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Cover Photo: Snow leopard and Common leopard captured on the same trap in Gaurishankar Conservation Area, Nepal. Photo Credit: NTNC-GCAP
Design and layout: Ritu Topa/arrtcreations@gmail.com

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Editorial

Science based conservation from the grassroots

In 2009, a team from the Snow Leopard Conservation Foundation (SLCF) helped to set up a livestock insurance program among the local communities around the Tost Mountain area in the South Gobi, Mongolia, due to livestock depredation by snow leopards. When establishing the program, a young herder named Enkhburen (Buren) Nyam was elected by the fellow herders to be one of the insurance program committee members who would help to run the program locally. Buren himself was having a hard time to co-exist with snow leopards and he wanted to find a solution to help himself and his fellow herders to manage snow leopard issues. Through the years of working for the program, his perception of snow leopards began to change, with the realization that for a healthy environment, the local community really needs these big cats in their natural habitat to be protected. This led him to become keenly interested in exploring more about snow leopard and the ecosystem that he and his fellow herders have shared with them for generations.

In 2015, with the support from SLCF, herders around the mountain organized themselves into self-help groups calling themselves “a conservation community”, developing their own norms, electing leaders, community rangers and designating “areas” of responsibility. The area of responsibility each community has are now known as Community Responsible Areas or CRA’s.

Recognized for his passion for nature, Buren was elected as a community ranger along with 6 other herders who represents each of their CRA’s. However, some of these community lands which they share with snow leopards had been affected by mining and were on the brink of being lost. Mining created a tremendous challenge and a threat to local livelihoods and wildlife through pasture and habitat destruction. These herder rangers needed to be part of a campaign to protect their CRA’s and to elevate their status into State Protected Areas. In 2016, with leadership from SLCF, many likeminded partners came together to protect the Tost Mountain as a state protected area for snow leopard and local people.

The seven community rangers, including Buren, patrol their individual CRA’s regularly, conducting wildlife monitoring as well as checking for any illegal activities taking place. CRA’s are patrolled twice a month by motorcycle, horse and camels, with each ranger covering thousands of kilometers over the course of a year, spending up to 184 days in the field with over a hundred patrols completed.

(above and below): Community rangers in Tost Mountain Nature Reserve Mongolia, elected by their fellow herders patrol their land on a regular basis

For his extensive work in protecting his CRA from threats like mining, contributing efforts for patrols and raising awareness among the community members, Buren, as the youngest community ranger at 35, was recognized as a "Conservation Hero" by the Disney Wildlife Conservation Fund 2021.

SLCF's Long Term Ecological Study (LTES) team has been training the community rangers in basic skills in monitoring surveys, and soon after noticed that these rangers, who are out among nature every day and skilled observers, have a lot more potential to engage in basic field research and data collection. Today, the seven community rangers help conduct annual camera trapping for snow leopard and ungulate surveys over thousands of square kilometers, while out patrolling their own CRAs, bringing well needed support for the National Park.

Understanding the importance of local and indeginious people's role in conservation hasn't always been recognized as we've struggled with

Three community rangers planning routes for their next patrol

conservation challenges over the last decades. Today however, the role local peoples play in conservation of the areas they intimately know is an important aspect of creating and maintaining effective conservation measures. Buren and his fellow rangers are an example of indigenous and local communities taking up this important role in protecting natural areas and their biodiversity. Just recently, in December 2023, the 1st Asian Rangers Forum in Guwahati, India, highlighted the inclusion of indigenous and local community rangers and their importance in conservation with its Guwahati Declaration. Another milestone for recognizing local communities role in nature protection was made with the Kashka Suu Declaration presented to COP 15 a year earlier on the 2nd of December 2022. This was created and agreed to by 22 global conservationists with cumulative 45 decades of experience with community based conservation. In November 2023, this same group established the Ethical Conservation Alliance, launched at the Whitley Fund For Nature to support conservation practitioners globally.

Snow leopard conservation clearly needs local people like the community rangers in Mongolia, adding an important aspect to wildlife habitat protection. At the same time, conservation science provides a vital role in understanding species, which all conservation initiatives should be based on. With much more to learn about snow leopard and its ecosystem, research and local communities' contributions to wildlife protection, the Snow Leopard Report can help bring all this together as a key contributor to the knowledge pool of species conservation.

Bayarjargal Agvaantseren
Director Snow Leopard Network
Regional Conservation Coordinator, Snow Leopard Trust

Snow Leopard REPORTS

Field Note

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Snow Leopard Intrusions into Livestock Corrals in Badakhshan, Afghanistan: Challenges and Solutions

Zalmai Moheb*[1] · Kharoosh Sahel[1] · Muhibullah Fazli[2] · Musa Hakimi[2] · Salahuddin Ismaily[1]

1. Wildlife Conservation Society–Afghanistan
2. National Environmental Protection Agency of the Islamic Emirate of Afghanistan
* (Corresponding author, mohebzalmai@yahoo.com)

Key words
Panthera uncia, corral intrusion, livestock predation, occurrence record, problematic animal

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Abstract

Snow leopards (*Panthera uncia*) frequently prey on livestock throughout their range, posing a potential threat to human livelihoods and endangering the predator's own survival. In this study, we document seven incidents of snow leopards intruding into livestock corrals and engaging in surplus killing in three districts of Badakhshan, Afghanistan. Six of the predation incidents were attributed to a single individual, occurring in five locations of Wakhan District and eventually in Yumgan District, where the captured animal was relocated. The remaining predation incident occurred in Keran-wa Munjan District, marking the first recorded evidence of snow leopards in this area. In all but one of the incidents, the predator was trapped in the corral it intruded and safely released back to the wild with the

support of the National Environmental Protection Agency (NEPA) and Wildlife Conservation Society (WCS) team in Afghanistan. Local communities have been supportive in releasing the snow leopard despite losses of over 50 livestock. To mitigate negative interactions between snow leopards and livestock, conservation efforts should focus on conserving prey species, implementing predator-proof measures for livestock corrals, and utilizing collar tracking when a trapped snow leopard is found in a corral. Unfortunately, when an individual repeatedly enters livestock corrals and continues killing livestock, capture and relocation to captivity often become the only viable option to address the problem and ensure the animal's safety from retaliatory action by affected herders.

Main text:

Intrusion by snow leopard (*Panthera uncia*) into livestock corrals, leading to surplus killings, is a common occurrence throughout the species' range, including in the Wakhan National Park in northeastern Afghanistan (Mishra and Fitzherbert 2004, Moheb and Paley 2016). Livestock predation impacts community livelihoods, particularly in areas where livestock husbandry serves as the primary source of income (Moheb et al. 2022 and increases the risk of retaliatory killing of snow leopards. Several factors contribute to livestock predation by snow leopards, such as a decline in wild prey populations, human encroachment in wildlife habitats, inadequate protection of livestock by herders, and an increase in predator density (Suryawanshi et al. 2013, Khorozyan et al. 2015, Chen et al. 2016, Rashid et al. 2020).

In this study, we present seven documented cases of snow leopard intrusions into livestock corrals across three districts of Badakhshan. Five incidents occurred in Wakhan, one in Keran-wa Munjan, and one in Yumgan District. A snow leopard, identified as a healthy adult female in all cases, entered household corrals in three neighboring villages in western Wakhan, where it killed and injured over 50 sheep and goats on five separate occasions within a span of 67 days (Table 1). In four incidents in Wakhan, the leopard became trapped in the corral (Fig. 1) but managed to escape on one occasion. It was

Table 1

Details of the snow leopard livestock predation incidents in Badakhshan, Afghanistan in early 2023.

Date	Villages	District	Corral Protection	No. Sheep & Goat		Predator[1]	
				Killed	Injured		
11-Feb-23	Wark	Wakhan	Weak[2]	13	3	Present	Released
13-Feb-23	Kishnikhan	Wakhan	Weak	2	2	Present	Released
19-Feb-23	Wark	Wakhan	Weak	22	-	Absent	Escaped
22-Feb-23	Wark	Wakhan	Weak	-	-	Present	Relocated
4-Mar-23	Razer	Keran-wa Munjan	Weak	1	-	Present	Released
18-Apr-23	Qazideh	Wakhan	Weak	12	-	Present	Relocated
Early May-23	Ab-e Jukhan	Yumgan	Unknown	Unknown	Unknown	Present	Unknown
		Total		**50**	**5**		

[1] Status of predator when herders reached the impacted corrals and actions taken.

[2] Local corral with no proper protection that is accessible to predators through its ventilation, roof, or door.

Figure 1: *Intruded snow leopard trapped inside corral when the corral owner arrived at the site in Kishnikhan Village on 13 February 2023.*

eventually captured and relocated to Yumgan District, where it continued to kill livestock, leading to its re-capture. Although genetic verification was not preformed, the phenotype, locations and dates strongly suggest that these six incidents were caused by a single individual. Additionally, a different snow leopard (based on the distance and date of the incident), entered and got trapped in a corral in Keran-wa Munjan District, located approximately 100 km southwest of Wakhan, marking the first recorded presence of a snow leopard in the area outside the IUCN confirmed range (McCarthy et al. 2017).

Recent incidents of snow leopard depredations in Badakhshan showcased a unique response from local communities. The National Environmental Protection Agency (NEPA), as the responsible government organization, received support from the Wildlife Conservation Society (WCS) field team in Wakhan, effectively persuaded local communities to release the animal unharmed. Although these incidents sparked anger among the communities, they ultimately agreed to release the predator. In four instances, Wakhan villagers had direct access to the intruded animal, yet it was either released in the same area (n = 2) or relocated to a different site within the species' range (n = 2). The collaborative efforts of NEPA and the local communities with the technical support of WCS played a crucial role in the successful resolution of these encounters.

The local authorities in Wakhan, engaged with the provincial authorities, to get directives how to handle these cases. During the fourth incident, a traditional cage built made of wood beams and gabion was prepared (Fig. 2), and the animal was enticed to enter by smoking out the corral. It was relocated to Rig-e Jurm area (Fig. 3), approximately 35 km east of its capture location. Over a month later, during the fifth predation incident, the same animal was captured in the corral and subsequently transported to Faizabad, the provincial capital. It was kept there for one night in a relatively calm environment with adequate food and better cage conditions before being released (Fig. 4) in Sar Ab-e Jukhan, Yumgan District, about 100 km southwest of the capture site. The animal was

Figure 2: *Local communities trapped a female snow leopard in Wakhan after a fourth intrusion into a corral. The animal was remarkably calm.*

Figure 3: *District authorities and the head of NEPA Department in Badakhshan softly released the captured snow leopard in Rig-e Jurm, Wakhan District.*

Figure 4: *District authorities and the head of NEPA Department in Badakhshan released the captured snow leopard in Sar Ab-e Jukhan of Yumgan District.*

Figure 5: *District authorities and the head of NEPA Department in Badakhshan released the snow leopard captured by local people after killing a livestock in Razer Village of Keran-wa Munjan District.*

marked with red paint on its head, allowing for easy identification when it was recaptured in another livestock corral it had intruded (Table 1). The Yumgan District authorities then took the animal and reportedly released it in Keran-wa Munjan District. The sucessful outcome of these incidents, with the conflict animals being spared from harm by impacted herders, highlights the importance of prompt and supportive action by the authorities, such as NEPA. It also demonstrated the trust exhibited by local communities when provided adequate support.

In Keran-wa Munjan and Yumgan districts, there was no apparent negative perception or retaliatory response against the predator. In Wakhan, where occasional livestock losses to snow leopard predation occur, we attribute the positive outcome to previous public awareness efforts, a generally positive perception of the species, adherence to the regulations, and the responsive action of local authorities and conservationists.

Local and provincial authorities promised the affected households' compensation and requested WCS to predator-proof their corrals. Additionally, WCS will continue mobilizing community rangers to patrol the area, raising awareness about the conservation of snow leopards and their natural prey. Preserving wild prey species, implementing predator-proofing measures for livestock corrals, collaring intruder predators when trapped inside corrals, and maintaining vigilance regarding snow leopard presence are vital preventive actions to safeguard this mountain predator from retaliatory harm, as well as protecting the livelihoods of communities in northeast Badakhshan, heavily reliant on livestock as their primary source of income. Unfortunately, when an individual snow leopard repeatedly enters livestock corrals and kills livestock, capture and relocation to captivity often become the only viable solution to resolve the issue and safeguard the animal from harm by affected herders.

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Snow Leopard REPORTS

Field Note

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Predation Patterns and Hunting Behaviour of Snow Leopards: Insights from an Ibex Hunt

Örjan Johansson[1,2,*] · Enkhburen Nyam[3] · Purevjav Lkhagvajav[3] · Justine Shanti Alexander[2,4] · Gustaf Samelius[2,5]

1 Grimsö Wildlife Research Station, Swedish University of Agricultural Sciences, Riddarhyttan, Sweden
2 Snow Leopard Trust, 4649 Sunnyside Avenue North, Seattle, USA
3 Snow Leopard Conservation Foundation, Khan-Uul Sukhbaatar District, 3rd 4th Khoroo, Street Sharav, Chingis Ave53-9, Ulan Baatar 17042, Mongolia
4 Department of Ecology and Evolution, University of Lausanne, CH-1015, Lausanne, Switzerland
5 Nordens Ark, Åby Säteri, 456 93 Hunnebostrand, Sweden
* Corresponding author: Örjan Johansson, orjan.johansson@slu.se

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Abstract

The hunting behaviours of the snow leopard (*Panthera uncia*) are poorly understood. In this note, we describe the successful hunt of an adult male ibex (*Capra sibirica*) by a known male snow leopard in Tost Mountains, Mongolia. The hunt started in a mountain slope close to three large boulders and progressed downhill for 115 m until it concluded at the bottom of a drainage. By comparing the habitat where the ibex was killed to the kill sites of 158 ibex and 17 argali (*Ovis ammon*) that were killed by GPS-collared snow leopards, we demonstrate that the majority (62%) of these kills occurred in drainages. We propose that in successful hunts, snow leopards commonly ambush from above, causing prey individuals to typically flee downhill. Thereby

the prey maintain their momentum and it is not until they are slowed down upon reaching the bottom of the drainage that the snow leopards are able to subdue them.

Main text

Most felids are ambush predators that stalk their prey to within striking distance for the final ambush (Ewer 1968, MacDonald, Mosser and Gittleman 2010). Hunting success depends on access to cover that allows the felid to get close to the prey. Pursuits rarely last for more than 50 m, but struggles can continue further before the prey is subdued (Laundré and Hernández 2003, Haglund 1966). The snow leopard (*Panthera uncia*) is an apex predator of the alpine ecosystems of High Asia. Throughout their range, snow leopards primary prey on wild sheep and goats, including bharal (*Pseudois nayaur*), Siberian ibex (*Capra sibirica*), Himalayan tahr (*Hemitragus jemlahicus*) and argali (*Ovis ammon*) (Lyngdoh et al. 2014, Mallon, Harris and Wegge 2016). These prey species weigh between 30 and 180 kg (Wilson and Mittermeier 2011), while the average weight for male and female snow leopards is 42 and 36 kg, respectively (Johansson et al. 2022). This indicates that snow leopards differ from other large solitary felids that prefer to hunt prey similar in size or smaller than themselves (Hayward et al. 2006a, Hayward et al. 2006b, Hayward et al. 2012). Anatomically, snow leopards have forelimbs adapted for climbing, rapid pursuit across rocky terrain and grappling large prey (Smith et al. 2021). Due to the difficulty of observing and tracking snow leopards, our understanding of their hunting techniques is limited to a few film-clips showing them hunting by ambushing prey from above and pursuing it downhill (BBC, Planet Earth I, Wilderness Films India).

In this note, we report on a successful hunt of a large male ibex, compare the habitat of the hunt to a large dataset of ibex and argali kill sites by GPS-collared snow leopards, and propose explanations for the species' hunting techniques.

During our long-term snow leopard and ibex research in the Tost Mountains (lat 43, long 100) of Southern Mongolia, on 26 September 2022, we encountered an adult male ibex that had been killed by a snow leopard the night before or possibly two nights earlier. Based on the annular rings on the horns, the ibex was determined to be nine years old and estimated to have weighed around 90 kg. We set up a camera trap (Reconyx Hyperfire 2) at the kill site, and the images confirmed that the snow leopard returned to feed in the evening of September 26. From the images, we identified the snow leopard based on its spot patterns as a male that was captured and fitted with a GPS-collar on 12 April, 2023, at the time weighing 41 kg and estimated to be between six and eight years old. We were able to track the path of the hunt by signs such as fur, blood, broken branches, disturbed rocks and pugmarks. We found the first disturbed rocks on a mountain slope with approximately 30° angle near three large boulders. Despite intense efforts, we could not locate any sign beyond this point and conclude that the snow leopard had likely ambushed the ibex here after which the ibex fled downhill (Fig 1 & 2). Approximately 70 m after the ambush, we found the first broken branches of Mongolian almond bushes (*Prunus mongolica*) and fur, indicating that the snow leopard had pounced or lunged on to the ibex. Over a distance of 13 m, the amount of fur increased rapidly, suggesting an intensified struggle, here the slope angle was approximately 20-25°. The ibex then turned into a shallow drainage, and 20 m later, we found the first blood.

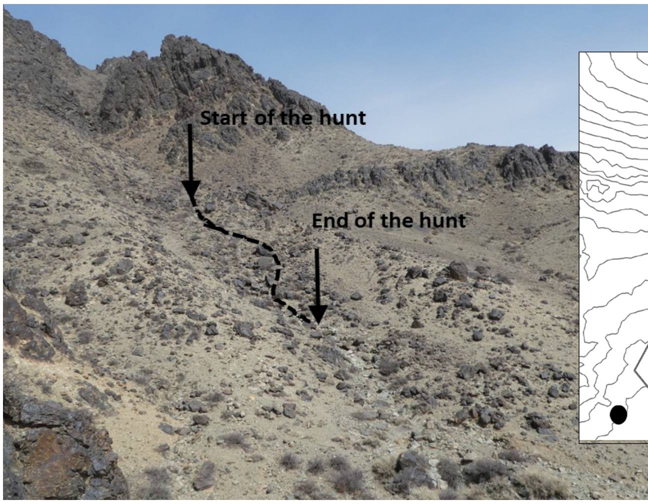

Figure 1: *Picture showing the area where the hunt occurred. The start and end of the hunt are shown by the arrows and the approximate route of the hunt is indicated by the dashed line.*

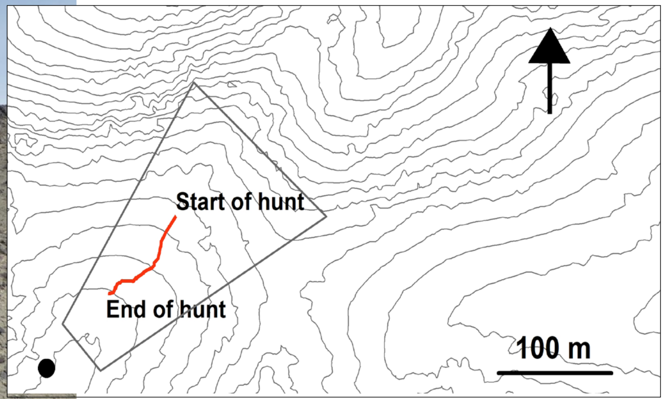

Figure 2: *Map of the hunt where the red line shows the route of the hunt, the thin gray lines are 10 m elevation curves. The view of the photograph in Figure 1 is outlined by the black polygon and the location where the photograph was taken by the black dot.*

Twelve meters further down, the ibex was killed where the drainage flattened out to about 10-15° angle. Total length from the ambush to the kill site was 115 m (Figure 1 & 2).

In a study on predation patterns by GPS-collared snow leopards (Johansson et al. 2015), the kill sites of 17 argali and 158 ibex were classified according to habitat. The majority of these prey (62%) were found killed in the bottom of drainages such as creek beds, gullies and small ravines, with 12 argali (71%) and 97 (61%) ibex.

The snow leopard hunt described here follows the previously described pattern of successful snow leopard hunts where the cat is attacking the prey from above, and the prey flee downhill. As an explanation of the observed pattern, we propose that it is likely beneficial for the snow leopard to stalk and ambush from above and that they are unable to subdue the prey because during the downhill escape the prey maintain momentum. This is true even if the snow leopards lunge on to the prey, especially because the prey is often heavier than the snow leopard itself. It is not until the prey lose momentum by reaching the bottom of the drainage that the snow leopards are able to subdue them. Ambush predators generally do not pursue their prey for long distances, as they need to catch the prey before it reaches its maximum speed and outrun the predator (Schaller 1972, Bailey 1993). The hunt of the male ibex described here lasted for at least 115 m and we suggest that the downhill momentum commonly increase the length of the pursuit compared to other large cats. However, this note is based on tracking and not a direct observation of the hunt, it is possible that we have misinterpreted the signs, it is especially difficult to determine the site of the ambush and where the pursuit starts. Further research on the hunting behaviour of the snow leopard is needed to understand their hunting technique and how topography and other habitat variables affect hunting success. This can be achieved through dense GPS-collaring schedules and detailed tracking of the hunt.

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Snow Leopard REPORTS

Research Note

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Variation in plant composition along a gradient of increasing distance from wells in a mountain steppe in southern Mongolia

Temuulen Ulziibadrakh[1] · Bayarsaikhan Uudus[1] · Purevjav Lkhagvajav[2] · Justine Shanti Alexander[3,4] · Örjan Johansson[3,5] · Koustubh Sharma[3,6] · Gustaf Samelius[3,7,8]

1 National University of Mongolia, Ulaanbaatar, Mongolia
2 Snow Leopard Conservation Foundation, Ulaanbaatar, Mongolia
3 Snow Leopard Trust, Seattle, USA
4 University of Lausanne, Lausanne, Switzerland
5 Swedish University of Agricultural Sciences, Uppsala, Sweden
6 Snow Leopard Foundation, Bishkek, Kyrgyzstan
7 Nordens Ark, Hunnebostrand, Sweden
8 Corresponding author: gustaf@snowleopard.org

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Abstract

Habitat degradation and heavy grazing by livestock are common conservation challenges across the steppes of Mongolia and Central Asia. Livestock grazing patterns are generally not uniform and are typically greater near campsites and watering holes. In this study, we examined how plant composition in a mountain steppe in southern Mongolia varied along a gradient of increasing distance from wells. We found that the cover and average height of *Ephedra prezewalskii* increased with increasing distance from the wells whereas soil chemistry and the other variables of plant composition that we examined were similar along the gradient of

increasing distance from the wells. These results suggest relatively limited impact of livestock grazing on plant composition in our study. However, our study was limited in space and time and further studies are needed to understand the impact of livestock grazing in this mountain steppe in southern Mongolia.

Introduction

Recent decades have seen a significant decline in grassland and rangeland quality across the steppes of Mongolia and central Asia where a large portion of the steppes are now considered degraded (Angerer et al 2008, Berger et al. 2013, Hilker et al 2014). The change in grassland and rangeland quality is attributed both to increasing livestock numbers and to climate change (Angerer et al 2008, Marin 2010, Hilker et al 2014). Livestock grazing patterns generally vary in space and time and are often greater near campsites and wells that are used frequently and often on a daily basis (Fernandez-Gimenez and Allen-Diaz 1999, Pringle and Landsberg 2004, Stumpp et al 2005). Distance from wells therefore have often been used as a measure of grazing pressure that is highest at the wells and decrease with increasing distance from the wells (Fernandez-Gimenez and Allen-Diaz 1999, Narantsetseg et al 2018). Heavy grazing by livestock can have negative impacts on wild herbivores and conservation of wild herbivores in Central Asia therefore depends to a large extent on managing and mitigating the impacts of livestock grazing and climate change (Mishra et al. 2004, Berger et al. 2013). The objective of this study was to examine how plant composition in a mountain steppe in southern Mongolia varied along a gradient of increasing distance from wells.

Methods

Study area

This study was conducted in the Tost Mountains (43° N and 100° E) in southern Mongolia in June and July 2022. The area is part of the Gobi Desert with annual precipitation less than 130 mm and the temperature ranging between -30 in winter and 40° C in summer. Tost Mountains and the surrounding steppes are part of Tost-Tosonbumba Nature Reserve established in 2017 and are home to iconic mammals such as snow leopards (*Panthera uncia*), ibex (*Capra Sibirica*), and argali (*Ovis ammon*). The vegetation is sparse with short grasses and shrubs common in the valley steppes and small shrubs common in the gullies and on the mountainsides. Tost Mountains are home to about 90 semi-nomadic herder families that tend to stay in the mountains in winter (early November–late March) and in the surrounding steppes during the rest of the year (Mijiddorj et al 2018). The size of the Tost mountain are about 1,500 km^2 and the average livestock holding was about 400 livestock per family that comprised mostly of goats (*Capra aegagrus*) and sheep (*Ovis aries*) but also horses (*Equus ferus caballus*) and camels (*Camelus bactrianus*) (Samelius et al. 2020). Goats and sheep are herded and brought to wells on a daily basis whereas horses and camels are largely free-ranging and visit wells and waterholes less frequently (Mijiddorj et al 2018).

Vegetation sampling

We sampled the plant composition at two wells in the Tost Mountains that were visited on a daily basis by goats and sheep. At these two wells, we put two transect lines at each well (one to the north and one to the south) where we sampled the plant composition every 100 meters

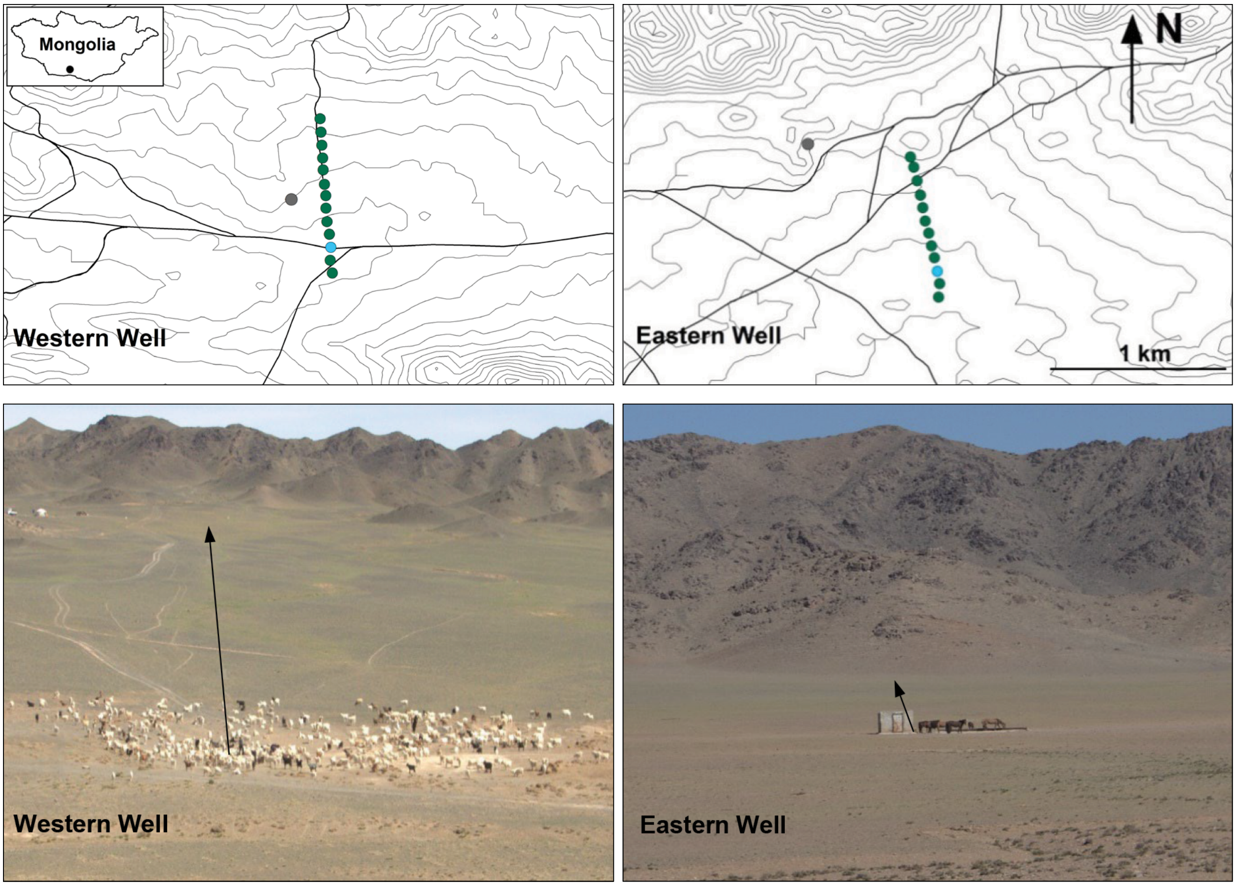

Figure 1: *Location of vegetation sample plots along transects of increasing distance from wells in the mountain steppes of the Tost Mountains in southern Mongolia. The transect lines and sample plots are shown by green dots on the maps and by the black arrows on the photographs. The wells are shown by blue circles on the map and by the start of the arrows in the photographs. Also shown on the maps are small roads (thick grey lines), herder camps (grey circles), elevation curves (thin grey lines), and the location of the Tost Mountains in Mongolia (insert map in upper left map). The wells were visited daily by goats and sheep and occasionally by horses and camels.*

(Figure 1). We standardized the habitat for the transects to be mountain steppe to avoid variation caused by habitat type which resulted in the transects to be of different lengths (n = 23 sample plots from four transects that ranged from 200 to 1,000 m, Figure 1). We sampled the vegetation in June and July, and on each of the sample plots, we sampled (1) total plant cover and plant cover for each of the five most common species based on cover for all sample plots combined (called most common species hereafter) at 3 x 3 m sample plots and (2) average height for each of the five most common species at 1 x 1 m sample plots (where we calculated average height for all plants on the plot). The 1 x 1m sample plots were located at the centre of the 3 x 3 m sample plots. In addition, we also measured soil pH and soil moisture at the centre of the sample plots and we calculated Shannon-Wiener indices for each 3 x 3 m sample plot based on plant cover of all species present at each plot and used this as our measure of plant diversity.

Statistical analyses

We examined how plant diversity, average height of the five most common plant species, soil pH, and soil moisture varied in relation to distance from wells by mixed linear models where we used sample plot as random factor to control for repeated measures and where we included month to control for seasonal variation (n = 23 sample plots from four transects and two wells). Similarly, we examined how overall plant cover and plant cover of the five most common species varied in relation to distance from wells by beta regressions where we used sample plot as random factor to control for repeated measures and where we included month to control for seasonal variation (n = 23 sample plots from four transects and two wells). For the beta regressions, we re-scaled plant cover by following Douma and Weedon (2019). All analyses were performed in program R version 3.6.2 (R Development Core Team, 2014).

Results

Mean plant cover for all plants combined in June and July was 23% (range = 5-43%, Table 1). *Stipa glareosa* was the most common species in June and July in that it had the highest cover at 39 of 46 sample plots. Mean cover for *Stipa glareosa* in June and July was 13% (range = 1-36) and mean cover for the other four of the five most common species in June and July were 1.2% for *Artemisia xerophytica* (range = 0-5%), 0.8% for *Ephedra przewalskii* (range = 0-7%), 0.4% for *Artemisia frigida* (range = 0-2%), and 0.2% for *Oxytropis aciphylla* (range = 0-2%).

Plant composition variable	Mean	Range	St. dev.
Overall plant composition			
Plant diversity (Shannon-Wiener index)	1.3	0.6-1.8	0.3
Plant cover	23%	5-43%	10%
Plant cover individual plants			
Stipa glareosa	13%	1-36%	9%
Artemesia frigida	0.4%	0-2%	0.6%
Artemesia xerophytica	1.2%	0-5%	1.3%
Ephedra prezewalskii	0.8%	0-7%	1.6%
Oxytropis aciphylla	0.2%	0-2%	0.4%
Mean height of individual plants			
Stipa glareosa	4 cm	2-7 cm	0.9 cm
Artemesia frigida	2 cm	1-3 cm	0.4 cm
Artemesia xerophytica	2 cm	1-4 cm	0.7 cm
Ephedra prezewalskii	3 cm	1-4 cm	0.7 cm
Oxytropis aciphylla	2 cm	1-3 cm	0.6 cm
Soil chemistry			
Soil pH	7.9	7.8-8.0	1.1
Soil moisture	1.1	1.0-1.1	0.03

Table 1: *Mean, range, and standard deviation of different plant composition variables in the mountain steppes of the Tost Mountains in southern Mongolia in June and July in 2022*

Plant composition variable	**Test statistic**	**p-value**	**β ± SE**
Overall plant composition			
Plant diversity (Shannon-Wiener index)	0.12	0.73	7 10-5 ± 2 10-4
Plant cover	0.09	0.77	-7 10-5 ± 3 10-4
Plant cover individual plants			
Stipa glareosa	0.08	0.77	-3 10-4 ± 6 10-4
Artemesia frigida	0.06	0.82	-4 10-5 ± 2 10-4
Artemesia xerophytica	0.30	0.59	3 10-4 ± 3 10-4
Ephedra prezewalskii	14.8	**<0.001**	1 10-3 ± 3 10-4
Oxytropis aciphylla	0.25	0.62	-6 10-5 ± 2 10-4
Mean height of individual plants			
Stipa glareosa	1.4	0.24	-7 10-4 ± 6 10-4
Artemesia frigida	0.1	0.76	-2 10-4 ± 4 10-4
Artemesia xerophytica	1.9	0.18	7 10-4 ± 5 10-4
Ephedra prezewalskii	4.2	**0.06**	9 10-4 ± 4 10-4
Oxytropis aciphylla	2.3	0.15	7 10-4 ± 5 10-4
Soil chemistry			
Soil pH	2.0	0.23	1 10-5 ± 1 10-5
Soil moisture	0.33	0.56	-1 10-5 ± 2 10-5

Table 2: *Impact of distance from wells on different plant composition variables in the mountain steppes of the Tost Mountains in southern Mongolia in June and July in 2022. The analyses were based on mixed linear models for all variables except plant cover that was based on beta regression. We used sample plot as random factor to control for repeated measures and we included month to control for seasonal variation (n = 23 sample plots from four transects and two wells). The test statistic for the mixed linear model is the F value and the test statistic for the beta regression is the z value. The slope estimates (β) are given as change per meter and are based on re-scaling of plant cover following Douma and Weedon (2019).*

The Shannon-Wiener index and total plant cover were similar along the gradient of increasing distance from the wells (F = 0.09 0.12, p = 0.73 - 0.77, Table 2). The cover for *Ephedra prezewalskii* increased with increasing distance from the wells (F = 14.8, p<0.001) and there was also a tendency for average height of *Ephedra prezewalskii* to increase with increasing distance from the wells (F = 4.2, p = 0.06) although this was statistically significant only at α = 0.10. The cover and average height for the other four of the five most common species were similar along the gradient of increasing distance from the wells (F = 0.06 - 2.3, p = 0.15 - 0.82, Table 2). Soil pH and soil moisture was similar along the gradient of increasing distance from the wells (F = 0.56 - 2.0, p = 0.23 - 0.33, Table 2) with a mean pH of 7.9 (range = 7.8 - 8.0) and mean soil moisture of 1.06 (range = 0.96 - 1.1) for June and July combined on a relative scale from 1 to 10 where 1 repreents dry conditions and 10 represents moist conditions.

Discussion

Habitat degradation and heavy grazing by livestock are common conservation challenges across the steppes of Mongolia and other parts of Central Asia (Berger et al. 2013, Hilker et al. 2014). In this study we found that cover and average height of *Ephedra prezewalskii* increased with increasing distance from wells (although the latter was statistically significant only at α = 0.10) whereas plant diversity, overall plant cover, and cover and average height for the other four of the five most common species were largely unaffected by distance from the wells. There was thus some, but overall, relatively limited evidence of livestock grazing affecting the plant composition at these wells. Limited impact of livestock grazing in our study was further suggested by *Stipa glareosa* being the most common species at the majority of the sample sites and no tendency for more grazing- and trampling-resistant plants dominating close to the wells as reported in a study from the neighbouring province of Bayankhongor (Narantsetseg et al. (2018). Similarly, limited impact of grazing was suggested also by the soil pH and soil moisture being similar along the gradient of increasing distance from the wells which differs from Wang and Ripley (1997) that found that that soil pH increased with increasing grazing intensity and that soil moisture decreased with increasing grazing intensity in a grassland in north-eastern China. An alternative explanation to much of the plant composition being largely unaffected by distance to the wells could be that there was heavy grazing throughout our study area and therefore limited changes in plant composition and soil chemistry along the gradient of increasing distance from the wells. However, we suggest that this was unlikely because then we would not expect *Stipa glareosa*, but other grazing- and trampling-resistant plants, to be the dominating plants throughout most of the study area (Narantsetseg et al. 2018).

Evidence of relatively limited impact of grazing on the plant composition in our study differs from that in many other parts of Mongolia where the plant composition have been reported to change along gradients of increasing distance from wells (Fernandez-Gimenez and Allen-Diaz 1999, Sasaki et al. 2005, Narantsetseg et al. 2018 but see Fernandez-Gimenez and Allen-Diaz 1999 and Narantsetseg et al. 2018 for how the impact of livestock grazing varied between study sites). It is important to note though that our study was based on small sample size (two wells) and that it was conducted relatively shortly after the onset of plant growth and during a time of the year when many of the herders were on the summer ranges outside of the Tost Mountains (Mijiddorj et al. 2018). Similarly, we did not sample at the wells (i.e. 0 m from the well) where the plant cover was noticeably lower than at the sample sites along our transects that started 100 m away from the wells (Ulziibadrakh, personal observation). Further studies are thus needed to understand the impacts of livestock grazing better in the newly established Tost-Tosonbumba Nature Reserve. We also suggest that studies that compare impacts of livestock grazing in both the mountains and the surrounding steppes may be especially informative.

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Camera trapping reveals habitat overlap between snow leopards and common leopards in Gaurishankar Conservation Area, Nepal

Madhu Chetri [1,2*] · Purna Bahadur Ale[2] · Morten Odden[3]

1 National Trust for Nature Conservation, P.O. Box. 3712, Khumaltar, Lalitpur, Nepal
2,3 Faculty of Applied Ecology, Agricultural Sciences and Biotechnology, Inland Norway University of Applied Sciences, NO-2480 Koppang, Norway
* Corresponding author: mchetri@gmail.com

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Camera traps, Habitat overlap, Lapchi Valley, *Panthera uncia*, *Panthera pardus*

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Abstract

We provide camera trap records of the presence of two large predators: the snow leopard *Panthera uncia* and common leopard *Panthera pardus* from the same habitats in Lapchi Valley of Gaurishankar Conservation Area. Camera traps were laid for 2,304 (mean 88.62 ± SD 103.34) trap nights in 26 locations (elevation range: 2,140 to 4,350 m, area: 141.63 km2). A total of 55, 219 pictures were recorded from November 2022 to May 2023. Out of 26 camera stations, two camera stations captured the images of both species at an altitude of 4,000 m and 4,260 m in Lapchi Valley. The Relative Abundance Indices of snow leopards and common leopards were 7.51 ± SD 6.35 and 9.84 ± SD 6.35 per 100 trap days/nights, and independent detection rates were 0.41 and

0.52 respectively. This is the first evidence of habitat overlap between two large vulnerable predators in Gaurishankar Conservation Area. The nature of the coexistence or competition between these predators needs further investigation.

Introduction

Both snow leopards *Panthera uncia* and common leopards *Panthera pardus* are classified as vulnerable on the IUCN RED LIST (Stein et al. 2020, McCarthy et al. 2017). The species faces several threats because of human encroachment including poaching and trade of their body parts. Data on population status and densities of the two species are limited for the Nepal Himalayas. Similarly, there is no robust population estimate globally, due to their elusiveness, harsh terrain in which they inhabit (snow leopards), and wider distribution (common leopards). However, IUCN RED LIST estimated a population of mature individual snow leopards to be in the range of 2,710 – 3,386 (McCarthy et al. 2017). No such estimates are available for common leopards, and it is believed that the suitable habitats have declined by > 30% globally in the last 22.3 years (Stein et al. 2020).

In 2016, in Qinghai Province, China, common leopard and snow leopard were photographed in the same location (Khagda 2017). Lovari et al. (2013a) found a diet overlap between snow and common leopards, but not in habitat use, in Sagarmatha National Park. However, there have been no records and evidence of the two species sharing the same habitat in Gaurishankar Conservation Area (GCA). In this manuscript, we provide the first evidence of the presence of snow leopards and common leopards in the same habitat in Lapchi Valley of GCA.

Methods

Study Area

We conducted a camera trapping survey from November 2022 to May 2023, in Lapchi Valley of GCA (Fig 1), GCA (area: 2,179 km^2, location: E 85° 46.8’ - 86° 34.8’ and N 27°34.2’ - 28°10’, altitude ranges: 968 – 7134 m asl.) is located in between two important national parks – Langtang National Park in the west, and Sagarmatha National Park in the east and acts as a biological corridor (Fig 1). It was established in 2010 and is managed by the National Trust for Nature Conservation. It covers three districts – Dolakha, Rammechhap, and Sindupalchok. The northern border is adjacent to the Tibetan autonomous region of the People’s Republic of China. It is continuous with the largest nature reserve in Tibet, i.e., Qomolangma National Nature Reserve. The area is rich in both floral and faunal diversity due to diverse physiographic and climatic zones which vary from mid-hills to high mountains and from subtropical to arctic (GCA 2022). Nearly 70,000 people are living within GCA. The main source of income for the local communities are animal husbandry and terrace farming. At higher elevations, rangelands are used for grazing livestock such as goat, sheep, cow, horses, dzo (yak-hybrid), and yak. Transhumance traditions are also present in some remote northern villages, for example in Lapchi Valley where approximately 100 residents Buddhist community people live following a pastoral lifestyle. Lacphi Valley encompasses an important beyul and pilgrimage center for Tibetan Buddhism.

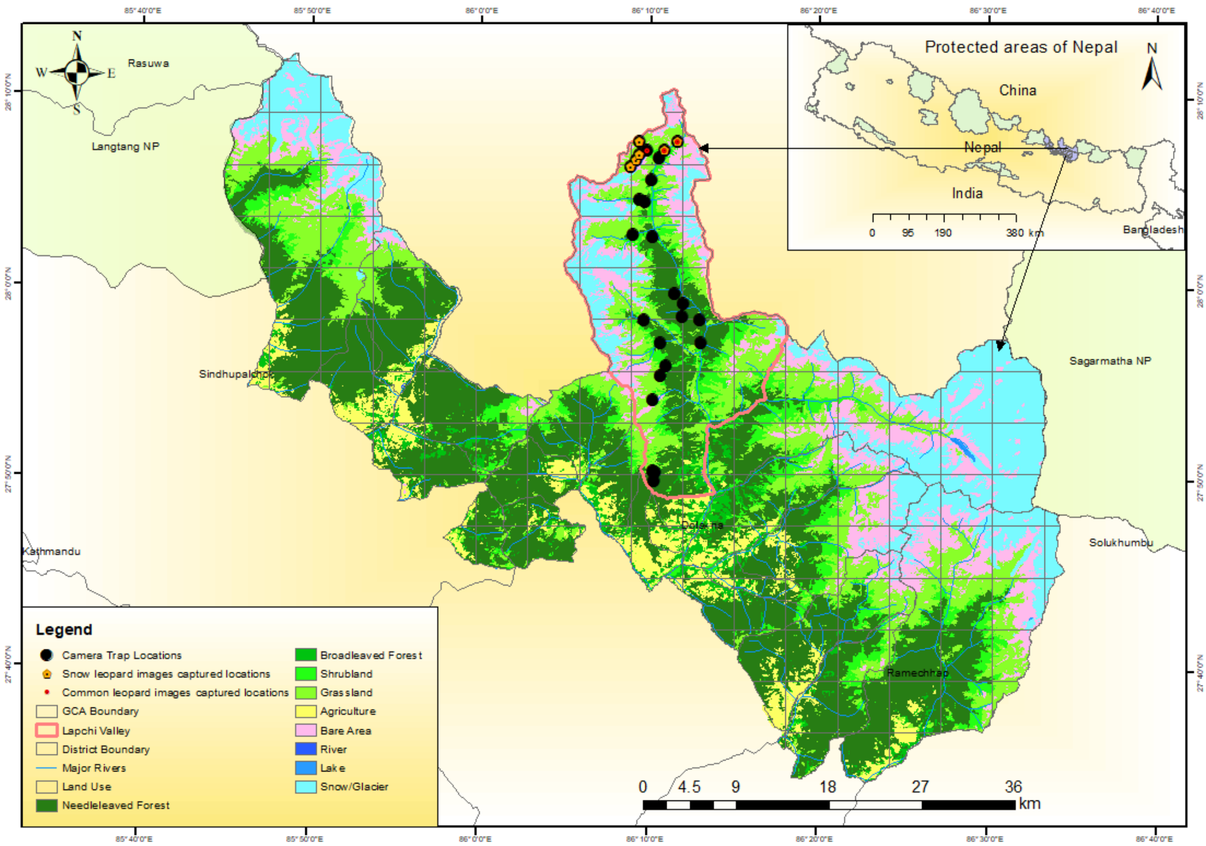

Figure 1: *Location map of the study area showing study grid cells.*

Site Selection and camera trapping

We divided the entire Lapchi Valley into 5x5 km grid cells using ArcGIS. Camera traps were placed on major livestock trails, junction of the trails, ridgeline and in the mountain passes. Camera traps were deployed in 8 grid cells covering an area of 141.63 km^2 and monitored regularly. Each grid cell had one to two pairs of camera traps. In total, we deployed 40 camera traps across 26 locations at an elevation range of 2,140 to 4,260 m asl, with a minimum distance of 1 km between each trap. Regrettably, we lost 7 camera traps, so the analysis was conducted using data from 33 camera traps only.

Data management and analysis

All camera trap images were managed by using CameraSweet program as described by Sanderson and Harris (2013). Relative Abundance Index (RAI) is expressed as the number of independent images per 100 trap nights (Harris et al. 2010; Jenks et al. 2011; Sanderson and Harris 2013). We computed RAI only for wild mammals. Other species photographs including humans, birds, yak, dog, horse, and unknown species were not included in the analysis. We defined capture events as separate images of a species at a particular location with a time gap of 30 minutes.

Results

A total of about 55,219 pictures were recorded from November 2022 to May 2023. A comprehensive analysis was conducted on 1,816 photographs of various species obtained from camera traps (Table 1). Out of the 386 independent images, 29 images were of snow leopard from 6 camera locations, and 38 images were of common leopard from 8 camera locations. These images were captured over a span of 2,304 trap nights (mean 88.62 ± SD 103.34). Two camera stations located at Lyamadinka kharka (4,260 m) and Lapchi Deurali (4,000 m) capture images of both snow leopards and common leopards (Photo A and B). The Relative Abundance Indices of snow leopards and common leopards were 7.51± SD 6.35 and 9.84 ± SD 6.35 per 100 trap days/nights and independent detection rate are 0.41 and 0.52 respectively. Although scrape and pugmark signs of both common – and snow leopards were recorded near Lapchi village (3,870 m), we were able to obtain pictures of only common leopards. A total of 19 mammalian species were recorded from the Lapchi valley. The highest RAI recorded was of Himalayan musk deer (24.87) followed by Mainland serow (10.62), Leopard cat (10.1), Common leopard (9.84), and Snow leopard (7.51) respectively (see Table 1).

Discussion

The occurrence of snow leopards and common leopards in the same ranges raises many interesting questions for future research in the Gaurishankar Conservation Area. Similar records are also available from other snow leopard range countries (see Pal et al. 2022, Buzzard et al. 2017, Snow Leopard Trust 2017). In addition, recent record from the Great Himalayan National Park in Himachal Pradesh, India at an elevation of 2,495 m also indicates the potential cooccurrence of the common leopard with the snow leopard (Bandyopadhyay et al. 2019). With the changing climate, the tree line is moving upward (Hansson et al. 2021) which might create more suitable habitat for the highly adaptable common leopard, and shrink the habitat for more specialized snow

Photo 1A & B. *Snow leopard and common leopard in the same habitat. Snow leopard and Common leopard camera trap photos in Lapchi Valley of Gaurishankar Conservation Area, Nepal.*

SN	Species	RAI (number of independent camera-trap captures/ 100 trap-nights)	Minimum-Maximum elevation (m)	IUCN Status
1	Asiatic Golden Cat Pardofelis temminckii	0.26	3530*	NT
2	Royle's Pika Ochotona roylei	0.26	4120*	LC
3	Kashmir Gray Langur Semnopithecus ajax#	0.52	2140*	EN
4	Himalayan Marmot Marmota himalayana	0.78	4070-4120	LC
5	Yellow-throated Marten Martes flavigula	0.78	2790-3750	LC
6	Himalayan Tahr Hemitragus jemlahicus	1.04	2640-3600	NT
7	Wild Boar Sus scrofa	1.3	2640-3340	LC
8	Himalayan wolf Canis lupus chanco	1.55	4000-4260	LC
9	Northern Red Muntjac Muntiacus vaginalis	1.81	2310-3240	LC
10	Bharal/Blue Sheep Pseudois nayaur	1.81	3870-4120	LC
11	Himalayan Goral Naemorhedus goral	1.81	2140-3340	NT
12	Assam Macaque Macaca assamensis	5.7	2140-2790	NT
13	Himalayan Black Bear Ursus thibetanus	5.96	2640-3750	VU
14	Snow Leopard Panthera uncia	7.51	3990-4260	VU
15	Common Leopard Panthera pardus	9.84	2790-4260	VU
16	Leopard Cat Prionailurus bengalensis	10.1	2310-4000	LC
17	Himalayan/Mainland Serow Capricornis thar	10.62	2640-3750	VU
18	Red Fox Vulpes vulpes	13.47	3460-4260	LC
19	Himalayan Musk Deer Moschus leucogaster	24.87	3220-4260	EN

Note: * Recorded only in one location, # species needs genetic verification

Table 1: *Relative Abundance Index (RAI) of the major species in Lapchi valley of Gaurishankar Conservation Area, Nepal.*

leopards. Forest et al. (2012) reveals that 50% of the current snow leopard habitat in the Himalayas will be altered due to shifting tree line, which will ultimately lead to shrinkage of snow leopard habitats and alpine zone. Currently, it is important to investigate whether the spatial overlap between the two predators leads to competition for food. Lovari et al. (2013a) found that the two species share food but not habitat in Sagarmatha National Park, which is adjacent to our study site. The snow leopard mostly preferred habitats above tree line and common leopard preferred forest habitats and sometimes visited the edge of tree line for hunting (Lovari et al. 2013a). Our camera trap that photographed both species was deployed in a human trail leading to Tibet and alpine pasture for livestock grazing. The lower slope is very close to the forest edge of the upper tree line dominated by Himalayan birch (*Betula utilis*) and the under scrub is dominated by dwarf Rhododendron (*Rhododendron nivale*) and Juniper (*Juniperus indica*). Lovari et al. (2013b), found that in areas where prey availability is limited, the two species live in sympatry and interspecific competition could develop at the junction of close and open habitats. This seems true in our study area, as the number of preferred prey species of snow leopards, mainly the blue sheep (Chetri et al. 2017) is very low. During May 2022, we counted a total of 32 individual blue sheep (*Pseudois nayaur*) in four herds. Other prey species found in the area are Himalayan musk deer (*Moschus leucogaster*) and a small number of Himalayan marmots (*Marmota himalayana*). Villagers also claim high livestock depredation, which reveals livestock may play an important role in substituting wild prey of both snow leopard and common leopards. Our camera traps also captured images of snow leopards from forest habitats at an altitude of 3990 m. We assumed this was mainly due to the low number of prey animals in the alpine zone. Snow leopards move to lower elevations in the forest habitats to hunt forest-dwelling species such as Himalayan goral (*Naemorhedus goral*), Himalayan musk deer, and Himalayan tahr (*Hemitragus jemlahicus*). This indicates that there might be a high habitat overlap between the two predators in GCA. However, our understanding of how these two species interact remains limited. There is a need to increase research efforts to understand how these two species associate, which may differ depending on environmental and biological factors. Further studies concentrating on seasonal movements, habitat use, and diet overlap might increase our knowledge of these important predators in GCA.

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Conflict of Interest

No known conflicts of interests.

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“When we privilege computer work, camera-traps and other technologies, at the expense of field work, as well as of the researcher’s eyes and brains, the risk is to turn the real world into a virtual one, perhaps impressive and showy, but often deceptive. Insights come from watching animals in the wild, thus learning to think as they do.” – **Professor Sandro Lovari**

Snow leopard tracks in the Gobi desert, Mongolia (*Photo by Justine S Alexander)*

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