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Chapter

Ecology and Conservation of Mountain Ungulate in the Western and Trans Himalayas, India

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Abstract

The Western and Trans-Himalayan region of India is home to several unique and threatened mountain ungulates including Kashmir red deer or Hangul, Kashmir Musk deer, Urial, Argali, Tibetan Antelope or Chiru, Tibetan Gazelle, Wild Yak, and Wild Ass that are endemic to this region. However, this ecologically significant and diverse biodiversity is threatened by climate change, habitat degradation, and fragmentation accompanied by overexploitation in the form of poaching. In locations where the ungulates are common, the situation inevitably leads to human-wildlife conflict. All these have caused many wildlife species to become ecologically isolated, reduced in numbers, and in the process of becoming locally extinct. Over the years, I have undertaken extensive surveys to assess the status of 20 ungulate species inhabiting the Himalayan region belonging to four families, namely *Bovidae*, *Cervidae*, *Equidae*, and *Moschidea* including the eight out of the 10 most highly endangered ungulates in India, which are unique to this region. The results of our findings on the current status, information on the lesser known aspects of ecology, and critical factors determining the population decline, knowledge gaps, conservation threats, and management suggestions are presented in this paper.

Keywords: Himalayas, ungulates, Hangul, Chiru, musk deer, argali, Urial, gazelle

1. Introduction

Himalayas are one of the 36 Biodiversity hotspots in the world. The Himalayan region spreading across 2400 km from Kashmir in the North West to Arunachal Pradesh in the east covers nearly 6.41% of the total area of India. The Himalayas are geographically divided into four biotic provinces or sub regions, namely the Northwest Himalayas, Western Himalayas, Central Himalayas, and Eastern Himalayas [1].

The Western Himalayas largely comprises the North Western Himalayas ($30^{\circ} 18'$ to $32^{\circ} 06'$ north and $72^{\circ} 32'$ to $79^{\circ} 04'$ east), which ranges from Kashmir to river Sutlej in Himachal Pradesh [1] and the Western Himalayas ($29^{\circ} 5'$ to $31^{\circ} 25'$ north and $77^{\circ} 45'$ to 81° east) comprising of the Garwal and Kumaon hills and eight hill districts of Uttarakhand between Kali and Sutlej rivers [1].

Much of the geographical area of North Western and Trans Himalayan region of India encompasses largely the Jammu and Kashmir and Ladakh besides Lahul and

Spiti districts of Himachal Pradesh and is located at the intersection between the temperate Palearctic and tropical Oriental Biogeographic regions of the World [1].

South to north the mountain ranges here are the Shivaliks, Pir Panjal, Great Himalaya, Zaskar, Ladakh, and Karakoram, and enormous biodiversity and endemism are seen in these ranges as a result of the extreme variations related to temperature and rainfall [1–4]. Between Pir Panjal and the Greater Himalayan mountain range lies the Kashmir valley, which with an area of ca. 15,520 sq.km, is the largest valley in the entire Himalayan range.

As the Western Himalayas merges with the Hindukush and then the mountains of Central Asia, the faunal diversity of the region is marked by the presence of Northern Palearctic elements [1, 2, 5]. The rich diversity of species inhabiting the north western and Trans-Himalayas region is shown by the mammals (110 species, 26% of diversity of India) over 500 species of birds (40% of avifauna of India), and 68 species of reptiles (13% of reptilian diversity of India) [4, 5]. Besides, the area exhibits enormous diversity in ungulates including unique species such as Kashmir red deer or Hangul (*Cervus hanglu hanglu*), Kashmir Musk deer (*Moschus cupreus*), Markhor (*Capra falconeri*), Asiatic Ibex (*Capra sibirica*), Himalayan Tahr (*Hemitragus jemlahicus*), Himalayan Serow (*Capricornis thar*) Himalayan Gray Goral (*Nemorhaedus bedfordi*), Urial or Shapu (*Ovis orientalis*), Greater Blue sheep (*Pseudois nayaur*), Argali (*Ovis ammon*), Tibetan Gazelle (*Procapra picticaudata*), Tibetan Antelope or Chiru (*Pantholops hodgsoni*), Wild Ass (*Equus kiang*), and Wild yak (*Bos mutus*) most of which having their origin in Central Asia & Middle East, have remarkably adapted to the region [1, 3, 4] although some of them share their ranges with the parts of the Central and eastern Himalayan region [4].

Of the 34 ungulate species found in India, 20 species belonging to four families, namely *Bovidae*, *Cervidae*, *Equidae*, and *Moschidae* occur in the Himalayas. Eight of the 10 most highly endangered species of ungulates in India with only single populations [6] are found only in this region. The endemic Kashmir red deer or Hangul and the Kashmir Musk deer inhabiting this region are highly endangered as they are confined to a restricted area in this Himalayan range [4]. The only global population of around 150–180 Hangul individuals is restricted to a confined area of Dachigam National Park and adjoining landscape in Kashmir Himalayas [7–9]. Immediate feasible conservation steps are needed to save these species. Although endemic and endangered sufficient basic information on these species is not available for planning and implementing suitable conservation measures for these species.

In this article, the information on the status distribution, ecology, and conservation of key mountain ungulates including eight of the 10 most highly endangered species of ungulates in India found in the region is presented. The chapter has separate sections for each group of species, namely section for mountain deer, Antelopes and Gazelles, Goat antelopes, Wild Goat and sheep, and section for other mountain ungulates, which include Wild yak and the Tibetan Wild Ass—the only unique member of the Odd toed ungulates of family *Equidae*.

2. Ecology and conservation of unique mountain deer of the region

2.1 Kashmir red deer or Hangul (*Cervus hanglu hanglu* Wagner 1979)

The Kashmir red deer or Hangul (*Cervus hanglu hanglu*), in the State Animal of Jammu & Kashmir, is a highly threatened species endemic to a much restricted

area in the Greater Himalayan mountain range of the Kashmir Valley [7, 10–12]. The Hangul, which was earlier considered as one of the six eastern most subspecies of the European red deer (*Cervus elaphus*), is one of the three subspecies of the Central Asian clad of Red deer recently recognized by IUCN as an effective taxon and given a separate species status as Tarim Red deer (*Cervus hanglu*) [11–13]. The Hangul is classified as critically endangered by IUCN owing to small population, highly restricted range distribution globally confined to small pockets in the Kashmir Himalayas. The conservation of this species is subjected to strong demographic stochasticity and loss of genetic diversity. The deer were once widely distributed in the mountains of Kashmir along the Zaskar Mountain range from Shalurah and Karen in the Kishenganga catchment over to Dorus in Lolab Valley and the Erin catchments in Bandipora in the north to Bringi valley and Marwah/Wadwan in Kishtwar High Altitude National Park (NP) in the lower Chenab Valley in Kashmir Himalayas. It was also reported in the past in the GamagulSiya-Behi Sanctuary in the adjoining Himachal Pradesh [14, 15]. At present, the only genetically viable global population of ≤ 200 Hangul is restricted to a small area, which includes the Dachigam National Park (141 sq. km) and adjoining relic range areas across the Greater Himalayan mountain range in Kashmir totaling to around 808 sq. km. There is no animal in captivity [5, 7, 9, 10, 16–18].

The Hangul is a mixed feeder, but it ingests disproportionate amounts of browse in almost all seasons, and also bark-strips woody species such as *Pinus wallichiana*, *Robinia pseudoacacia*, *Parrotiopsis jacquimontiana*, *Lonicera quinquelocularis*, and *Prunus cerasifera*, mostly during spring and winter [8]. Our studies have indicated that the Hangul feeding habits varied according to resource availability in different seasons. In spring, the Hangul food consisted mainly of dicotyledonous shrubs, trees, and herbs together with the monocotyledon grasses and herbs, which included *Carex cernua*, *Panicum crusgalli*, *Poa anua*, and *Hamerocallis fulva*, among the monocots, and *Dipsacus mits*, *Inula royeleana*, *Berberis lycium*, *Quercus robber*, and *Jasminum humile*, among dicotyledonous plants [8]. Hangul in summer consumed *Poa anua*, *P. crusgalli* (monocots) and *Verbascum thapsus*, *Fagopyrum cymosum*, *Jasminum humile*, and *Prunus armenica*, among dicots. In autumn, maximum Hangul was observed feeding on *Indigofera heterantha*, *Isodon plectranthus*, *Lonicera quinquelocularis*, *Smilax vaginata*, *V. thapsus*, *Fagopyrum cymosum*, *Geranium pratense* (all dicots) besides debarking on *Prunus cerasifera* and *Parrotiopsis jacquimontiana*. The winter diet, however, mainly constituted browse (trees and shrubs) although during significant number of sightings, Hangul was observed debarking on trees. Hangul consumed *Salix alba*, *Quercus robber*, *Aesculus indica*, *Prunus pyrus*, *Parrotiopsis jacquimontiana*, *Lonicera quinquelocularis*, *Berberis lycium*, besides *Carex cernua* (in late winter), among monocots [8].

Our studies have indicated that the Hangul habitat use varied between sexes and across seasons. The female Hangul habitat use was consistent across seasons, but male Hangul showed differences in seasonal use of habitats. Hangul showed strong preferences for Riverine habitats in the valleys and Grassland/Scrub habitats in the mountain slopes of the Dachigam National Park. The deer uses primarily the riverine forest habitats including the mixed oak and mixed *Morus* habitats during winter months as these habitats provided sufficient food, shelter, and cover to avoid chilly winds [8]. Whereas during summers, the Hangul tend to inhabit largely coniferous forests associated with rugged, broken terrain, or foothill ranges, which provide good shelter from summer heat and nutritious diet. The deer also shows preference for mid-altitudes between 1700 and 2300 m and 1900–2300 m, and South-facing slopes (North, East, and Northeast and Northwest aspects) were generally favored by both male

and female Hangul in the Dachigam National Park [8]. The deer also showed greater use of lower and middle altitudes (between 1700 and 1900 m and 1900–2300 m). South-facing slopes (North, East, Northeast, and Northwest aspects) were generally favored by both male and female Hangul in Dachigam National Park. The use of slope by Hangul in Dachigam National Park varied between the seasons. In spring, summer, and winter, Hangul generally used flat slopes, but in autumn the deer used very steep slopes in the Dachigam National Park [8].

The deer population has shown wide fluctuations over the years and has declined drastically from 5000 deer in 1947 [14, 15, 19] to around ≤ 200 Hangul at present [9]. Our studies so far have indicated that besides other causes, the major factors affecting the long-term survival of the Hangul deer are declining population trends and distributional range, very low adult sex ratio and fawn-to-female ratio [7, 8, 17, 18] loss of high-altitude summer habitat to graziers [9, 20] and the problem of survival of the young and inadequate recruitment of calf to adulthood due to factors such as considerable predation by common Leopard, dogs, and meso-carnivores (Fox and Jackal) [7–9, 18]. The sex ratio in the deer population is female-biased with 17.76 male: 100 females and the spring calf-to-female ratio very low with 13.70 calves: 100 females (SE = 2.49). The spring calf-to-female ratio showed significant decline ($t = 3.4$, $p = 0.01$) from 23:100 in 2004 to its lowest level of 9:100 in 2006 [7, 10] before showing some recovery to 13.70–15.00 calves: 100 between 2017 and 2020 [4, 9, 21]. The preliminary mitochondrial DNA and nuclear microsatellites also have indicated a relatively low genetic diversity in Hangul as compared with other red deer species predisposing them to inbreeding depression in lieu of their small population size [7, 8, 22].

A population viability model with demographic parameters for Hangul in Dachigam NP indicated that this population can easily shift toward extinction [9, 21]. We strongly recommend a set of management actions to reduce the risk of extinction faced by the small population of this threatened deer. The initiation of the conservation breeding and reintroduction program to augment the wild deer population in its past range in the Kashmir Himalayas and a robust science-based Hangul population monitoring and surveillance program are the vital steps in this direction.

2.2 Kashmir musk deer (*M. cupreus* Grubb, 1982)

Musk deer (*Moschus spp*), which have been classified into seven species [23] with six species listed as endangered [13], are endemic to the mountains of south Asia. Of these six endangered species of Musk deer, five species, namely the Kashmir musk deer *M. cupreus*, Himalayan musk deer *Moschus leucogaster*, Alpine musk deer *Moschus chrysogaster*, Black musk deer *Moschus fuscus*, and the Dwarf Musk deer *Moschus berevostkii*, inhabit different zones of the Indian Himalayas [24, 25] with the first three species having isolated distributional ranges along the mountain ranges in the north-west Himalayan region.

The Kashmir musk deer has historically been reported and described from the Kashmir region of the Western Himalayas from elevations between 2000 and 4200 asl [4, 26, 27] although some recent reports of presence of isolated populations from Nuristan, northeast Afghanistan [25], which is the western limit of the species and genetic analysis based on a few tissue samples [28] and species distribution modeling study [29–31], have indicated the occurrence of Kashmir musk deer in the Mustang area of central Nepal, which forms the eastern limit of the species. However, the reported occurrence of the species beyond the Kashmir Himalayas may not be true and warrants detailed investigation.

In Kashmir, the Kashmir musk deer occurrence is confirmed from isolated habitats all along Greater Himalayan and Pir Panjal mountain ranges above 2500 m asl. The fairly significant population has been observed in the protected areas particularly the Kishtwar National Park, Rajparyan wildlife sanctuary, Overa-Aru wildlife sanctuary in the southeast, and Baltal-Thajwas wildlife sanctuary and Gurez-Tulel landscape in the northeast along Greater Himalayan and Zaskar range, besides Hirpora wildlife sanctuary in the southwest and Kazinag National Park including Limber-Lachipora landscapes in the northwest along the Pir Panjal mountain range, Dachigam National Park, and adjoining landscapes [4].

Kashmir musk deer is the least studied among all species of musk deer of the Himalaya. This is due to its restricted distribution to an area that has been politically sensitive as a result of extended periods of armed conflict making the area extremely unsuitable for field research [3, 4, 27]. There is as such very little information available on the ecology and biology of the Kashmir musk deer. However, our decade's long field observations in its distributional range areas indicate that the populations of Kashmir Musk deer have declined in the recent years owing to habitat loss and poaching in some of its distribution areas in the Pir Panjal range areas and in Gurez-Tulel area bordering Pakistan adjoining Zaskar mountain range in Kashmir [4]. Globally also, the populations of musk deer in their distributional ranges are reported to have dramatically dwindled to half of the original size in three generations (approximately 21 years) primarily because of poaching and habitat degradation [32–34]. There is, however, lack of information about the status, distribution, effective population size, exact number, and genetic structure of Kashmir Musk deer in India, which are a must for planning a conservation strategy of any endangered species. The information on the population status, distribution, ecology, and biology and threats to the populations of Kashmir musk deer endemic to Kashmir Himalayas is limited or not available so far [3, 4]. There are no population estimation records available for the species in its endemic distributional range in Kashmir. Owing to their small and declining population size with restricted geographic range, the species require immediate conservation action before their extinction in the wild. There is a dire need for intensive scientific studies to understand the ecology and biology of the species including comparative ecology with the Himalayan Musk deer.

2.3 Himalayan musk deer (*M. leucogaster* Hodgson, 1839)

The Himalayan Musk deer were once continuously distributed all along the southern side of the Greater Himalaya in India from Central Kashmir through Himachal Pradesh up to Sikkim, Bhutan, Nepal, and marginally in China, between 3000 and 4300 m and tree line [26, 35, 36]. However, as a result of human habitations, habitat alterations, and poaching, they are now restricted to a few isolated pockets throughout its former range [30, 33, 35, 37]. In Jammu and Kashmir, the Himalayan musk deer shares range and habitats with Kashmir musk deer in some of its range areas in Kishtwar NP and Bani WLS bordering Himachal Pradesh.

In general, Himalayan Musk deer are solitary and shy animals with crepuscular and largely nocturnal activities known to inhabit mature conifer and broadleaved forests preferably prefer oak forest, rhododendron forest, blue pine, *Betula*, *Fir*, and juniper forests and grassland habitat [32, 38–40]. The deer are considered predominantly a browser, feeding mainly on shrubs, forbs, leaves, moss, lichens, shoots, grasses, and twigs [32, 41]. The Musk deer are “nibblers” rather than browser, as they selectively feed on young leaves, buds, fruits, and flowers of dicotyledonous

plants [35]. Lichens are reported to constitute the bulk of the musk deer's winter diet, mostly [32]. In Nepal, musk deer have been observed climbing trees to feed on lichen and to escape from predators [38].

Although degradation of Musk deer habitats all across its distributional range is a concern, poaching and snaring of musk deer for trade fuelled by high demand for use in traditional Chinese medicines and perfumes in China, India, and other countries since the fifth century and the high price paid for musk pod pose the biggest threat to the long-term survival of Musk deer [42, 43]. Snaring adopted by the poachers to kill the musk deer not only kills the adult males, which only carry the musk pods but also the young and the females. The estimated number of musk deer killed in the Himalayas is estimated to vary between 5350 and 16,000 every year during 1970s and 1980s [35].

2.4 The alpine musk deer (*M. chrysogaster* Hodgson 1839)

This subspecies of musk deer of alpine scrub and meadows is largely distributed across the alpine zones of Central and Eastern Himalayas in Aurnachal Pradesh and Sikkim. In the western Himalayas, Alpine musk deer has some patchy distribution to confined areas in the Uttarakhand [26, 36].

Musk deer is an endangered animal under the IUCN category and is listed in CITES Appendix 1 for Afghanistan, Nepal, India, and Pakistan and in Appendix II for Bhutan and China [13, 30, 44, 45]. Although number of studies and conservation efforts have been undertaken for conservation of musk deer populations and sustainable utilization of musk to meet the growing demand of musk trade in China and some parts of India, concerted efforts are still needed to enhance our knowledge and understanding on the population status, distribution, and ecology and biology of the musk deer for its effective management and long-term conservation planning in its habitats. Increased protection to musk deer and its habitat, creating general awareness about the musk deer, and wildlife research and management are absolute necessities for the conservation of this species.

3. Antelopes and gazelles

3.1 Tibetan antelope or Chiru (*Pantholops hodgsoni* Abel)

Tibetan Antelope or Chiru is endemic to the Tibetan Plateau at elevations of 3250–5500 m [46, 47] and ranges across the whole Qinghai-Tibet Plateau, China, and a small area of northwest Nepal [48]. At present, Chiru are restricted mainly in the remote Chang-Thang area of north-western Tibet [49] with a small population occurring seasonally in extreme north western parts of Tibet in India in Daulat Beg Oldi (DBO) in Karakoram (Nubra) wildlife sanctuary and Changchenmo Valley of eastern Ladakh [48, 50]. However, most of the Chiru that come to Changchenmo Valley are males, and the females prefer the neighboring Lingti Tsiang plains in the Aksai Chin region, where they often fawn, and a small sedentary female Chiru population inhabits Daulat Beig Area (DBO) of Ladakh region in India [49–52]. The estimated populations of Chiru in the India Tibetan plateau in Daulat Beg Oldi and Changchenmo wildlife sanctuary range between 250 and 270 animals [50, 53–55].

It was till recently not clear whether the population of Chiru, which seasonally migrate to India from Chinese province of Tibetan (Xinjiang) [56], is truly

migratory like the other populations of Qinghai Tibetan Plateau (QTP) [57–59] or is resident. It is reported that individual female Chiru travels distances of 300–400 km in late spring and early summer [60]. During our recent studies between 2012 and 2015, we confirmed that a small population of around 15–20 Chiru individuals to have become resident and are staying in Chang Chenmo Valley in eastern Ladakh during winters as well resulting in the year-round distribution of Tibetan antelope within eastern Ladakh in India [50, 53–55]. We also documented for the first time the genetic variation of the Indian population of the Tibetan antelope from other populations of China and results indicated a separate resident population of Chiru in Indian Changthang region and the presence of relatively low genetic diversity in the surviving Tibetan antelope population in India [50, 53, 55].

The population decline due to poaching and habitat degradation for Tibetan antelopes or Chiru is of grave concern. The Chiru are poached for their wool, known as shahtoosh-King of wools, which has been posing great threat for long-term survival of the species. Shahtoosh is different from other wools as it cannot be sheared or combed because the fibers are very short and attached to the bases of guard hairs; in turn, it can only be obtained after sacrificing the animal. One individual yields about 125–150 g of shahtoosh, and weaving one shawl requires wool from four to five individuals [49, 58, 61]. The recent estimates have indicated that every year, more than 20,000 individuals are poached for their fine wool to make shahtoosh shawls and scarves [57, 62–64]. During our studies in Changchenmo along the China boarder (LAC) despite the area being under high security surveillance, we collected two heads of poached Chiru and observed that two indigenous circular foot traps placed over a hollow tin bucket, concealed, and tied to a stack were also encountered on a regular Chiru trail [54, 55] The drastically declining population of Chiru during the recent years cannot long endure the additional stress of poaching, habitat disturbances, and any chances of disease. As such the monitoring of economic circumstances may be as important to Tibetan antelope or Chiru conservation as regular scientific-based population monitoring, surveillance, and management.

3.2 Tibetan gazelle (*P. picticaudata* Hodgson 1846)

The Tibetan Gazelle, a species endemic to the Tibetan Plateau, with small population occurring in confined areas in the Hanley plains in Changthang area of Ladakh in the Indian Trans-Himalayas. In the Ladakh region, its range had declined from ca. 20,000 km² in the early 1900s to ca.1000 km² in the late 1980s. The recent range-wise surveys carried out during 1999–2003 for assessment of the Gazelle's conservation status in Ladakh indicate that the present population of Tibetan Gazelle in Ladakh is ca. 50, restricted to a range of about 100 km² [65–68]. Apart from this single survey conducted during 1993–2003, there have been no intensive studies undertaken on the species in Indian. Habitat fragmentation and livestock grazing are the major threat to long-term conservation of the species in its distributional range in Hanley plains in Indian Changthang.

There is a dire need for undertaking studies to understand the biology and ecology of the species for effective management and conservation planning of the species and its habitats in its restricted range areas in Indian Changthang region. Besides, the reassessment of its IUCN Red List Status is imperative for long-term conservation of the species.

4. Goat: Antelopes

4.1 Himalayan gray goral (*Nemorhaedus bedfordi* Lydekker 1905)

The Himalayan gray Goral is one of the three subspecies of Goral [13, 69, 70] endemic to the Kashmir and Western Himalayas largely ranging from Pakistan to north India, Nepal, Bhutan, up to Mishmi hills of Assam [4, 70–73]. Although, recent genetic study while confirming the classification of Groves and Grub (1985) has confirmed existence of three species of Goral and suggested Himalayan Gray Goral *Nemorhaedus bedfordi* as subspecies of Himalayan Goral *Nemorhaedus goral* [74].

In India, Himalayan gray Goral is distributed largely in Jammu and Kashmir and Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh [75]. It inhabits steep open and rugged grassy hill or rocky and scrub habitats in the southerly aspects at elevations of 900–300 m and above up to 4200 m asl. [39, 76] usually in small groups of 4–8 individuals.

In Jammu and Kashmir, it occurs in Kazinag National Park and Nagnari Conservation Reserve while as Tatakuti-kalamuund Wildlife Sanctuary and Khara Gali Conservation Reserve in Pirpanjal range of the Himalaya are thought to be the potential goral areas [36, 77–80]. During our surveys, we recorded occurrence of Goral in confined areas in Greater Himalayas and Pir Panjal mountain ranges in Kashmir and Chenab Valley [81].

In Jammu and Kashmir, it occurs in Kazinag National Park and Nagnari Conservation Reserve while as Tatakuti-kalamuund Wildlife Sanctuary and Khara Gali Conservation Reserve in Pirpanjal range of the Himalaya are thought to be the potential goral areas [77, 79, 80].

Increasing human settlements result in habitat loss and increased hunting pressure Deforestation, grass extraction, timber and fuel wood, collection, illegal poaching, and competition with livestock are crucial threats to the survival of wild ungulates [39, 41, 82]. Anthropogenic pressures and disturbances especially movement of local people and operations by security forces in upper reaches are a few of the major threats to Himalayan goral population, which need to be evaluated if its conservation is a priority.

Himalayan Gray Goral is categorized as near threatened (IUCN 2017) and listed as Appendix 1 species by CITES. The effective management of species needs an extravagant understanding of its biology, but very few have addressed the goral at global level [83–89] with detailed assessment of the ecology and biology of the population surviving in the Greater Himalayas and Pir Panjal mountain ranges of Kashmir required for long-term conservation planning.

4.2 Himalayan Serow (*C. thar* Hodgson, 1831)

The Himalayan Serow is one of the four races of the widely distributed Serow in India [76]. Recent genetic study has indicated four species of Serow and suggested grouping together of *C. thar* and other two species *C. milnedwardsii* and *C. maritimus* into *Capricornis sumatraensis* [74].

Himalayan Serow is distributed in the southern Himalayas from Jammu & Kashmir in the west to Arunachal Pradesh in the east. In western Himalayas, the Himalayan Serow is widely distributed largely all along the Greater Himalayan range [36]. In Jammu & Kashmir, we have recorded Himalayan Serow widely distributed along the Great Himalayan mountain range largely from Jammu, Chinab Valley,

Kishtwar National Park and adjoining landscape, Zabarwan Hills, Dachigam National Park [4], and recently reported from Bani WLS [81].

In its distribution range, the Himalayan Serow inhabits the boulder strewn thickly wooded gorges at elevations between 1800 and 3000 m. The Serow are very active during morning hours in the open hill slopes, generally more or less solitary but occasionally in groups of 4–6 individuals seen foraging together. During our survey, we have recorded a herd of seven serow foraging on the open grassy slopes of the Brain-Nishat conservation reserve in the Zabarwan hills in Srinagar during spring season in 2000 and 2001 [4, 81]. This is the least studied species in its distributional range in the Himalayas and calls for systematic surveys and studies to understand ecology and biology of the species for conservation planning.

5. Unique wild goats and sheep of the region

5.1 The Markhor (*Capra falconeri* Wagner)

The Markhor *C. falconeri*, the large goat of the world, is native to the Himalayas and Central Asia occurring from the Kashmir Valley westwards to the Hindu Kush [36, 45, 48, 76, 89, 90] through Afghanistan in the west [91] northern and central Pakistan, southern Tajikistan, and southern Uzbekistan [24]. In India, the Markhor is restricted to confined areas in the parts of Pir Panjal mountain range in the south-western Kashmir in the Western Himalayas [77, 79, 90, 92]. The Pir Panjal Markhor or Kashmir Markhor (*C. falconeri cashmiriensis*) as it is called is reported to occur all along the Pir Panjal range in Jammu & Kashmir from the Banihal pass in the south through Poonch, Hirpora (Shopian), Gulmarg (Nilkanth area), Boniyar (across LOC), Bonyar, Kaji Nag, Shamsbari south, Shamsbari (across LOC) and Shamsbari north [48, 93], and Baltistan, Gilgit, and Chitral on the other side of the Kashmir in Pakistan [36]. However, recent studies and surveys have indicated that the Pir Panjal Markhor now has a restricted distribution in Kazinag National Park and Hirpora Wildlife Sanctuary in Kashmir with an estimated population of 280–330 individuals (Anonymous 2005) although some confirmed reports of its occurrence were obtained from the Boniyar and Poonch survey blocks. In most of the other range areas such as entire Shamasbari and Baderwah-Kishtwar blocks, the Markhor populations are reported either extinct or are near extinction.

The Markhor in the Pir Panjal range inhabits the dense pine and birch forest habitats interspersed with grassy glades, which offer a preferred grazing ground for the animal. The food preferences of Markhor change according to season and availability [48]. It generally feeds on grass, leaves, and other available vegetative matter. However, during spring and summer, it consumes primarily grasses and forbs, while in the winter, it feeds primarily on browse for nourishment [71, 94].

Though the Markhor is protected as Schedule 1 species under Indian Wildlife Protection Act 1972 (amended 2006) and its status put down recently from endangered to near threatened by IUCN [94], the threat against its survival remains very much in place. Poaching, overgrazing, and constant conflicts at the border besides large-scale developmental activities including limestone and gypsum mining in and around the prime habitats seem to be major threats to Markhor conservation in Jammu & Kashmir. Apart from a single intensive study by Ahmad [90] and a few brief surveys by Ahmad and coworkers [77, 79, 80, 90], no detailed studies have been undertaken on the species. More detailed ecological studies on the Markhor

including understanding the movement and ranging pattern of the species across the Pir Panjal landscape, strengthening the protection and habitat restoration measures, participatory management of Markhor areas with the Indian Army, nomadic herders, and Local communities, capacity building in terms of infrastructure, manpower, and training; of the implementing agencies such as forest and Wildlife departments are some of the measures need to be taken immediately to conserve this largest goat of the world we are bestowed with. Need to strengthen the research and awareness measures to better understand measures required to be undertaken for effective management and long-term conservation and survival.

5.2 Himalayan Tahr (*H. jemlahicus smith*, 1826)

Himalay Tahr, one of the least studied species, is considered to inhabit most inaccessible habitats. Fragmented distribution in western and central Himalayas from Jammu and Kashmir (rare west of Doda) to Sikkim near-threatened mountain goat.

Found on the southern temperate and sub alpine forested slopes along greater Himalayas between 1500 and 5300 m preferably at higher elevations between 2000 and 4400 m best known in Kedarnath WLS in Uttarakhand [30, 41] and Kishtwar National Park in Jammu & Kashmir [4] with a small population reported from Bani WLS adjoining Himachal Pradesh [81].

There is very limited scientific information available on the species. There is urgent need for initiation of population assessment and occurrence surveys and intensive studies to enhance our knowledge and understanding on the ecology and biology of the species for effective management and conservation planning.

5.3 Argali (*O. ammon hodgsoni* Blyth)

Argali or Great Tibetan Sheep, locally known as Nayan, is the largest but the rarest wild sheep found in the world [76]. It is distributed across the Tibetan Plateau from eastern Ladakh eastwards to Sikkim with some populations crossing over the adjacent mountains into Spiti Valley of Himachal Pradesh, Kumaon hills, Nepal, and Bhutan [76]. In India, the main population of around 300–360 survives in the Ladakh mainly in the eastern part of the Indian Changthang region in Gya Miru, Changchenmo, and Tsokar with a smaller population in Sikkim and extremely rare in Lahul and Spiti Valley of Himachal Pradesh [36, 95–97].

It is one among the two Argali subspecies categorized as Near Threatened by the IUCN and listed as Appendix 1 species by CITES. The preference for open areas, generally closer to human settlements, has made it an easy hunt for nomadic herders, army personnel, and some government officers who hunted the species for meat, besides trophy hunting by hunters [96, 97]. Competition from Pashmina goats seems to be current threat, hindering the recovery of Argali in Ladakh [97].

Despite its restricted range distribution confined to a small area of around 10,988 km² in Changthang and eastern Ladakh and small population with earlier records of around 200 individuals [56], Argali is one of the least studied species in the region [95]. During our studies and surveys from 2012 to 2015 apart from some sightings of Argali recorded around Marsmicha north east of Pangong, we could record a significant population of Argali (240 individuals in 21 sightings) with a mean group size of 11.43 ± 9.17 Argali largely using sandy plateau habitats in the Changchenmo Valley in the eastern Ladakh [54, 55]. Though some isolated population of Argali is reported from Hemis National Park, but during several surveys ranging including one

15-day survey in the Hemis NP, I have not been able to locate any Argali individual in the area. Range-wise population status survey and detailed studies in its restricted range area in the region are required to understand its current population status in India and lesser known aspects of ecology and biology prerequisite for effective management and conservation planning of the species and its habitats.

5.4 Urial or Shapu (*O. orientalis vignei* Blyth 1984)

The Ladakh Urial, a smallest of all wild sheep, is endemic to Trans-Himalayas mainly inhabiting the gentler grassy hills and open arid alpine steppe habitats of Ladakh in India to northern Tibet besides Gilgit and Astor, Punjab, Sind, and Baluchistan in Pakistan and south Persia [64, 76]. In India, its restricted distribution to the confined areas in Indus and Shayok valleys in Ladakh besides two isolated populations of around 100 Urial reported from Kargil around Junkar Lake and around Chicktan areas [36, 95] has led to its vulnerable status in the region [56, 70, 98].

The population of Urial has declined drastically largely due to the proximity of its distribution habitats to the highway and human habitation resulting in loss of habitats to humans and bringing the species into direct conflict and easy access to poaching [95]. The population was estimated to be about 2000 individuals [99, 100] and indicated 30–40% increment from 700 individuals reported two decades earlier [98] and 1000 Urial reported from Indus and Nubra valley in 1991 [56]. But a recent study puts the number again below 800 individuals [101], which is perhaps the lowest so far. The recent surveys have estimated densities of 1.27 (1.27–1.39) urial km² and 0.96 (0.96–1.10) urial km² across the two landscapes covering 18% of surveyed area [102]. Competition with livestock, hunting by security agencies and locals, and depredation by free-ranging dogs have been the major threats [103]. During our recent surveys in 2001, we recorded around 100 urial in three different sightings along main Srinagar-Leh highway near Saspool, Nemu, and in Markhah Valley in the Hemis National Park [81].

Apart from a short study by Raghavan and Bhatnagar [103, 104], little is known about the species, and there is need for detailed systemic scientific studies to understand the ecology and biology of the Urial for the species long-term conservation planning in its suitable habitats in its narrow distribution range in Ladakh.

5.5 Asiatic ibex (*Capra siberica* Pallas 1776)

One of the large mountain goats distinct from other *caprids* by its characteristic horn and beard [36, 76]. The Ibex is distributed widely in the mountain ranges of Central Asia from Altai in Afghanistan to the western Himalayas and upto Kumaon in Uttarakhand with eastern limits set by upper reaches of the Sutlej river east of which it does not occur [76], and one reason that could determine this occurrence is the high precipitation east of the Gorge. There could be 15,000 Himalayan ibex, which is an important prey for snow leopard [105].

The Ibex inhabits the higher elevations above the tree line usually preferring rugged and rocky precipitous terrain and dry grassland steppes between 3400 and 4400 m in the Himalayas and 4000–5500 m in the trans-Himalayas [76, 106]. It usually grazes on the thickets along the rocky hills and unlike most other caprids, it is known to dig craters through snow to access forage in winters [6, 28, 76]. The Ibex and Blue sheep are the main prey for the snow leopard, and they share similar habitats at

many places such as Nubra Valley and either side of the Zaskar river in Kargil, with Ibex using steeper slopes at higher elevations closer to Blue sheep, which prefer more open pastures at lower elevations [56, 106, 107]. The presence of Ibex and blue sheep in an area is usually thought as indicator of occurrence of snow leopard in the area.

Although earlier Ibex used to occur in large densities throughout its wide distributional range in Ladakh, the population was reduced due to large-scale hunting in the past and competition with livestock during summers. The earlier estimates of Ibex occurring in low densities ranging from 0.4 to 1.5 Ibex/Km² throughout its range in Ladakh and 2.3 Ibex/ Km² in Pin Valley National Park, Himachal Pradesh [6, 106] compared to a density of 6 Ibex/Km² reported from former USSR Russia [48, 95].

Apart from pioneering studies by WII in Spiti Valley [106] and some small studies in Hemis National Park, no detailed studies have been undertaken on the species.

5.5.1 Great blue sheep (*P. nayaur* Hodgson)

The Blue sheep or the Bharal, it is usually called, is intermediate between sheep and goat. Its horns are rounded and smooth and curved backwards over the neck and it lacks facial glands [76]. Unlike goat in Bharal, ram is not bearded, and it has glands between the hooves in all four feet, and it does not have “goaty” odor [76]. Bharal is typically a Tibetan animal also found in Ladakh, Kumaon Himalayas, Nepal, Sikkim, and Bhutan [76]. It has a wide distribution in almost all the Asian mountain ranges in China [49], Nepal [48, 108], Bhutan, and parts of Pakistan [48]. In India, Bharal is one of the most common ungulates found in the Trans-Himalayan region in Ladakh [54, 55, 95, 99, 109].

The Bharal usually inhabits grassland habitats close to cliffs between tree line and snow line at elevations between 3300 m and 5500 m. Bharal are a mixed feeder both grazer and browser foraging largely on grass, moss, and dwarf shrubs. In Ladakh, the Bharal has a wide and continuous distribution ranging from Kargil and Zaskar in the east to Changthang area in the west up to upper catchment of the Changchenmo valley in the Far East [54, 55, 71, 95, 110]. It is, however, absent from the southern slopes of Ladakh range (north of Indus) except at few localities [52, 95]. It is reported to occur in low densities between 0.5 and 2.5 Bharal/km². They live in large herds usually in summers in the high-altitude summer pastures where they have been observed in groups of up to as many as 200 individuals with densities of 20 Bharal/Km² [52, 95, 110]. During our surveys in the Changchenmo Valley, we have recorded 74 Bharal in the seven sightings with an encounter rate of 0.49 ± 0.27 . The average group size was 10.57 ± 8.34 , and the largest group recorded comprised around 70 individuals [54, 55].

Excessive overgrazing by livestock and poaching coupled with predation by dogs are some of the major challenges for the Bharal populations in the landscape. Blue sheep and Ibex are the major prey for the snow leopard in its entire distribution range and as such the conservation and management of bharal populations are essential to ensure sustenance of the predation pressure and long-term conservation of large predators and associated prey in the landscapes.

6. Other unique mountain ungulates of the region

6.1 The wild yak (*Bos mustus* Przewalski 1883)

The wild yak, the only wild oxen of the region, is endemic to the Tibetan Plateau and part of the Kansu Province in China. In India, the wild yak is restricted to only

Changchenmo Valley in the eastern Ladakh [76] although there are some recent unconfirmed new records from Sikkim and other Trans-Himalayan areas of India [36].

Wild yak is one of the highest dwelling animals in the world inhabiting the habitats with the harsh coldest and dry desert environmental conditions between elevations ranging from 14,000 to 20,000 ft. (4270–6100 m) asl. Wild yak is considered behaviorally close to American Bison (Menon 2014). Despite its restricted distribution to confined area of Ladakh in India, the wild yak is again one of the least studied species. During our studies on Chiru in Changchenmo from 2012 to 2014, we recorded a total of 19 sightings of 85 individuals of wild yak in a mean group size of 4.47 ± 3.89 individuals [54, 55]. The Wild Yak were largely seen either solitary or in a group of 2–3 individuals at higher elevations above 5000 m asl. Along south-east of Hot Spring and K. Hill besides Kugrang nullah during summer but used to congregate in large groups in areas along river basin in and around hot spring in association with Chiru and Kiang from late autumn till spring [54, 55].

An extensive in-depth study to understand the ecology and biology of the animal is imperative for effective management and long-term conservation of the species and its habitats in its limited distribution range in Changchenmo Valley of eastern Ladakh in India bordering China.

6.2 Tibetan wild ass (*Equus kiang kiang* Moorcraft 1841)

Tibetan Wild Ass is endemic to the Tibetan Plateau and Indian Trans-Himalayas in eastern Ladakh confined mainly in Changchenmo and Hanle Basins [36, 54, 55, 76].

It is an animal of high open hills and valleys of cold deserts of Trans-Himalayas. There is very limited scientific information available on the species particularly from its limited distributional range in the Indian Trans-Himalayas.

We carried out range-wise surveys in the eastern Ladakh in the Changchenmo valley and adjoining Neuma Valley from Upshy till Chushul via Tsomorari, Mahe, loma, and Hanley in the Changthang cold desert sanctuary, Leh, Ladakh in 2004, 2006, 2007, 2008, 2012–2015. In Neuma valley of Changthang WLS, in July 2007, a total of 89 Wild Ass or Kiang were sighted between Tsomorari and Chushul. Whereas in May 2008, a total of 67 kiang were sighted in the same stretch, with an encounter rate of 0.74–0.92 Kiang/km. In the Changchenmo valley, however, the Kiang occurs in significant densities with encounter rates that showed an increase in 10 years from 1.88 Kiang/km walk recorded in the surveys in 2004 to as high as 4.12 kiang/km recorded in 2014 [54, 55]. A maximum of 395 Kiang were sighted in the area in one season in 2014 in 162 transect walks carried out, with the group size varying from solitary animal to a group of 76 sighted. In the 81 Km long drive transect between Phobrang and Hotspring post of the Changchenmo valley of Changthang, however, a maximum of 95 Wild Ass or Kiang were sighted in 2014 with an encounter rate of 1.17 Kiang/km walk.

Detailed ecological studies are recommended to be initiated to fully understand the lesser known aspects of ecology and biology of this endangered and the only member of the odd-toed (*Persiodactyla*) ungulate of family *Equidae* found in the Indian Trans-Himalayas.

7. Recommendations and conclusion

Striking a balance between biodiversity conservation and sustainable development poses major challenges at the global level during twenty-first century. In the

perspective of limited knowledge and risk of local extinction, conservation of a species remains a challenge. Basic ecological information about a species assists in understanding their survival requirements and to provide a basis for further management policies.

The Himalayan ecosystems face great conservation challenges due to increasing threats of ill-planned developmental activities, uncontrolled grazing by domestic livestock, and unlimited resource use leading to the degradation of its wildlife habitats and in this changing environment, the inhabiting ungulates often modify their activity pattern in response to habitat differences, seasons, and disturbance factors. Of the 31 caprine species found worldwide, 12 have been reported from the Himalayas and its allied mountain ranges, the richest in any part of the world. However, scientific information on a number of them is meager. Barring a few ecological studies, which have been carried out in the recent past, most of the information is based on preliminary surveys and short-term studies.

This region despite inhabiting more number of threatened species than other regions in India has remained little explored. Many of the 20 ungulates unique to the western and Trans-Himalayan region of India are highly threatened and endemic to this region. These species although having their origin in Central Asia & Middle East display greater adaptive variations in this region than in any other part of the world. The Kashmir red deer or Hangul, Tibetan Antelope or Chiru, and Musk deer have been of great social, economic, and cultural value for the people of the region. However, the poaching, habitat loss, habitat degradation and fragmentation, and overexploitation and hunting/poaching of these wild bioresources coupled with human-wildlife conflicts have caused many wildlife species to become ecologically isolated, drastically declined, and locally extinct or at the brink of extinction, which is the case with these threatened Himalayan ungulates as well. Around 87% of the mountain ungulates are protected as Schedule 1 species under the Indian Wildlife Protection Act 1972 and twelve [12] of the 20 mountain ungulates unique to this region are listed under different threat categories by the IUCN.

Since the ungulates as major prey for mammalian predators, they are indicators of health of the habitat. However, there has been drastic decline in the populations and reduction in the distribution ranges of many of the mountain ungulates particularly the eight most highly endangered species occurring in the Indian Trans-Himalaya with only single populations. As in other parts of the world and in the country, the drastic decrease in the populations of major ungulates in the region has created an imbalance in the ecological pyramid. The decline in the prey populations particularly ungulates in the Protected Areas (PAs) and reserve forests has forced the carnivorous species to stray out to prey on livestock and even injuring or killing to varying degrees resulting in a more frequent human-wildlife interfaces and conflict situations across the region.

The conservation and management of the ungulate populations are vital for long-term conservation of large carnivores and in reducing the large carnivore depredation of livestock and damage to humans, which in turn can go long way in mitigating the growing human-wildlife interfaces and conflicts in the region. There is need for furthering our understanding about the critical ecological factors that are pushing unique Himalayan wild ungulates particularly the most threatened species with single population unique to this region, toward extinction and in providing several science-based solutions to reverse the declining populations of threatened wild ungulates to ensure recovery of their populations in the wild including strengthening the

- Lack of comprehensive database of species and ecosystems including lack of baseline information on aspects of ecology and biology of species.
- Minimal comprehensive systematic survey and studies to understand population trends of flagship/endemic or threatened species
- Need for extensive and in-depth assessment of flagship species in the critical landscape.
- Lack of information on the status of significant disease prevalent in the wildlife under free range and disease transmissions from livestock to wild and humans.
There is as such need for surveillance and monitoring of wildlife diseases, disease

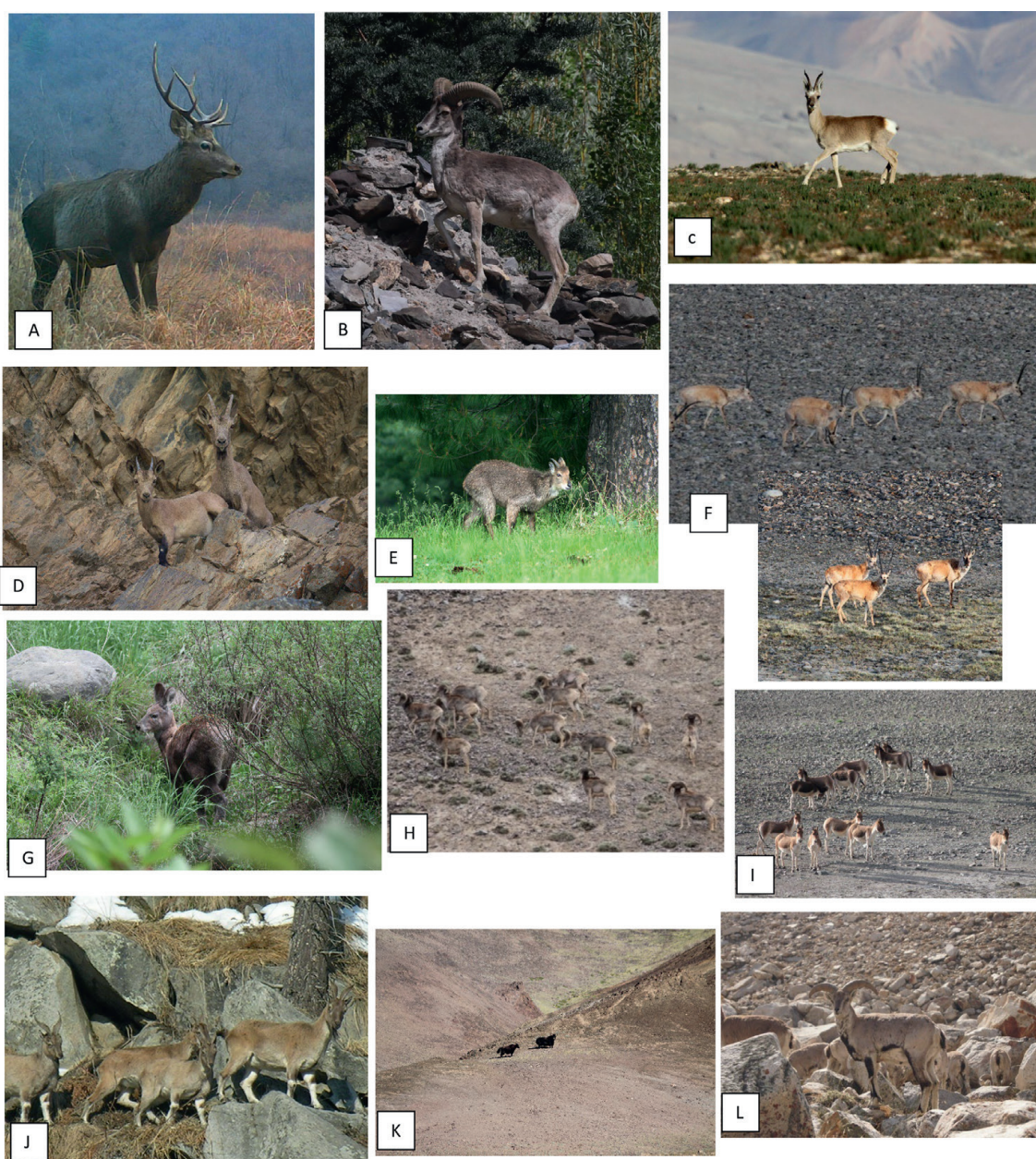


Figure 1.
A) Kashmir red deer or Hangul B) Urial C) Tibetan Gazelle D) Asiatic Ibex E) Himalayan Grey Goral F) Tibetan Antelope or Chiru G) Kashmir Musk deer H) Argali I) Tibetan Wild Ass or Kiang J) Markhor K) Wild Yak L) Blue Sheep.

transmission and outbreak in the wild particularly in the mountain ungulates, which share resources with livestock, and their treatment has become relevant.

- Since livestock has outnumbered wild ungulates in the landscape, creating overlap of diet and forage competition, there is need for understanding the wildlife-livestock interaction in the Himalayan ecosystems particularly at highland pastures.
- There is also need for studies to assess the biomass productivity of pastures and pasture development and enrichment through improved fodder varieties to ensure coexistence of mountain ungulates and livestock (**Figure 1**).


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