) in Uttarakhand and three PAs in Himachal Pradesh. These PAs are Govind Pashu Vihar Wildlife Sanctuary (WS), Gangotri National Park, (NP) Askot WS, and Valley of Flower NP, buffer zones (Sundar dhunga Glacier and Dung) of Nanda Devi BR in Uttarakhand, The Great Himalayan NP, Sangla WS and Kugti WS in Himachal Pradesh. Overall, most of the Himalayan range surveyed is classified as the Biogeographic Zone 02 B except areas of Great Himalayan NP and Kugti WS which falls in the Biogeographic Zone 02 A (Rodgers and Panwar, 1988). The survey routes taken for the above study sites are shown in Figure 1.

In general, this Himalayan belt represent similar habitat for the high proportion of high altitude wildlife located

**Table 1.** Information on human settlements, livestock presence, tourism and signs of grass cutting/grazing.

Pressure	Low	Medium	High
Grazing	<5 livestock group	6-9 livestock groups	10-15 livestock groups
Human settlements	<15 households	15-25 households	26-50 households
Tourism	<20 tourists/ day	20-74 tourists/ day	75-200 tourists/ day

above forests. There is a vast tract of mountains and plateaus immediately north of the Greater Himalayan chain, comprising the Trans-Himalaya. These mountains lie in the rain-shadow areas of the Himalaya and some of them are cold deserts such as higher areas (above 4000 m) of Nanda Devi BR, Gangotri NP, Askot WS and Sangla WS and mostly consists of subalpine scrub, alpine meadows and vast areas under permafrost, glaciers and rock faces. The region is characterized by severe winters lasting over six months, with temperatures dropping to as low as - 20°C in some places. These harsh conditions have given rise to hardy and highly adapted flora, fauna and people.

## METHODS

The field surveys were conducted from March to November, 2008. Due to the topography and remoteness of the area all field work was carried out in the form of field expeditions that is, camping in the different areas. One field survey was usually 10-15 days. Altogether, 1000 km were traversed on foot covering an altitudinal zone of 2100 to 5100 m. The sampling was done in 504 km in the areas having potential of snow leopard presence (Anon, 2008).

### Snow leopard occurrence and distribution surveys

Sign surveys (Jackson and Hunter, 1996; McCarthy et al., 2008) were conducted in snow leopard habitats above 3000 m from MSL (the minimum snow leopard range in India) in Uttarakhand and Himachal Pradesh. Two types of signs were recorded: scat and pugmarks. Snow leopard scat tends to be uniform in diameter (an average of 1.8 cm) comprised of several slightly constricted cords or connected with blocky segments (up to 8 - 10 cm) with blunt ends (Janečka et al., 2008a).

During the surveys, evidence of snow leopard and associated species such as common leopard (*Panthera pardus*), Asiatic black bear (*Ursus thibetanus*), Himalayan brown bear (*Ursus arctos isabellinus*), Tibetan wolf (*Canis lupus chanco*), red fox (*Vulpes vulpes montana*), blue sheep (*Pseudois nayaur*), Asiatic ibex (*Capra ibex*), musk deer (*Moschus chrysogaster*), Himalayan tahr (*Hemitragus jemlahicus*) and Himalayan marmot (*Marmota himalayana*) were searched for and recorded on the trails by the same observer. At each site where a sign was found, its GPS location, date and elevation were recorded using Garmin 72. Slope, aspects, land ruggedness, habitat types and distance to cliff were recorded ocularly. The habitats with snow leopard evidence were classified based on the categories of the Snow Leopard Information Management System (SLIMS) by Jackson and Hunter (1996) and further refined by McCarthy et al. (2008).

To avoid the chance of misidentification of snow leopard scats with other predators such as Tibetan wolf, common leopard and red fox, DNA was extracted from all the scats using Qiagen stool DNA extraction kit (Qiagen, Valencia, CA, USA; Janečka et al., 2008b)

and species and individual identification was done at the Wildlife Institute of India, Dehradun (WII unpublished).

### Snow leopard-human conflicts

Shepherds were interviewed using a pre-designed questionnaire format on livestock details and information on livestock loss was gathered from shepherds who were available during the survey and graze their livestock in snow leopard habitat. The cost of livestock was estimated during interviews of the shepherds and includes cost for sheep and goat that varied among areas.

### Food habits of snow leopard

Scats were collected and stored in polybags. These scats were oven dried and then crushed and teased for the indigestible material like hairs, hooves, bones (Floyd et al., 1978). All prey species were identified on the basis of the typical hair structure (cuticle and medulla), which were compared with the reference slides (Oli, 1993). Percentage frequency of occurrence was generated for each prey species found in the scats of snow leopard (Chundawat and Rawat, 1994; Anwar et al., 2011).

### Threats

Grazing pressure on the snow leopard habitat was assessed along each trail and also at places where evidence of snow leopard and associated species were found. The intensity of pressures was analyzed with the Software *Miradi* Version 2.4 under three step analyses: scope, severity and irreversibility ([www.miradi.org](http://www.miradi.org)). On survey routes, information on human settlements and livestock presence, tourism and signs of grass cutting/grazing were gathered in the field and through discussions with locals and forest department personnel. On the basis of the intensity of disturbances, these were categorized as low, medium and high as shown in Table 1: Pressure categories- Grazing: Average number of livestock in one group was 500. Only seasonal grazing takes place in snow leopard habitats; Human settlements: permanent/temporary and tourism: Number of the tourists per day and garbage material dumped due to tourism.

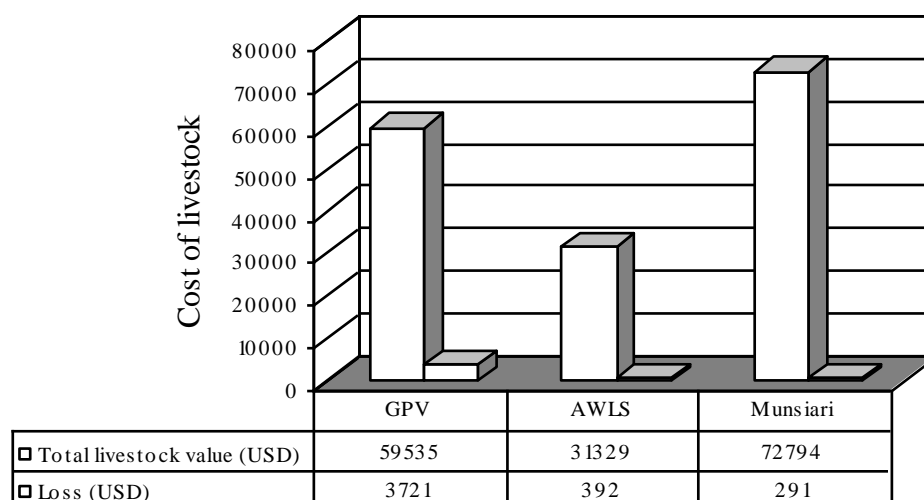
## RESULTS

### Occurrence and distribution of snow leopard

Our surveys recorded the presence of snow leopard from the surveyed regions of Uttarakhand. A total of 13 evidences of snow leopard were recorded. This evidence was in the form of scats (9) and pugmarks (4).

DNA was collected from all nine scats and three individuals were identified. Snow leopard evidence was recorded from 3190 to 4115 m from MSL with mean altitude of 3783 m. About 54% of evidence was recorded from alpine

## Livestock total cost and loss (USD) by snow leopard



**Figure 2.** Comparison of total cost (USD) and loss by snow leopard in three areas of Uttarakhand.

scrub and 21.4% evidence from grassland and barren land. Snow leopard evidence was recorded at slope range of 0 to 60°. About 39% of the evidence was found on the hill-slopes followed by valley floor (30%) and cliff (15%). We recorded 31% of snow leopard evidence on the north eastern aspect followed by North and South (23%), South West (15%) and South East (08%).

### Occurrence of prey species

The most common wild prey species found was blue sheep. A total of 340 individuals were recorded in 23 groups from Gangotri NP, Nanda Devi BR, Askot WS and Sangla (Raksham-Chitkul) WS. Almost 73% sightings were recorded from grasslands and open areas, 17% from shrub land and 10% from riverine patches. Another wild prey species recorded was Himalayan marmot along three survey routes in Askot WS and Gangotri NP. Eight individuals were recorded from alpine meadows. One group of Asiatic ibex was recorded first time from Kugti WS, Himachal Pradesh with five individuals in shrub land habitat (Maheshwari et al., 2010).

### Snow leopard-human conflicts

We interviewed 16 shepherds in Govind Pashu Vihar WS, Askot WS and Sundardhunga Glacier and Dung areas of Munsiri region of Nanda Devi BR where livestock population total was almost 8000 and comprised of goat, sheep, horse and mule. No information was availa-

ble from rest of the areas of Uttarakhand and Himachal Pradesh.

Livestock depredation was recorded as the only component for snow leopard-human conflicts and it varies. In Govind Pashu Vihar WS, the maximum livestock loss from snow leopard was 6.25% ( $n = 350$ ) but it averaged 1.6% ( $n = 1365$ ) for the four herds. The total livestock loss (Figure 2) was costing about USD 59,535. Similarly, in Askot WS we found that the maximum livestock loss by snow leopard was about 1.25% ( $n = 2890$ ) in a herd but for eight herds it averaged 0.78% ( $n = 4630$ ). The loss in Askot WS was valued USD 31,329. All depredations occurred during summers when these shepherds visit the higher ranges of snow leopard habitats in Uttarakhand.

### Food habits of snow leopard

Nine scats were analyzed for assessing the food habits of snow leopard and six prey species were identified in the scats. About 80% of the scats had single prey and 20% of the scats had two prey species. About 36% of snow leopard diet comprised of domestic livestock (mule, goat and sheep) followed by blue sheep (18%) and 18% by rodents (Figure 3).

### Biotic pressures on snow leopard and its habitat

The intensity and occurrence of threats (grazing, developmental activities, tourism and human settlements) varied among areas surveyed. Overall, we found that 68.1% of the area surveyed in Uttarakhand and Himachal Pradesh is under grazing and 12.3% area faces threats

Percentage frequency of occurrence of different prey in snow leopard diet

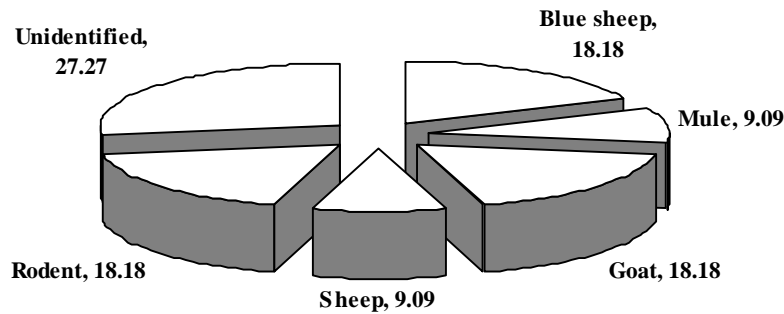


Figure 3. Food habits of snow leopard in Uttarakhand (April to December) 2009.

↓Threats↓ / ⇒Targets⇒	Snow leopard	Snow leopard h...	Summary Threat Rating
Tourism		Low	Low
Snow leopard-human conflicts	Low		Low
Human settlements		Low	Low
Grazing		Low	Low
Developmental activity		Medium	Low
<b>Summary Target Ratings:</b>	Low	Low	<b>Overall Project Rating</b> Low

Figure 4. Summary of threats (Miradi 2.4) to snow leopard and its habitat in the surveyed areas of Uttarakhand and Himachal Pradesh.

from settlements, tourism and defence activities. The summary of threats is summarized in Figure 4 and details about these threats are given below:

Grazing was found as a low threat to snow leopard habitat. No grazing was observed from Gangotri NP, Valley of Flower NP and Great Himalayan NP where it is not allowed by Forest Department. It is interesting to note that in Govind Pashu Vihar WS, Askot WS and Dung (Uttarakhand) and Kugti WS and Sangla WS (Himachal Pradesh) several families drive their unproductive livestock to sub-alpine and alpine areas for unsupervised grazing during the snow free period (May to October). Where ever grazing was recorded its severity was medium on the snow leopard habitat.

Developmental activities such as road construction were categorized as a medium threat to snow leopard habitat at Nilang Valley in Gangotri NP, Askot WS and Nanda Devi BR. At Nilang valley, it was observed that a gorge was blasted through, to make a road.

Human settlements posed low threat to snow leopard habitat because there were very few human settlements existing during the snow free period that utilized natural resources. Human settlements (locals) were recorded from Govind Pashu Vihar WS, where one village was located in snow leopard habitat. In Askot WS three villages that provide shelter for Kailash-Mansarovar tourists and two villages in Munsiri to Dung areas were present in snow leopard habitat.

Tourism (pilgrims and hikers) posed low threat to snow leopard habitat because tourism is confined to definite treks such as from Gangotri temple to Bhojbasu at Gangotri NP and Kailash-Mansarovar trek at Askot WS.

**DISCUSSION**

Snow leopard presence coincides with the presence of prey species such as blue sheep and Asiatic ibex and it

also helped in selecting the areas for snow leopard surveys. Furthermore, on the basis of these preliminary results, Uttarakhand Forest Department initiated camera trapping in Nanda Devi BR and captured images of snow leopard.

Livestock depredation is emerging as a significant problem across the snow leopard's range in the Himalaya and the other mountains of Central Asia (Oli et al., 1994; Jackson and Hunter, 1996; Mishra, 1997; Jayapal, 2000; Jackson and Wangchuk, 2001; Sathyakumar, 2003). These surveys suggested that shepherds are primarily concerned with their livestock depredation by snow leopard at Govind Pashu Vihar WS, Askot WS and Munsiri areas. It seems that snow leopard-human conflicts can be a manifestation of habitat degradation due to over-harvesting of the natural resources by humans. Conservation education efforts can help to enhance the understanding of the value of sustainable use of natural resources and importance of wildlife and help in mitigating these conflicts. The findings of snow leopard scat analysis are similar in some aspects with Chundawat and Rawat (1994) who reported that almost 96% scats consisted of single prey species. Here, we recorded 80% scats with single prey species. They reported 23.4% blue sheep (here we recorded 18.2%) in snow leopard diet followed by 12.5% domestic livestock (yak, goat and sheep) in Ladakh. But due to low sample size we are not able to document the food preference of snow leopard.

This survey also showed that livestock grazing is at present a low threat to snow leopard habitat. But overstocking of livestock may lead to habitat degradation. In general, we suggested that some areas need to be earmarked to be grazing free where wild ungulates can thrive without competition. Surveys showed that road construction at Nilang Valley, Askot WS and Nanda Devi BR may threaten existence of snow leopard, if not adequately planned. Roads cause habitat fragmentation and open the inaccessible areas to people and this often results in increased illegal activities (including hunting of snow leopard and its prey). It is suggested that while roads are planned, care should be taken to minimize habitat destruction.

There is a great need to provide basic amenities to the local people and defence personnel in areas along the international borders in Uttarakhand and Himachal Pradesh. But such activities including but not limited to construction of roads are causing side effects that need to be dealt with immediately. With the widening of existing roads and building of newer ones the threat of landslides have multiplied. The other important issue is the influx of labour from outside areas in large numbers who largely depend on natural resources for survival and some of them are also involved in illegal activities affecting wildlife.

These surveys were conducted in the remote areas of Uttarakhand and Himachal Pradesh. In these remote areas, the presence of forest department needs strengthening to combat poaching, regulate grazing and tourism. Otherwise,

the chances of maintaining and improving snow leopard and its prey base and habitat will be poor.

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