***Review Article***

**Physiological and nutritional adaptation mechanisms of domestic and wild animals in upper Himalayan region: A Review**

**ABSTRACT**

The upper Himalayan region's wild and domesticated animals have unique morphological, physiological, and dietary adaptations that allow them to survive in harsh weather. Specialized evolutionary mechanisms that promote thermoregulation, effective metabolic activities, and optimal nutrition assimilation are required because to the interplay of altitude, oxygen availability, temperature change, and unique dietary resources in these harsh environments. Yak (*Bos grunniens*), Churu, and Tibetan Wild Ass (*Equus kiang*) are among the 32 wild and 8 domestic animal species whose adaptive tactics are extensively examined in this analysis. These animals are resilient in high-altitude environments because of unique genetic and physiological changes they have experienced. Conservation biology, livestock management, and maintaining human populations that rely on these animals for agriculture all depend on an understanding of these adaptations. Understanding these adaptations is crucial for conservation biology, livestock management, and sustaining human populations dependent on these animals for agriculture, transportation, and ecological equilibrium in the region.

**Keywords**: High altitude, Himalayan region, Yak, Churi, Adaptation

**IMPORTANCE**

The manuscript is interesting and examines the mechanisms of animals to cope with harsh living conditions. The study presented main information about habitat, nutritional requirement, physiology, adaption, production and reproduction system of upper Himalayan animals. Although the study is presented as review, it should be a starting point for more in-depth studies of each of the species presented. The impact of climate change have also been observed in the upper Himalayan region, due to which both domestic as well as wild animals are effected. This review may help the policy makers, local residents, and researchers etc. to take effective measure regarding physiological and nutritional adaptation mechanism of these animals for long term conservation purpose. This article is a general awareness regarding some species availability and status of a particular region.

**INTRODUCTION**

Churu is the mixed crossbreed of Himalayan yak and Himalayan cow. Churu (male) and Churi (female) are usually the main domestic animal of upper Himalayan regions of Lahual & Spiti and tibet. In Lahaul, Churu and Churi are the regional names of these crossbreed. However, the other domestic animal including Himalayan Sheeps, Himalayan Goats, Himalayan Cow and Yaks also come under the main stream of domestic animals in these areas (Awasthi et al.2003). This study is a comparative study of all these domestic animals, their habitat and nutritional requirement, physiological adaption, production and reproduction, etc. The following listed points highlights the motivation behind this study.

* To study the habitat, nutritional requirement, physiology, adaption, production and reproduction system of upper Himalayan domestic animals.
* To enlist various crossbreed available in this area and their survival and domestication in this hard environment.
* To draw attention towards the production value of these domestic animals.

The upper Himalayan region of Himachal Pradesh including Lahaul & Spiti District and Leh and Ladakh area of Jammu and Kashmir is characterized as very hard area due to the low atmospheric pressure, low temperature, inadequate feed for animals and very low oxygen level. Survival of few domestic and wild animals is possible in this area due to the extreme terrestrial environmental conditions. Lahaul & Spiti District of Himachal Pradesh basically joins two different valleys of the adjoining areas i.e. Lahaul valley and Spiti valley. Both these valleys have its own biodiversity and ecosystem. Both the valleys are the habitat for some of the rare animals including, Red Fox, Ladak Pika, Himalayan Brown Bear, Snow Leopard, Himalayan Ibex, Tibetans Wolf and Mountain weasel, Himalayan Goat, Himalayan Sheeps, Himalayan Cow, Himalayan Dog, Yak and Churu whereas Wolly Hare, Marmot, Wild dog and Blue Sheep are only found in Spiti valley. Further, Jungle Cat, Flying Squirrel, Himalayan Tahr, Yellow Throated Marten, Asiatic Black bear, Gray Langur, Musk Deer, Rhesus Macaque and Himalayan Palm Civet are only found in Lahaul valley. Leh and Ladakh are the habitat for Snow Leopard, Blue Sheep, Himalayan Marmot, Ladakh Pika, Mountain weasel, Tibetan Hare, Tibetan wild ass, Tibetan argali, Red fox, Ladakh Urial, Eurasian lynx, Asiatic Ibex, Tibetan antelope, Tibetan Wolf, Tibetan Gazelle, Himalayan Dog, Himalayan Goat, Himalayan Sheep,Yak and Churu. Various upper Himalayan regions animals and their habitats are tabulated under Table 1 (Mishra et al. 2004) and (Pal et al. 2021).

**Table 1:** Upper Himalayan animals and their habitats.

|  |  |  |  |
| --- | --- | --- | --- |
| **Animal**  | **Wild**  | **Domestic**  | **Habitat** |
| **Lahaul Valley** | **Spiti Valley**  | **Leh Ladakh** |
| Red Fox | √ |  | √ | √ | √ |
| Ladak Pika | √ |  | √ | √ | √ |
| Himalayan Brown Bear | √ |  | √ | √ | √ |
| Snow Leopard | √ |  | √ | √ | √ |
| Himalayan Ibex | √ |  | √ | √ |  |
| Tibetans Wolf | √ |  | √ | √ | √ |
| Mountain weasel | √ |  | √ | √ | √ |
| Himalayan Goat |  | √ | √ | √ | √ |
| Himalayan Sheeps |  | √ | √ | √ | √ |
| Himalayan Cow |  | √ | √ | √ | √ |
| Himalayan Dog |  | √ | √ | √ | √ |
| Yak | √ | √ | √ | √ | √ |
| Churu | √ | √ | √ | √ | √ |
| Wooly Hare | √ |  |  | √ |  |
| Marmot | √ |  |  | √ |  |
| Wild dog | √ |  |  | √ | √ |
| Blue Sheep |  | √ |  | √ | √ |
| Jungle Cat | √ |  |  |  | √ |
| Flying Squirrel | √ |  | √ | √ | √ |
| Himalayan Tahr | √ |  |  |  | √ |
| Yellow Throated Marten | √ |  |  |  | √ |
| Asiatic Black bear | √ |  |  | √ | √ |
| Gray Langur | √ |  |  |  | √ |
| Musk Deer | √ |  |  |  | √ |
| Rhesus Macaque | √ |  |  |  | √ |
| Himalayan Palm Civet | √ |  |  |  | √ |
| Himalayan Marmot | √ |  |  |  | √ |
| Ladakh Pika | √ |  |  |  | √ |
| Tibetan Hare | √ |  |  |  | √ |
| Tibetan wild ass | √ | √ |  |  | √ |
| Tibetan argali | √ |  |  | √ | √ |
| Ladakh Urial | √ |  |  |  | √ |
| Eurasian lynx | √ |  |  |  | √ |
| Asiatic Ibex | √ |  |  |  | √ |
| Tibetan antelope | √ |  |  |  | √ |
| Tibetan Wolf | √ |  |  |  | √ |
| Tibetan Gazelle | √ |  |  |  | √ |

With a brief description about the animals of upper Himalayan region as stated above we have covered morphological adaption of these animals, the cross breeding for domestication in these animals, the feeding adaptation of these animals. Further, the productivity and domestication of these animals are evaluated. Finally the study is concluded with overall summary of these discussions.

**Morphological Adaptation for Extreme Terrestrial Environments:** The upper Himalayan region witnesses the diversity in environmental changes. In summers the temperatures of this region is about 20 to 28 $°C$ whereas in winters the temperature is about -30 to -40 $°C$ (Ayalew et al*.* 2021). Further, earlier spring, low oxygen level, low humidity in summers, less vegetation, etc. makes this region deadly for humans and animals. For humans many traditional and ultra-modern techniques are there to make this deadly environment liveable. Similarly, the survival of domestic animal is also comparable easier than the wild animals due to human involvement in their lives. On the other hand the situation for wild animals is very critical, but the special morphological and biological structure of their body provides a unique strength to these animals for survival. Most of the animals present in these areas have a unique biological structure including their compact body, hard outer skin layer, absence of sweat glands and thick outer layer of hairs on 70% - 95% area of their body which help them to dissipate minimum heat from their body (Chand, 1995). The size of lungs and hearts of these species are comparable larger than their other family species habitat in the lower and middle Himalayan range (Zaho et. al., 2024). This improves the oxygen uptake in these animals. Many other genetic structures in their body including shorter tongue, thin-walled pulmonary arteries and superior lingual, etc. makes their bodies adaptable in this hard area (Ayalew et al. 2021, Wang et.al. 2024, Cheviron and Brumfield, 2012). Table 2 illustrates the specific morphological structures and their adaptation functionality in these upper areas.

**Table 2:** Morphological/Biological Structure of animals’ habitat in upper Himalayan region and their adaption functionality. √ indicates the functions helping in adaption.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Morphological/Biological Structure** | **Body Heat**  | **Oxygen flow** | **Hypobaric Hypoxia**  | **Oxygen Uptake** | **Digestibility** | **Food Grinding** |
| Compact Body | √ |  |  |  |  |  |
| hard outer skin layer | √ |  |  |  |  |  |
| absence of sweat glands | √ |  |  |  |  |  |
| thick outer layer of hairs | √ |  |  |  |  |  |
| Lung Size |  | √ | √ | √ | √ |  |
| Heart Size |  | √ | √ | √ | √ |  |
| Shorter tongue |  |  |  |  | √ | √ |
| Thin-walled pulmonary arteries |  | √ | √ | √ |  |  |
| Superior lingual |  | √ | √ | √ | √ | √ |
| Arteries with smooth muscles |  | √ | √ | √ |  |  |

**Cross breed in upper Himalayan animals:** Usually the breeding processes in upper Himalayan animals are natural. In the absence of state-of-the-art biological and In Vitro Fertilization approximate 99% breeding process are natural in these areas. The wild yaks which were domesticated around 5000 years ago are from *Bos mutus* species whereas the domestic yaks are from *Bos grunniens* species (Akbar, 2011). The cross breeding of *Bos grunniens* species of yak and the *Bos Taurus* species of Himalayan cow produces the offspring which is popularly known as Churu (male) and Churi (female) in Lahaul area. Similarly, the cross breed of Himalayan horse and Himalayan wild Jenny is popularly known as Tibetan wild ass. Goat and sheep in this region are not crossbreds but due to their typical characteristics they are known as gaddi goat and gaddi sheep respectively. Some of the cross breeding examples of domestication of animals in upper Himalayan regions for better survival are listed under Table 3.

**Table 3:** Upper Himalayan animal’s cross breeding for domestication.

|  |  |  |
| --- | --- | --- |
| **Sr. No.** | **Animal**  | **Cross breeding** |
|  | Churu/Churi | Yak and Himalayan Cow |
|  | Tibetan Wild Ass | Himalayan Hours and wild Jenny  |

**Feeding adaptation of Himalayan animals:** The vegetation and availability of food plants are very less in the upper Himalayan regions. About 45 family of wild plants and 140 species of these plant families are edible in these regions. These 140 wild plants species are the only feeding resource for wild animals. Domestic animals have other manmade (human food waste) and processed feed available for survival. The availability of most of these wild plants are only in summers and spring seasons, whereas in winters only 10-15 % wild plants are available. Due to the unavailability of fodder most of the wild animals move towards the low hilly areas or near the valley in summers. For domestic animals left over and silage are the main resource of fodder in winter seasons. Out of these 140 species only 13 wild plant species commonly consumed by most of the wild and domestic animals. *Allium sp.*, *Trachydium roylei, Lindelofia anchusoides, Carex infuscate, Carex malanantha, Kobresia, Oxygraphis polypetala, Elymus longe-aristatus, Laymus secalinus* and *Stipa orientalis* are some of the main wild plants species consumed by most of the wild and domestic animals in these areas. *Carex* and *Kobresia* are the main plant species that is usually used as fodder for livestock animals in these areas (Awasthi et al*.* 2003) and (Miao et al. 2015). Due to less pollution and good fertility of land in this region the nutritional and medicinal values of these wild plant species is much higher than the similar plant species grown in the lower and middle Himalayan regions. The more nutritional and medicinal values of these wild plant species is one of the major reason behind the survival of wild and domestic animals in this region (Smith et. al., 2023). Table 4 lists the feeding plant species for wild and domestic animals in upper Himalayan region.

**Table 4:** Feeding plant species for wild and domestic animals in upper Himalayan regions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No.**  | **Plant Family**  | **Plant Species**  | **Wild Animals**  | **Domestic Animals** |
|  | Liliaceae | *Allium sp.* |  | √ |
|  | Apiaceae | *Trachydium roylei* |  | √ |
|  | Boraginaceae | *Lindelofia anchusoides* | √ | √ |
|  | Cyperaceae | *Carex infuscate* | √ | √ |
|  | Cyperaceae | *Carex malanantha* |  | √ |
|  | Cyperaceae | *Carex sp. 1* | √ | √ |
|  | Cyperaceae | *Carex sp. 2* |  | √ |
|  | Cyperaceae | *Kobresia* |  | √ |
|  | Ranunculaceae | *Oxygraphis polypetala* |  | √ |
|  | Poaceae | *Elymus longe-aristatus* | √ | √ |
|  | Poaceae | *Laymus secalinus* | √ | √ |
|  | Poaceae | *Stipa orientalis* | √ | √ |
|  | Rosaceae | *Geum elatum* |  | √ |

**Upper Himalayan domestic animals productivity:** Animals are domesticated in this area for production of milk, wool, flesh and land farming. The production of milk is not commercialized in this area due to very less fodder resources in winters. The people of this region are totally dependent upon their animals for milk in winters due to unfavourable climatic conditions, it is cut-off from other nearby regions where commercialization of milk occurs. The production of milk as well as the quality of milk drastically varies in these animals in summer and winter seasons (Qui et al.2012). In summers and spring season the production of milk in these animals are increased from 50% to 90% depending upon their fodder quality and availability of feed in winters and summers. Subsequently, the quality of milk is also improved in summers. The milk of yak and churi is considered as supper food in this region (Mishra and Ganju, 2010). The yak or churi milk is significantly richer in Protein, Fat, Lactose and Ash (Minerals). In addition to this it is also a rich source of Vitamin A, D and calcium. The production of milk is comparably higher in churi than Yak. The yak/churi milk is the main source of milk in this region as goats, sheeps and cows are less adaptable to the transient environmental conditions (Han et al.1998). Table 5 compares the nutritional value of milk in various domestic animals present in upper Himalayan areas (Akbar, 2011).

**Table 5:** Nutritional values (in %) in the Milk of upper Himalayan domestic animals.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** |  **Animal**  | **Protein** | **Fat** | **Lactose** | **Ash (Minerals)** | **Total Solid** |
|  | Goat | 3.7 | 4.8 | 5.0 | 0.85 | 13.9 |
|  | Sheep  | 5.5 | 7.6 | 3.5 | 0.87 | 19.3 |
|  | Cow  | 2.8 | 4.8 | 4.5 | 0.74 | 13.5 |
|  | Yak/churi | 5.3 | 7.2 | 5.0 | 0.9 | 17.7 |

Figure 1 illustrates this comparison pictorially.

**Figure 1:** Comparison of Nutritional values (in %) in the milk of Goat, Sheep, Cow and Yak/Churi domesticated in upper Himalayan areas.

 Second main reason behind the domestication of animals in these areas is wool. Sheep, goat and yak are the main source of wool in this region. In some remote villages of these areas Ibex are also hunted for flesh and wool. Yak and churi have adapted to live in -40 degree celcius temperature and they serve as rich source of wool. The yak’s wool is comparably warmer than the goat and sheep wool but the production of yak wool is a slow process (Mulero-Pazmany et al.2017; Qui et al.2012 and Schaller, 2000). So, the people of these areas are more dependent on sheep and goat wool.

**CONCLUSION**

Life in the upper Himalayan region is tougher due to drastic and extreme climatic condition however natural adaptation of animals in terms of physiology and nutritional assimilation has enabled the survival of both domestic and wild animals such that not only these beings survive but they also provide for the human life residing in these regions. Although the production of domestic animal varies with the availability of fodders and management of housing in these regions still the nutritional value of their milk and quality of their wool is usually higher than their counterpart species in lower and middle regions. Further a lot of research and studies can be taken up w.r.t fodder that can be grown or made available to these domesticated animals for extended period of time under such extreme climates for better production and greater good. Overall this study is a brief description of various lifeforms and their differences in terms of physiology, nutritional value of their milk and present fodder availability at these higher regions.

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1. Nil

2.

3.

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