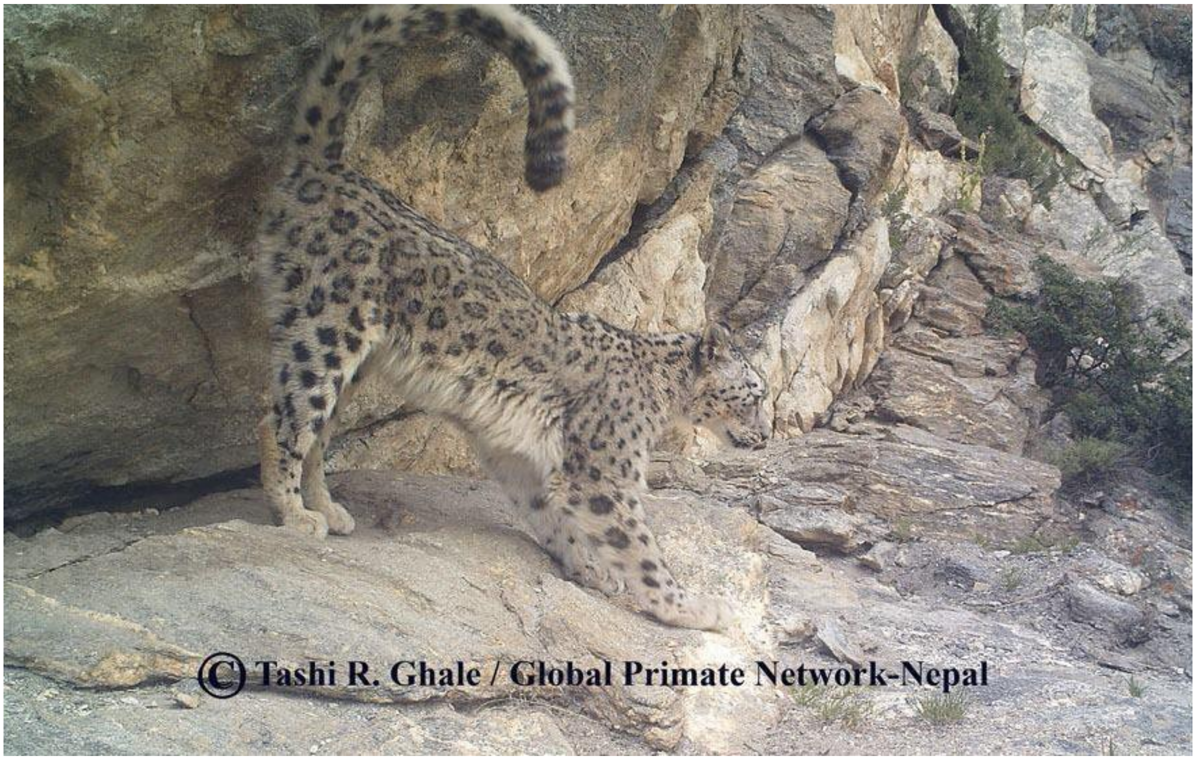
Abundance, Distribution and Conservation of Snow Leopard (*Panthera uncia*) in Humla District, Nepal



A Final Report:

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1. Executive Summary

The snow leopard (*Panthera uncia)* is categorized as an 'Endangered Species' in the IUCN Red Data Book and protected by the National Parks and Wildlife Conservation Act, 1973; thereby making it a priority species for conservation. This is the first study aiming at assessing status, distribution and conservation threat of snow leopard and its prey in Limi valley of Humla district and the first study to successfully capture a camera trap image of the species in the area.

Snow Leopard Information Management System (SLIMS) technique (Jackson & Hunter, 1996) was followed with a sign survey. Based on the sign survey, camera trapping location were identified and one camera was placed in each grid for larger area coverage and confirming presence of snow leopard. Point count was used for estimating the abundance of prey in the valley. Similarly, structured questionnaires were used to collect information on livestock loss to snow leopard and related conservation threats.

In total, 19 transect (average length = 616.5m) were walked covering a total length of 11.7 km. Snow leopard sign abundance of 12.89 ± 2.96 (mean ± SE) per km with scrapes abundance of 10.64 ± 2.50 (mean ± SE) per km was observed. Of the total signs, 82% were scrapes followed by 11% feces, 3% pugmark and 4% others (Rock scent/hair). The study revealed a total of 4 mammal species: Snow leopard (*Panthera uncia*), Beech marten (*Martes foina*), Pikas (*Ochotona species*) and Blue sheep (*Pseudois nayaur*). Pikas appeared the most abundant species (RAI = 72.63) followed by Beech marten (RAI = 14.74), Snow leopard (RAI = 6.32) and Blue sheep (RAI = 6.32). A total of 192 blue sheep (n= 89, 46.4% female, n = 64, 33.3% male, n=26, 13.5% lamb and n=13, 6.8% yearling) were counted in 10 different herds throughout Limi valley.

In total, 150 household were surveyed, consisting of Halji (n=75), Jang (n=40) and Til (n=35). Respondents' age ranged from 19 to 85 years with an average age of 42.15 years. Males constituted the 68% of respondents and 32% were female. 80% of the respondent household were engaged in farming and livestock herding with 85.3% illiterate. 150 household surveyed holds 1794 different types of livestock comprising 60.8% yak, 19.2% goat and sheep, 8.5% horse, 7.1% hybrid and 4.4% cattle with an average of 11.96 livestock per household. In total, 94 livestock (yak=61, goat and sheep=31) were lost to snow leopard in 18 months with an average annual loss of 5.22 animal per year.

Retaliatory killing due to livestock loss and hunting of blue sheep from outsiders are serious threats in the valley. Community awareness and conservation activities, with emphasis in herders focused program, such as incentive based program; are very urgent for long term conservation of snow leopard in the valley.

2. Objectives

This study was designed to assess both the status and distribution of snow leopard and its prey- blue sheep- in Limi valley, Humla district; and the extent of human-snow leopard conflicts. Key objectives of the study were:

- To assess the status of snow leopard and its prey in Limi valley
- To assess livestock depredation pattern and intensity in study area
- To map the snow leopard potential distribution and human-snow leopard conflict hotspots

3. Methods

3.1 Study area

The study was conducted in Limi valley of Humla district in north-west Nepal. Limi valley consists of three villages with total of 181 household namely; Halji, Jang and Til. It has a population of 904 (Male=409, Female=495). Humla holds temperate, cool-temperate and alpine climatic zones, and is spread across an area of 5655 sq. km. with a population of 57556 (NPHC, 2011). Limi valley is also known as wildlife capital of Humla because of high diversity of wildlife including endangered wild yak, snow leopard etc.

3.2 Data collection

Home range of five radio-tagged snow leopards in Western Nepal between 1981-1984 was found to be 11-37 sq. km (Rodney M Jackson, 1996). However, based on GPS-based telemetry studies from other parts of the cat's range (Jackson, *pers. comm.),* home ranges are expected to be larger than this. Snow leopard distribution has been reported from an elevation of 3000 to above 5000 M in Nepal Himalaya (Jackson & Ahlborn, 1988). According to this information, areas between 3000 to 5100 m were divided into 5x5 sq. km (average home range size for Humla) grid using ArcGIS. Sign surveys, camera trapping and prey count were carried out in these systemic grids for better spatial coverage and robust data.

3.3 Questionnaire surveys

The questionnaire surveys were carried out with local's villagers to generate information on livestock loss and conflict hotspots. The survey was carried out in local Tibetan dialogue and Nepali language. Questionnaire surveys also helped identify priority areas for SLIMS. Livestock kill sites were identified. Field verification were done through herder's interview and location were geo-referenced using GPS receiver (Gramin e-trex, WGS 1984).

3.4 Sign surveys

Transect-restricted sign surveys was carried out within the grids to search for signs like pug marks, scrapes, fecal etc. Primary signs indicated the presence of snow leopards following the Snow Leopard Information Management System (SLIMS) protocol developed by Jackson & Hunter (1996). The results of the sign-surveys is expressed as no. of signs/100 km which gave us a rough idea about the abundance of the species in the area. Based on the sign survey and habitat use pattern, camera trapping locations were selected.

3.5 Camera-trapping

Camera-trapping has long been used to survey and monitor the occurrence of wildlife species around the world (Carbone et al., 2001). Thus, we deployed 17 camera traps over two week time period. We wanted to rotate the camera after a fixed number of trapping nights (to be determined) for larger coverage of the area and more reliable data but due to high human movement in the area we couldn't do that. RAIs from camera trap images are very useful to explore patters in our camera trap data since relatively little camera trap data has been published (Cove et al., 2013; Jenks et al., 2011). Capture-recapture and patch occupancy provide extremely useful tools for the detection of trends in wildlife population abundance and species presence/absence (Carbone et al., 2001; Jenks et al., 2011) and also provides important basis for studying prey-predator interaction (Linkie & Ridout, 2011). Hence, camera-trapping offers an important non-invasive tool for assessing patterns of abundance throughout space and time, as well as linking with activity patterns, habitat use and reproductive information, which are key elements for wildlife conservation.

3.6 Point count

Direct counting is the widely used technique to estimate the prey densities in the past. We couldn't use double-observer method due to unexpected circumstances and field conditions. Thus, direct counting method was used, and counting was made from the specific vantage point as suggested by Jackson and Hunter (1996). Observations were made in the morning (06.00-10:30 am) and afternoon (02.00-05.30 pm) during the active period using 8 X24 binocular and 15-60x spotting scope. When blue sheep were sighted, they were classified by sex and age into 4 main categories: lambs, yearlings, females and males. Males were further classified into 3 classes Class I (2–3 years; horn length 15–35 cm), Class II (4–7 years; horns curved backward with a length of 30–45 cm) and Class III (7+ years; horns curved and over 45 cm in length) following (Wegge, 1979; Oli, 1997; Aryal et al., 2010).

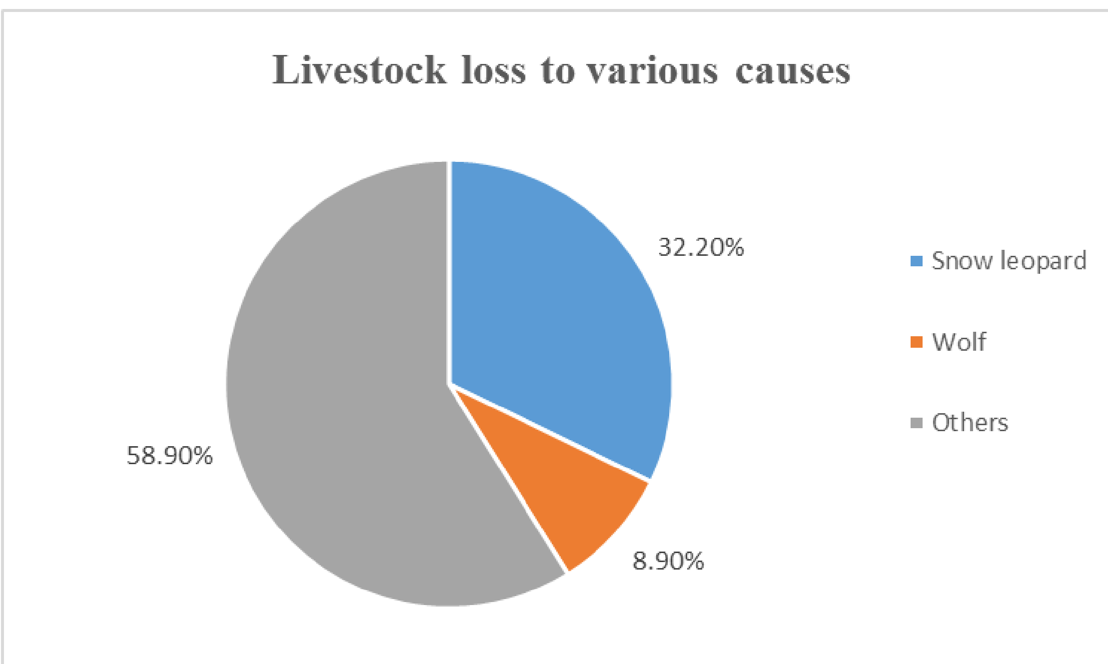
4. Results

4.1 Questionnaire survey

In total, 150 household from Limi valley (Limi VDC, Humla); Halji (n=75), Jang (n=40) and Til (n=35) were surveyed using structured questionnaires. Respondents' age ranged from 19 to 85 years with an average age of 42.15 years. Family size range from 1 to 16 people with average family size of 5 people. Out of the total respondents, 68% were male and 32% were female. 80% of the respondent household were engaged in farming and livestock herding, 8.7% were involved in labor work, 7.3% in trade and business, 2.7% in service and 1.3% were old and retired. Education level of respondents was very low. The big majority (85.3%) were illiterate, followed by a 5.3% with higher secondary level study, 4.7% primary school, 2% high school, 1.3 % lower secondary level and 1.3% were monk. Agriculture and livestock raring is found to be the major occupation in the valley. 150 household holds surveyed held 1794 different types of livestock comprising 60.8% yak, 19.2% goat and sheep, 8.5% horse, 7.1% hybrid and 4.4% cattle with an average of 11.96 livestock per household.

Livestock Loss to Carnivores

In the last two years, 34% of total household respondents lost livestock to carnivores like snow leopards and wolf. In total, 94 livestock (yak=61, goat and sheep=31) were lost to snow leopard in 18 months (full year 2014 and until summer 2015). A total of 292 livestock were lost in 18 months (2014-2015) due to various causes such as snow leopard, wolves and others like disease, cold, avalanche etc. as shown in the pie-chart below (***figure 1)***.



All of the respondents have heard and or seen snow leopard in the valley. We used color photo plates of different wildlife present in the valley to see whether respondent are able to identify it correctly or not. Nearly all (80%) respondents correctly identified snow leopard and all respondents correctly identified blue sheep- the principle prey species of snow leopard in the valley. Similarly, 85.3% correctly identified wolf, 54.7% identified jackal, 51.3% identified common leopard, Himalayan thar by 68.7% and Argali sheep by 36%. This shows that locals have a good knowledge of the wildlife present in the valley.

4.2 Sign Survey

In total 19 transect were covered in Limi valley during July-August, 2015 with a total length of 11.7 km (mean = 616.5m, min = 180m & max = 950m). Sign transects were established along predictable travel lanes used by snow leopards like human trails, ridgelines, and cliff bases where cats are most likely to deposit signs (Jackson and Hunter, 1996; Ale et al., 2007). Of the total signs observed, 82% were scrapes followed by 11% feces, 3% pugmark and 4% others (Rock scent/hair) as shown in figure 1. Average snow leopard sign abundance was found to be 12.89 ± 2.96 (mean ± SE) per km, with scrapes abundance of 10.64 ± 2.50 (mean ± SE) per km in Limi valley, Humla.

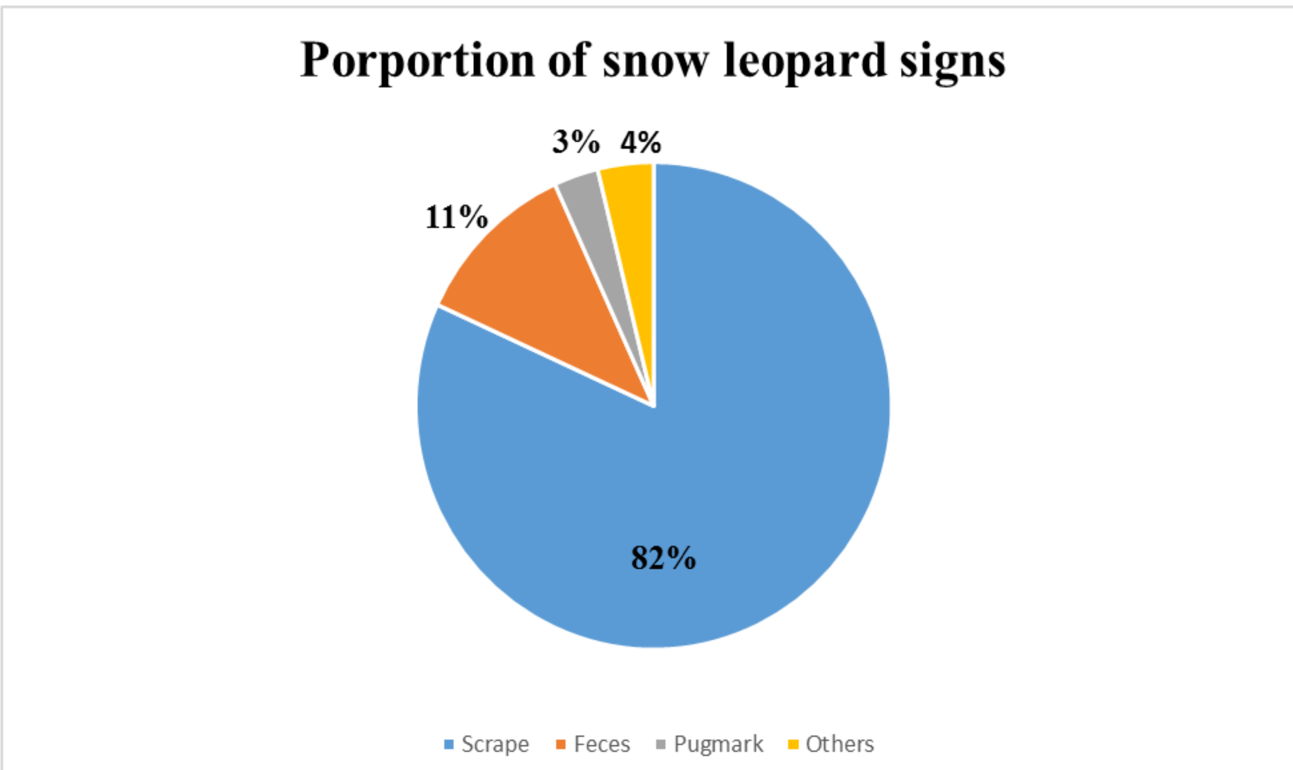


Fig.2: Proportion of snow leopard signs encountered during transect survey

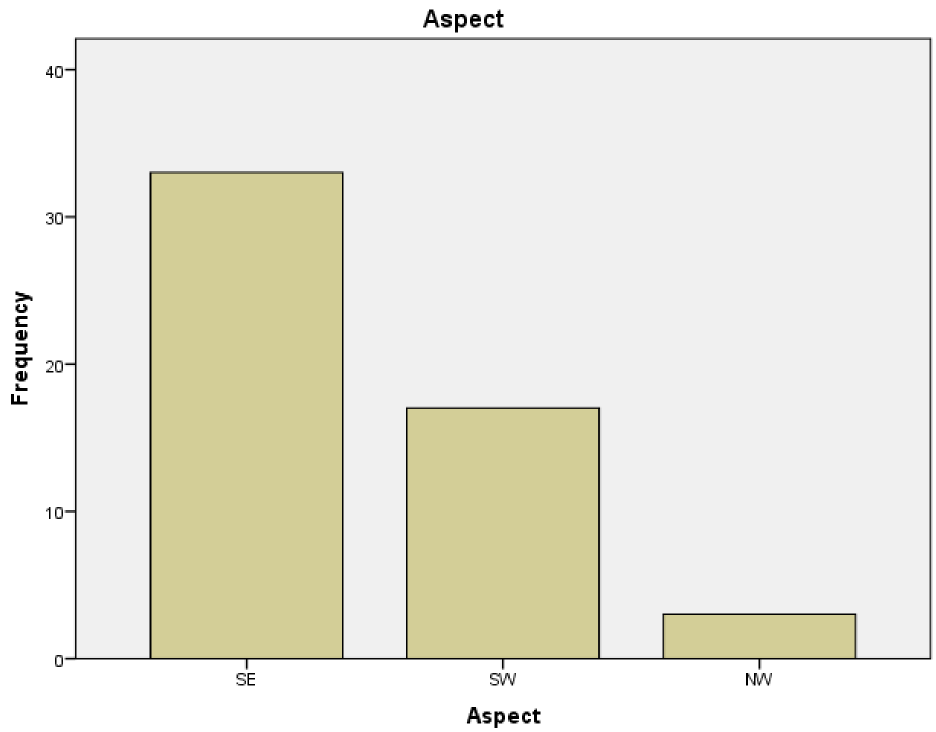
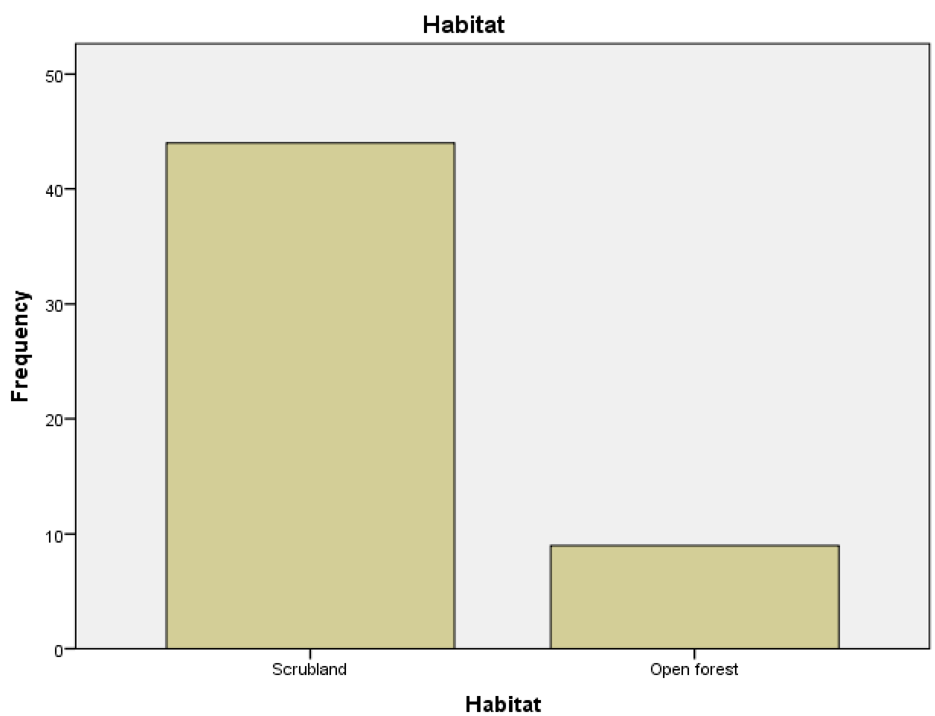


Fig. 3: Sign frequency with respect to aspect



Fig, 4: Sign frequency with respect to habitat types

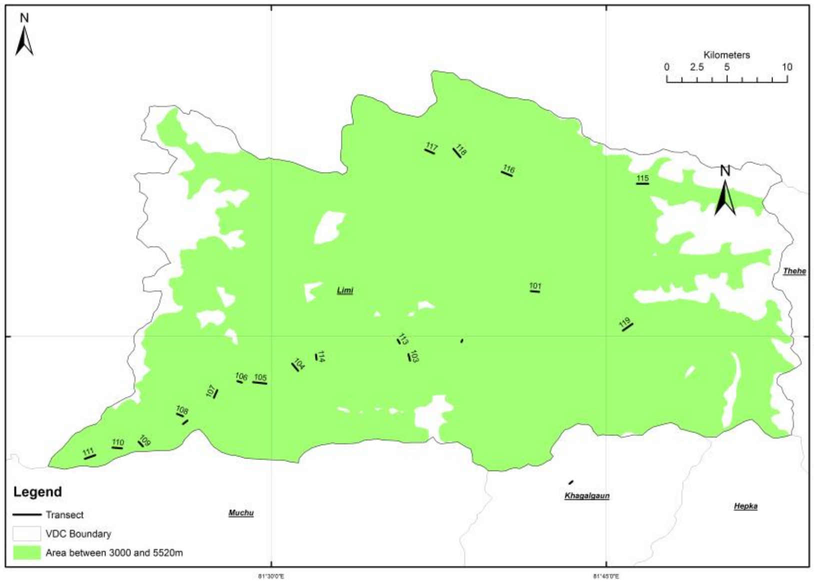


Fig.5: Transect distribution in Limi valley

4.2 Camera trapping

4.2.1 Species Abundance: One record of each species per location per PERIOD

Using remotely-triggered camera traps, we explored the snow leopard pres/abs and sympatric mammalian diversity in trans-Himalayan Limi valley, Humla district, Nepal. The camera trap survey was carried out between July-August 2015 and consisted of a total survey effort of 197 trapping days in 16 camera trap sites. Camera trap data was analyzed following Sanderson & Harris (2013). The camera trap sites were distributed along the altitudinal gradients ranging from 3092 m asl to 4608 m asl.

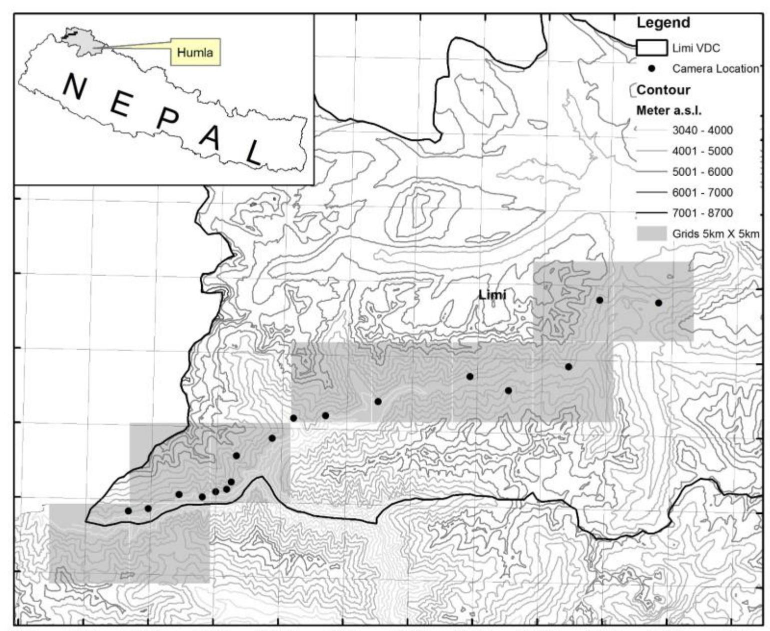


Fig. 6: Camera trap distribution in 5x5 sq. km grid in Limi valley, Humla

The study revealed a total of 4 mammal species: Snow leopard (*Panthera uncia*), Beech marten (*Martes foina*), Pikas (*Ochotona species*), and Blue sheep (*Pseudois nayaur*). We assumed the independent picture of each species at each camera trap locations in every 60 minutes which we call here a PERIOD. Based on the independent pictures (One record of each species per location per PERIOD), the Pikas appeared the most abundant species (RAI = 72.63) followed by Beech marten (RAI = 14.74), Snow leopard (RAI = 6.32) and Blue sheep (RAI = 6.32) (See Table 1).

Our camera traps survey has revealed first camera trap images of snow leopard and stone marten in the valley. It has also provided their relative abundance index, which will be crucial for planning future surveys and understanding detailed ecology, behavior and conservation threats in the area. These preliminary findings will also be helpful for conservation organizations to implement the effective conservation actions for these carnivores to regulate the high-altitude ecosystems in the region.

Species	No of pictures	Relative abundance	Average no of individuals	Abundance of individuals
Snow leopard	6	6.32	1.33	7.41
Blue sheep	6	6.32	1.33	7.41
Beech martens	14	14.74	1.21	15.74
Pikas	69	72.63	1.09	69.44
Total	95	100	-	-

Table 1: One record of each species per location per PERIOD

4.2.2 Occupancy

Naïve occupancy: Species naive location occupancy proportion

Species	Fraction of locations Occupied	Number of locations Occupied (16)
Pikas	0.563	9
Beech marten	0.438	7
Snow leopard	0.125	2
Blue sheep	0.125	2

Monthly detection rate: Use independent records from only those locations that ever recorded species

2015	Blue sheep	Pikas	Snow leopard	Beech marten
2015-07	0.21	0.57	0.32	0.16

Snow leopard Occupancy

Detection history of 7 occasion for each 16 camera trap site was created using 3 days in each trap occasion. Eight different covariates i.e. Elevation (E), Prey abundance (P), Human disturbance (HD), Grazing (G), Distance to settlement (DS), Prey hunting (H), Terrain type (T) and Aspect(A) for each camera trap location were collected. We used PRESENCE v. 8.4 (Hines, 2006) to run single season single species occupancy models (MacKenzie et al., 2002) to estimate the probability of site use (for detail methods see Alexander et al., 2015). Occupancy estimation was carried out for an area of ca. 260 sq. km. including 2.5 km buffer area. In total, 100 model were run using potential 8 covariates which are likely to influence the site use by snow leopards. The estimated average occupancy for all site was found to be (ψ) =38.5% with detection probability (p) = 23%. The Top 3 models were selected based on ΔAICc value. Model summary is presented in table 2.

Models	**AICc**	**ΔAICc**	**Akaike weight**	**Model Likelihood**	**K**	**LL**
ψ(HD),p(E)	21.79	0.00	0.36	1.00	4	13.79
ψ(E),p(HD)	22.05	0.26	0.32	0.88	4	14.5
ψ(P),p(P)	22.08	0.29	0.31	0.87	4	14.08

Table 2: Summary of model selection results

Model	**ψ ± SE**	**p ± SE**
ψ(HD),p(E)	0.38 ± 0.00	0.05 ±0.05
ψ(E),p(HD)	0.41 ± 0.13	0.09 ±0.04
ψ(P),p(P)	0.38 ± -.81	0.55 ±0.21

Table 3: Average occupancy and detection for all parameter

4.3. Point count

A total of 192 blue sheep (n= 89, 46.4% female, n = 64, 33.3% male, n=26, 13.5% lamb and n=13, 6.8% yearling) were counted in 10 different herds throughout Limi valley (Table 4). From total of 64 males counted, n=24, 37.5% belongs to class I, n=32, 50% class II and n=8, 12.5% class III respectively.

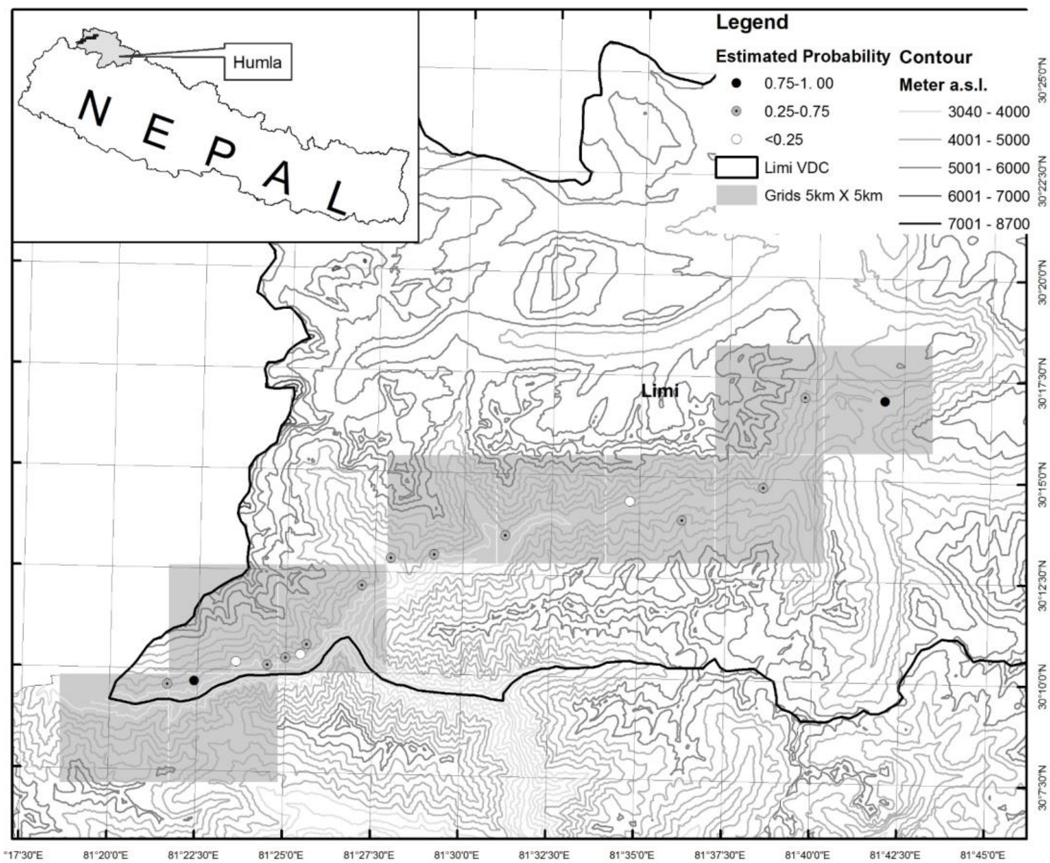


Fig. 7: Estimated probability of site used (Occupancy) in Limi valley

SN	Locations	Number	Female	Lamb	Yearling	Male	Class I	Class II	Class III
1	Pulgung	37	12	6	3	16	8	5	3
2	Chhuprangmo	31	11	5	2	13	2	9	2
3	Gyaam Sarba	4	2	0	1	1	0	1	0
4	Richundar	4	0	0	0	4	0	4	0
5	Takpachen	20	10	0	3	7	3	4	0
6	Chhumdung	13	8	1	0	4	2	2	0
7	Chhangjikang	40	15	4	2	19	9	7	3
8	Tashi Thang	21	15	4	2	0	0	0	0
9	Chhongerche	9	6	3	0	0	0	0	0
10	Til	13	10	3	0	0	0	0	0
Total		**192**	**89**	**26**	**13**	**64**	**24**	**32**	**8**

Table 4: Abundance and classification of blue sheep in Limi valley

4. Discussion

Livestock loss to snow leopard in Limi valley makes 5.22% of total livestock holding which is higher than 2.6% loss in Manang valley in 1989/90 (Oli et al., 1994) and 2.8% in Khangsar village (Jackson et al., 1994). This might be because of lower natural prey abundance in the valley and higher interaction with wolves. Signs abundance of snow leopard in Limi valley was fairly high 12.89/Km compared to 4.18 signs/Km in Everest region Nepal (Ale et al., 2007), 3.2 all signs/ Km in Rolwaling (Ale et. al, 2010), 5.8 signs/ Km in Mustang (Ale et al., 2014). Humla is located outside the current network of protected area, and is believed to have one of the highest density of snow leopard in Nepal (Rodney Jackson, *Pers. Comm.).* Anecdotal evidence suggests that 6-8 adult snow leopard inhibits Limi valley, Humla. Local suggest high sightings of snow leopard in the valley, especially winter and early spring.

Camera trapping was conducted for very short time (for only two week). We planned to keep conduct trapping for 45 trapping night but considering high movement of people in the study area for medicinal plant harvesting which is one of the key economic source in upper Humla we could not make it. However, within very short time period, we were able to capture snow leopard in two locations yielding two different individuals. This is the first camera trap image of snow leopard outside the current network of protected area in Nepal. Principal investigator witnessed the presence of snow leopard in the valley, sighting two adult snow leopard manually in May 2007 (Rinzin P. Lama, *unpublished*) in the same location where present photographs of snow leopard were captured. In around Halji village, in winter of 2011, four independent sighting of snow leopard were reported (Astrid Hovden, *Pers. Comm.*). High encounter of snow leopard are reported in inner valley of Limi such as Ning khola, Rakaru and Hel every winter and spring,where villagers keep their livestock in winter and early spring. One mother with three cubs was sighted in Rakaru in winter of 2014 (Phuntsok Tamang, *Pers. Comm.*) and one mother with two cubs was sighted at goat kill site in Takchi in July 2015 (Ngutub Tamang, *Pers. Comm.*). In recent years, snow leopard sightings are lower than in the past. One of the reason is considered to be prey hunting by outsiders. Limi is a locally protected area where hunting is prohibited. However,during spring, people from other areas in upper Humla go to harvest medicinal herbs and hunt. Retaliatory killing is another threat to the species. Discussion with local's revels kill of two leopard in retaliation to livestock loss between 2010 to 2015 , and one adult male leopard found dead trapped in snow avalanche by locals in Jertsue area in 2012. One adult male leopard was found dead in avalanche in winter 2014 in Kit, an area adjoining to Limi valley boarder to Tibet (Indra Lama, *Pers. Comm.*).

Prey abundance is relatively very low in Limi, as we counted only 192 blue sheep. Nevertheless, the density of Himalayan marmot in the valley is very high, which can contribute in a significant amount to summer diet. Thus, dietary analysis of snow leopard is very important to see the composition of prey biomass and design conservation programs accordingly.

Majority of the local people identified snow leopard and blue sheep correctly. However, locals were not aware of the ecological importance of snow leopard. Hunting and poaching by people from other areas is a big threat to wildlife in the valley, as it is very difficult to monitor because of geographical difficulties and lack of communication infrastructures. Community level awareness and conservation activities are very urgent for long term conservation of snow leopard and other wildlife in the valley. People focused incentive programmes such as compensation, predator deterrent tools, alternative livelihood are equally important to encourage local's participation in conservation. Strong coordination among researchers, locals, government bodies like police and forest officers is important for effective law enforcement and monitoring illegal activities in the valley.

Other wildlife sighted in the Valley:

Tibetan wolf (*Canis lupus chanco*), Tibetan fox (*Vulpes ferrilata*), red fox (*vulpes vulpes*), Royle's pika (*Ochotona roylei*), Larged ear pika (*Ochotona macrotis*), Plateau pika (*Ochotona curzoniae*), Tibetan wild ass (*Equus hemionus*), Argali (*Ovis ammon*), Musk deer (*Moschus christogester*), Mountain weasel (*Mustela altaica*), Himlayan marmot (*Marmota himalayana*), Golden jackal (*Canis aureus*).

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5. Photographs

Picture 1: Adult snow leopard photographed in Limi valley

Picture 2: Blue sheep photographed in camera trap in Limi valley

Picture 3: Tibetan wild ass in Limi valley

Picture 4: Fresh snow leopard scrape

Picture 5: Fresh snow leopard pugmark

Picture 6: Juvenile Himalayan marmot

Picture 7: Rinzin (PI) counting blue sheep **Picture 8: Royle's pika (*Ochotona roylei*)**

Picture 9: Rinzin (PI) interviewing herders

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