

Snow Leopard

Ecology and Conservation Issues in India

Abhishek Ghoshal

Snow leopard, an elusive mammal species of the cat family, is the top-predator of the Central and South Asian, high-altitude ecosystem. Snow leopards occur at low densities across the Central Asian mountains and the Indian Himalayan region. Owing to their secretive nature and inaccessible habitat, little is known about its ecology and distribution. Due to its endangered status and high aesthetic value, the snow leopard is considered as an ‘umbrella species’ for wildlife conservation in the Indian Himalayas. This article summarizes the current knowledge on snow leopard ecology and conservation issues in the Indian context.

Large Mammal Conservation Issues in India

Several species have lost their habitats, and once contiguous wildlife habitats have been severely affected by human pressures globally. Across different ecosystems, numerous species today face large-scale range contraction and extinction. The risk of extinction for a species is driven by a combination of its life-history traits, ecological factors, an array of natural biotic and abiotic factors, and anthropogenic disturbances. Among all animals, large mammals are particularly more vulnerable to local extinctions due to their body size, high food requirements, and need for larger spaces. Within large mammals, large carnivores especially, require a considerable area for hunting, finding mates, and maintaining territories. Carnivores also face retribution killing under many circumstances due to interaction with humans, as they often inflict losses through livestock depredation. Large carnivores are often considered to be the ‘umbrella’ or ‘flagship’ species that govern the dynamics of an ecosystem. However, due to their large



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ranging nature and elusive characteristics, gathering reliable ecological information at large spatial scale is extremely challenging in the case of most large carnivores. The deficiency of reliable information significantly hinders carnivore conservation since conservation efforts need to be implemented at large spatial scales.

India has an exceptionally rich and highly diversified flora and fauna, exhibiting complex composition, characteristics, and affinities. Over the past century, land-use changes and human population growth have severely affected most Indian mammal species and their habitats. About 20% of large Indian mammals face extinction, and many others have lost over 90% of their historical range [1]. Recognizing the need for baseline knowledge on the current distribution of large mammals, large-scale studies were implemented. These studies aimed to understand the geographical range and associated ecological, social, and cultural factors explaining the distribution patterns of several large mammal species in India. These studies have reported an overall decline in the distribution of most large mammals, especially large carnivores.

In comparison to many large mammals of the Indian tropics, our knowledge on the ecology and conservation issues of high-altitude large mammalian assemblage remains limited. One of the most charismatic and endangered species among large carnivorous mammals found in the Indian Himalayas is the snow leopard (*Panthera uncia*). The snow leopard is the top predator of the Indian Himalayas and the Trans-Himalayas, playing an important role in maintaining the food chain dynamics of the high-altitude ecosystem. That is why snow leopard is considered as the umbrella species for conservation of wildlife in the Indian Himalayas and the Trans-Himalayas.

Snow Leopard: Taxonomy

Snow leopard or *Panthera uncia* (Schreber, 1775) belongs to the family Felidae (family of cats). Genetically it is closest to tiger (*Panthera tigris*). The evolutionary divergence between tigers and



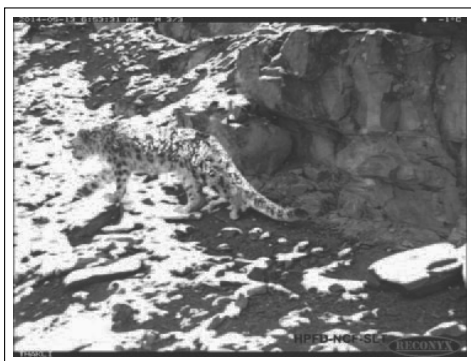


Figure 1. The yellowish smokey-grey pelage with dark grey open rosettes and black spots provide snow leopards effective camouflage in its mountainous habitat and snow.

(Camera trap image: NCF-SLT-HPFD)

snow leopards occurred over 2 million years ago. Genetic analyses of snow leopard reveal diploid¹ chromosome number to be 38, and the fundamental number is 36. Surprisingly, fossil records of snow leopards are meager; the only confirmed fossil remains belong to the upper Pleistocene period from the Altay caves of Central Asia.

¹Two complete sets of chromosomes contributed by each parent.

Snow Leopard: Morphology

The ability of snow leopards to camouflage with the surrounding landscape of rocks, sparse low vegetation, and snow is crucial for its hunting success (*Figure 1*). Snow leopards are whitish-grey in color (often with a hint of yellow), with dark-grey rosettes and spots. The snow leopard is perfectly adapted to live in the high-altitude environment. It has an enlarged nasal cavity for better breathing in the thin air of the high-altitudes. Short limbs (adults at shoulder height is about 60 cm) and strong chest muscles aid in climbing steep and rugged cliff-dominated areas. Long hair with dense, woolly underfur (belly fur grows as long as 12 cm) protects the snow leopards from icy winds. The tail, up to one meter long (75–90% of head-body length), is used for balancing on narrow rocky outcrops and cliffs (*Figure 2*). Snow leopards shed their hair and body fur (molting) twice a year. But the summer and winter coats are more or less similar. Adult males are larger than adult females (dimorphic); a male on average weighing between 45–55 kg, while a female 35–40 kg.

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Figure 2. Snow leopards use prominent landform features such as ridgelines, ravines, and cliff-bases for movements. The long flexible tail helps it balance in very steep areas. (Camera trap image: NCF-SLT-HPFD)



Figure 3. Snow leopards are usually solitary animals. This camera trap image shows four sub-adults, perhaps exploring their home range before venturing out to establish their own territories. (Camera trap image: NCF-SLT-HPFD)



Snow Leopard: Ecology

Snow leopards are generally solitary animals, yet groups of up to six snow leopards have been reported. During camera trapping² in the Spiti Valley of Himachal Pradesh, up to four snow leopards have been captured in a single frame (*Figure 3*). They mate during winter, usually between January and March. During this period, snow leopards mark their territories intensively using scent spray, scrape, claw raking, and scat. These social markings are made along their trails and are usually found along or close to prominent landform features such as ridgelines, cliff bases, large boulders, and the confluence of streams (*Figure 4*). Gestation period in snow leopards is between 93 to 110 days. Litter size may vary between one to five cubs. Cubs are generally born between June and July (peak summer).

²Camera with movement and/or heat sensor used to capture images of elusive wildlife.





Figure 4. Snow leopards, like any other member of the cat family, mark their territory by scent and scrape marking, and depositing scat. A snow leopard is seen scent-marking the undersurface of a rock-wall (Camera trap image: NCF-SLT-HPFD)

Home Range and Movement

Snow leopard is a large ranging species with overlapping home ranges. A study in Nepal, based on data from five snow leopards showed that their home ranges varied between 12 to 39 km² with substantial overlap between individuals and among sexes. Home ranges of snow leopards have been reported to be very different and are usually much larger in Central Asia. In Mongolia, reported home ranges of both males and females were greater than 400 km², and often more than 1,000 km². This is potentially due to low availability of food resources in the desert landscape. Intensive camera trapping across 4,000 km² area in Spiti Valley in Himachal Pradesh, showed an average home range size of 130 km². Individual snow leopards have been observed to cover straight line distances of 1 to 2 km between consecutive days, but may also undertake periodic long-distance travels of more than 20 km within a single day. Research suggests that a snow leopard remains within a relatively small area for a week to 10 days. Following this period, activity-core shifts to another distant part of its home range, perhaps in response to the availability of wild prey species. Several studies suggest that snow leopards mark their core areas significantly more than other areas within the home range. This suggests that social marking has an important role to play in spatially separating individuals.



Figure 5. Spiti Valley in Himachal Pradesh is a prime snow leopard habitat. The Kee monastery is an important religious establishment in the valley supporting snow leopard conservation.



Snow Leopard: Habitat

Snow leopards occur primarily in the alpine zone between 3,000 m to 5,200 m above mean sea level (Figure 5). However, in the northern limits of their distribution range, snow leopards are also found at much lower elevations (between 900 m to 2,500 m). Generally, steep (more than 40° slope), rugged, mountainous terrain with abundant stalking cover such as rocky outcrops and cliff dominated areas constitute suitable habitat for snow leopards. However, snow leopards do sometimes traverse open pastures, given there is ample cover available. Shrubs and grasses dominate the vegetation in snow leopard habitats, with trees being very rare. In certain areas, sparsely distributed patches of birch (*Betula* spp.), poplar (*Populus* spp.), and willow (*Salix* spp.) are seen. Snow leopards avoid dense forests. This preference potentially separates the distribution ranges of snow leopards and common leopards (*Panthera pardus*), as the latter is primarily adapted to inhabit forested zones. Snow leopards may migrate to lower elevations during winter to avoid deep snow and to follow primary prey species such as the blue sheep or bharal (*Pseudois nayaur*), Siberian or Asiatic ibex (*Capra sibirica*), and Kashmir markhor (*Capra falconeri*).

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Figure 6. Bharal or blue sheep, one of the primary prey of snow leopard, prefers high-altitude rolling terrain interspersed with cliffs.



Figure 7. A mixed herd of Asiatic ibex in Spiti Valley, Himachal Pradesh. Ibex is another main prey of snow leopard in the Indian Himalayas, found in steep and rugged areas west of the Satluj river.

Prey, Diet, and Depredation

Major wild preys of the snow leopard are ibex, bharal or blue sheep, Himalayan tahr (*Hemitragus jemlahicus*), argali (*Ovis ammon*), and marmots (*Marmota* spp.) [2]. Blue sheep and ibex constitute the primary prey species of snow leopards across its global distribution range (Figures 6 and 7). Apart from these, snow leopards also prey on urial (*Ovis* spp.), red deer or hangul (*Cervus elaphus*), roe deer (*Capreolus pygargus*), and musk deer (*Moschus* spp.). Snow leopards also consume vegetation, and scat has been reported containing only twigs [3]. Wild prey may contribute between 45%–98% to snow leopard diet. In some areas, domesticated livestock constitutes a major part of snow leopard diet (between 40%–70%), though usually livestock contribution remains between 15%–30% [4].

Snow leopards may inflict considerable losses to herders and

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local communities through livestock depredation. Loss of 3%–18% of local livestock holdings annually to snow leopards has been reported from certain Himalayan areas. As mentioned above, the overall contribution of livestock to snow leopard diet could be as high as 70% and include large-bodied livestock (e.g., horse, donkey) as well. In the Tibetan Plateau, losses of livestock averaging about 2% per village and up to 9.5% in some sites have been recorded. A study in Nepal's Annapurna Conservation Area found livestock remains in about 18% of snow leopard scat samples collected. This percentage soared to 39% in winter, potentially due to the scarcity of food sources owing to marmot hibernation, deep snow, and yak herds relatively huddling more together during winter. Livestock depredation by snow leopard continues to be a major challenge in the coexistence of humans and snow leopards.

Conservation Challenges in the Himalayas

The Indian Himalayas and the Trans-Himalayas form the southern limits of the global distribution range of snow leopards, and is home to about 10% of the global population (estimated at about 7,500), in less than 5% of its global range. Snow leopards mostly occur at low densities throughout its range (about one snow leopard per 100 km²). In India, snow leopards occur almost contiguously across 1,00,000 km² of the alpine zone of the Himalayas and the Trans-Himalayas above elevations about 3,000 m in the Western Himalayas and about 4,000 m in the Eastern Himalayas. A recent national scale assessment shows that 95% of potential snow leopard range in India is yet to receive any research attention, and about 80% of its habitat is unprotected. The overall snow leopard population estimate for India, according to this study, is around 500 individuals.

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The potential habitat of snow leopards across the Greater and Trans-Himalayan landscape, in general, is experiencing drastic socio-economic changes over the past few decades. Major changes have been documented in the Spiti Valley of the Lahaul and Spiti





Figure 8. Livestock grazing is a major livelihood in the mountains. Often grazing at high densities reduce forage availability to wild-preys of snow leopard, in turn reducing wild-prey densities.

district, owing to the advent of green pea (*Pisum sativum*) cultivation during the mid-1980s and the advent of apple cultivation around the same time in Kinnaur district. Studies on snow leopard habitats over the past two decades show that the economy of the region has rapidly shifted from traditional agro-pastoralism to market-driven agriculture. Consequently, human population growth, agricultural expanse, and excessive livestock grazing (Figure 8) have been pervasive in the region. Developmental activities like hydroelectric projects, road constructions, and tourism activities in prime habitats of snow leopards have opened up remote and hitherto undisturbed areas, increasing human access and pressures. Increasing job opportunities through infrastructure development projects are attracting laborers from distant places who differ socio-economically and culturally from the local inhabitants. These changes over the years and growing human needs have resulted in a gradual erosion of traditional tolerance; especially towards the snow leopard (for livestock depredation) and wild herbivores (for crop raiding and forage competition with the livestock). Many of the traditional threats are getting replaced by new and more devastating ones such as poaching by non-native laborers, habitat fragmentation due to fencing of agricultural lands, forage competition with wild herbivores due to intense and unchecked grazing (Box 1), etc. A rapidly increasing tourism infrastructure in villages and townships and the ensuing mismanagement of garbage is aiding in an increase in the population of free-ranging/feral dogs (Box 2). Feral dogs are hunting in

Climate change predictions suggest that about a third of the snow leopard habitat is vulnerable to shift in treeline and resulting shrinkage of alpine habitat in the Himalayas.



Box 1. Migratory Livestock Grazing: Long-standing but Poorly Understood Threat!

Migratory livestock grazing in the Himalayas utilizes seasonal variations in resource availability across higher and lower altitudes and is a widespread practice in the Western Himalayas (Uttarakhand, Himachal Pradesh, and Jammu & Kashmir). Under the already low productivity of the high-altitude ecosystem, migratory livestock grazing is likely to have strong impacts on pasture quality through lowered above-ground biomass and plant cover (*Figure A*). Changes in vegetation characteristics can, in turn, lead to competition and ultimately the displacement of wild prey to suboptimal habitats. Behavioral changes in wild prey have been documented through reduced foraging time and increased vigilance in areas with low vegetation availability [5]. Interference and exploitative competition are expected to lower population performance of wild prey, eventually leading to a decline in their population.

Research suggests a strong linkage between migratory livestock grazing in snow leopard habitats and local, regional and national markets for wool, milk, and meat. This linkage is the key towards economic demand for larger herd sizes. Trade-driven livestock production systems have been known to influence decimation of natural prey-base of snow leopards in Central and South Asian mountainous ecosystems [6]. Additionally, the issue of migratory livestock grazing has been socio-politically contentious, being more often dealt through activism than science-based ecological evidence.



Figure A. Sheep being herded to a pasture from a campsite of a migratory herder. Migratory livestock grazing is inherently carried out at very high densities as they are not constrained by winter forage availability. Notice the barren nature of the Trans-Himalayan slopes.

packs out in the wild for blue sheep and ibex and pose a serious threat to solitary species like snow leopards. Deprivation of prey species continues to be a primary threat to snow leopards in parts of the Greater Himalayas and some areas of Trans-Himalayas. The snow leopard habitat faces considerable threat from climate change as well. Climate change predictions suggest that about a



Box 2. Feral Dog: An Emerging Threat to Snow Leopard

Dogs are almost ubiquitous in India. They are now widespread even in the remote mountainous tracts of the country. A thin line that separates feral dogs from stray dogs of cities, towns, and villages is that the former relies heavily on food available in the wild. Unmanaged garbage dumps and improper disposal of livestock carcasses are mainstays for large populations of feral dogs. Garbage generated from rapidly increasing tourism facilities in large villages and townships, and dogs being abandoned by migratory herders are the root cause of the issue of feral dogs in the Indian mountains. Exotic predators such as feral dogs can have profound negative effects on native wildlife. The impact can be especially strong on smaller predators such as the red fox – *Vulpes vulpes* [7], other small mammals, and even top predators like the snow leopards. Predation, interference, competition, restriction of spatial distribution of species and access to forage rich areas, spatial segregation, hybridization, and disease transmission are the potential ways in which dogs can affect native wildlife. Apart from wildlife, dogs are also reported to cause considerable damage through livestock depredation, which even surpassed depredation by large native carnivores such as snow leopards and Tibetan wolves [4]. Dogs have been seen attacking and feeding on prey species of snow leopards such as blue sheep and ibex on numerous occasions. There are instances when a pack of dogs was seen to successfully chase away a snow leopard.

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Additionally, owing to the remote and rugged terrain of the snow leopard habitat, monitoring snow leopards and wild prey populations is extremely challenging (*Figure 9*). For the same reasons, protecting and patrolling snow leopard habitats to prevent illegal activities even in protected areas (PAs) is time and effort intensive, thus, often hardly feasible. Most conventional monitoring and survey techniques applied in the tropics (e.g., line transect and distance sampling methods for prey density estimation, and capture – mark – recapture technique for carnivore population estimation) prove to be costly and require to be modified for the mountainous terrain to be efficient.

Finally, there is an enormous limitation of trained professionals (biologists, researchers, and managers) in the field of high-altitude ecology and conservation in India; especially pertaining to snow leopards. The nodal agencies mandated with the task of habitat management and conservation – the State Forest



Figure 9. Research team of Nature Conservation Foundation, Mysore, walking a snow leopard sign transect above 5,000 m in Spiti Valley.



or Wildlife Departments – are often understaffed, inadequately trained, and resource constrained.

Conservation Action

Snow leopards have been given the highest level of legal protection in India under the Indian Wildlife (Protection) Act, 1972. Also, India is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Convention on the Conservation of Migratory Species of Wild Animals (CMS), providing additional protection to the snow leopard. Since the late 1990s, based on research and in partnership with local forest departments, different forms of specific conservation interventions were initiated especially in Ladakh (Jammu and Kashmir) and Spiti (Himachal Pradesh) regions. These steps include improved livestock corral to reduce depredation, livestock insurance program to compensate livestock loss to the local community, and establishing grazing-free reserves to increase wild prey population. The most recent forms of participatory local conservation initiatives are those of ‘Snow Leopard Enterprise’ (SLE) that focuses on empowering local women by facilitating the production of ‘wildlife friendly’ wool products, and engagement of snow leopard conservationists with pashmina wool growers to develop sustainable grazing practices for pashmina production and trade. The uniqueness of the Indian snow leopard habitat from other tropical ecosystems is the widespread occurrence

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of wildlife across the mountainous landscape. Here, wildlife is not limited to the protected areas but coexists with humans in multiple-use landscapes. Owing to this feature of the distribution range of snow leopard and the vast interface with local communities, the Government of India launched a landscape level participatory conservation program for the Indian high-altitudes called the 'Project Snow Leopard' (PSL) in 2009 [8]. The framework of PSL allows conservation of multiple-use large landscapes even outside PAs. Over the past decade, the snow leopard range countries have joined hands to develop national and trans-boundary conservation initiatives in the form of National Snow Leopard Ecosystem Priority Protection (NSLEP), Snow Leopard Survival Strategy (SLSS) [9], and Global Snow Leopard and Ecosystem Protection Program (GSLEP). As part of GSLEP, two large landscapes have been identified in India across Himachal Pradesh, Ladakh (Jammu & Kashmir), and Uttarakhand to secure breeding populations of snow leopard. Institutions and organizations working towards enhancing knowledge on snow leopard ecology and its conservation in India include (but may not be restricted to) Wildlife Institute of India, Nature Conservation Foundation – Snow Leopard Trust, World Wildlife Fund for Nature – India (WWF), and Snow Leopard Conservancy.

Epilogue

Snow leopard symbolizes the rich natural and cultural heritage of the Indian high-altitudes. The unique high-altitude ecosystem inhabited by snow leopards offer invaluable livelihood, ecosystem, and economic services to millions of local and national populace. Snow leopard habitat forms the source of most of the life-sustaining rivers of Asia, including Indus, Satluj, Brahmaputra, and Ganga. Snow leopard itself is a major attractor of tourism in the Himalayas, thereby, contributing to the local economy. Although challenges are many, it is on us to grab the opportunities of working together and help this unique, fascinating species persist in the future. The layer of thick snow in the Himalaya gets a bit monotonous without the occasional long, unbroken sets of

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snow leopard pugmarks.

Suggested Reading

- [1] M D Madhusudan and C Mishra, Why Big, Fierce Animals are Threatened: Conserving Large Mammals in Densely Populated Landscapes, *Battles Over Nature: Science and Politics of Conservation*, Eds. V Saberwal & M Rangarajan, pp.31-55, Permanent Black, New Delhi, 2003.
- [2] Lyngdoh *et al.*, Prey Preferences of the Snow Leopard (*Panthera uncia*): Regional Diet Specificity Holds Global Significance for Conservation, *PLoS ONE* 9(2): e88349. doi:10.1371/journal.pone.0088349, 2014.
- [3] R S Chundawat and R S Rawat, Food Habits of Snow Leopard in Ladakh, India, 1994, pp.127–132 in: J L Fox and Du Jizeng (Eds), *Proceedings of the Seventh International Snow Leopard Symposium*, (Xining, Qinghai, China, July 25–30, 1992), International Snow Leopard Trust, Seattle, Washington.
- [4] Suryawanshi *et al.*, People, Predators, and Perceptions: Patterns of Livestock Depredation by Snow Leopards and Wolves, *Journal of Applied Ecology*, Vol.50, No.3, pp.550–560, 2013.
- [5] M Kohli, M Sankaran, K R Suryawanshi, and C Mishra, A Penny Saved is a Penny Earned: Lean Season Foraging Strategy of an Alpine Ungulate, *Animal Behaviour*, Vol.92, pp.93–100, 2014.
- [6] J Berger, B Buuveibaatar, and C Mishra, Globalization of the Cashmere Market and the Decline of Large Mammals in Central Asia, *Conservation Biology*, Vol.27, No.4, pp.679–689, 2013.
- [7] Ghoshal *et al.*, Response of the Red Fox to Expansion of Human Habitation in the Trans-Himalayan Mountains, *European Journal of Wildlife Research*, Vol.62, pp.131–136, 2016.
- [8] The Project Snow Leopard, Ministry of Environment & Forests, Government of India, New Delhi, 2008.
- [9] Snow Leopard Network – Snow Leopard Survival Strategy, Revised 2014 Version Snow Leopard Network, Seattle, Washington, USA, 2014.

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