

**Habitat Preference of Himalayan Monal (*Lophophorus impejanus*) in
Langtang Valley, Lamtang National Park, Nepal**



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Central Department of Zoology
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DECLARATION

I hereby declare that the research work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All the sources of information have been specifically acknowledged by references to the authors(s) or institution(s).

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RECOMMENDATION

This is to recommend that the thesis entitled Habitat Preference of “**Habitat Preference of Himalayan Monal in Langtang Valley, Lamtang National Park**” has been carried out by Birat Raj Rajak for the partial fulfilment of Master’s Degree of Science in Zoology with special paper Ecology and Environment. This is his original work and has been carried out under my supervision. To the best of our knowledge, this thesis work has not been submitted for any other degree in any institutions.

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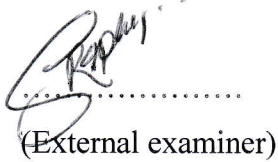
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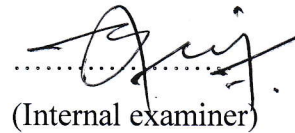
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ABSTRACT

Himalayan monal (*Lophophorus impejanus*) is the national bird of Nepal and is a protected species in Nepal. Despite being protected, the species is highly hunted by poachers for food trade. This species is found in higher elevation in forest land, shrub land and forages in grassland. Its population status and habitat preference are largely unexplored and hence, proper management is lacking for its conservation. This study, conducted in Langtang Valley region in Lamtang National Park in the month of November (winter) for 14 days, aimed to explore the habitat preference and associated threats to Himalayan monal. Survey was done from Ghodatabela (3000 m asl) to Kyanjin Ri peak (4300 m asl) using route census method. A total of 86 individuals of Himalayan monals were observed from 30 occurrence sites within the elevational range between 3100 m asl and 3900 m asl. Himalayan monals preferred the shrubland habitats with an occurrence ratio of 1.43. Generalized Linear Mixed Modelling (GLMM) from the collected data for habitat preferences showed that environmental factors NDVI and distance from walking trail had statistically significant negative correlation with number of Himalayan monal indicating that with decrease in the value of NDVI and distance from walking trail the number of Himalayan monal tends to increase, while the distance from water source has marginal statistical significance with positive correlation suggesting that with increase in distance from water the number of Himalayan monal also tends to increase. This model suggests that NDVI, distance from walking trail and distance from water plays significant role in selection of habitat by Himalayan monal. The distribution of Himalayan monal around the Langtang Valley region (3400–3500 m) was low suggesting Himalayan monal avoided settlement areas with high anthropogenic pressure. The threat assessment of Himalayan monal using semi structured questionnaire survey with local people revealed that poaching, anthropogenic pressure and free livestock grazing are major threats to Himalayan monal in the study area.

1. INTRODUCTION

1.1 Background

The Himalayan monal / Impeyan pheasant / Danphe (*Lophophorus impejanus*) belongs to Order Galliformes in the Phasianidae family. It is the national bird of Nepal. It is legally protected by the National Parks and Wildlife Conservation Act 1973 of Nepal and it is listed on CITES Appendix I and has been classified as near endangered nationally (Inskipp *et al.*, 2016), and is listed in the IUCN's least concern category (Inskipp and Baral, 2013).

This mountainous forest bird stands out with its metallic, rainbow-colored feathers, an iridescent blue head crest, and distinct differences between males and females. It is highly recognizable and considered one of the most easily identifiable pheasant species in the western Himalayas. Due to these remarkable characteristics, it has been designated as the national bird of Nepal and the state bird of Uttaranchal and Himalchal Pradesh in India (Ramesh *et al.*, 1999; Ramesh, 2003).

The Himalayan monal is a medium-sized bird. Males weigh between 1980 and 2380 g and females weigh between 1800 and 2150 g at 70 cm in length, Adult males having a large crest and multi-coloured plumage all over their bodies, whilst females, like other pheasants, are dull in colour with dark brownish black feathers on their upper regions (Delacour, 1977).

The males of this species display a distinctive appearance, including a lengthy metallic green crest, varying reddish copper tones on the back and sides of the neck, and a prominent white back visible during flight. Their tail feathers exhibit a consistent rufous coloration, becoming darker towards the tips. In contrast, the females feature white lower tail coverts marked with black and rufous barring. Notably, the female displays a conspicuous white patch on the front of the neck and a white stripe on the tail. Male chicks, during their first year, resemble female chicks but are larger in size, although their immaturity is less evident (Xiaochun *et al.*, 2011).

Males have been observed with multiple females, indicating that the species is polygamous. Typically, this bird exhibits a shy behaviour and tends to startle and take flight from a considerable distance. The primary food sources are terrestrial insects and tuber forms. In addition to grass roots and seeds, berries, nuts, sensitive leaves, shoots, mosses, insects, and grubs, the bird is frequently spotted digging for tubers and roots. Plant matter comprised the

majority of the diet, with invertebrate matter present in small amounts (Hussain and Sultana, 2013). During May-June, eggs are laid in primitive nests on the ground, usually behind stones, and are 4-6 (sometimes 2-3) in number. The incubation period is 28 days (although can range from 26 to 29 days). The nest of this bird is a simple indentation usually discovered concealed behind the shelter of a bush, a rock, or within the cavity of a large tree (Inskipp *et al.*, 2016).

The Himalayan monal is a native of all Himalayan protected areas, which include Nepal, Afghanistan, Bhutan, China (mainland), India, Myanmar, and Pakistan (Yin, 1970; Johnsgard, 1986; Bhujju *et al.*, 2007; Miller, 2010) and lives in the Himalayan montane ecosystem (Sathyakumar and Kaul, 2007).

It is fairly prevalent and common in Nepal, where lateral movements can occur between 3300 and 4750 meters in the summer and as low as 2500 meters in the winter. The presence of this bird has been documented across various mountainous protected areas, such as Makalu-Barun, Sagarmtha, Lamtang, SheyPhoksundo, Khaptad, and Rara National Parks. It has also been observed in the Dhorpatan Hunting Reserve as well as the Kanchanjungha, Gaurishankar, Manaslu, Annapurna, and Api-Nampa Conservation Areas. Additionally, records of this bird extend to Jumla, Humla, Myagdi, and Taplejung. (Inskipp *et al.*, 2016).

The Himalayan monal predominantly inhabits high-altitude temperate forests dominated by coniferous and oak trees, often accompanied by open grasslands. These habitats are typically situated at elevations ranging from 2400 to 4500 meters. The species tends to concentrate within a relatively narrow range between 2700 and 3700 meters (Grimmett *et al.*, 1998). Distance to forest and a forest-grassland mosaic, in particular, is significant since it reveals the species' preferences near the forest-grassland edge (Baral, 2022).

Observations have indicated that this species displays a preference for avoiding severe winter conditions in regions with pronounced seasonal climates (DNPWC and DFSC, 2018). During migration, they descend to lower elevations, reaching as low as 2000 meters in the winter months (Ramesh, 2003). In Nepal, suitable habitat for these birds can be found in the Himalayan barren terrain and open woodland, spanning an elevation range of 2500 to 4750 meters (BCN, 2013). Notably, they exhibit the ability to withstand snowy conditions and have been observed excavating through snow to access roots, tubers, other plant components, and insects (McGowan, 1994; Kumar, 1997).

The Himalayan monal is primarily found in forested areas characterized by rocky terrain, where the prevalent tree species include *Quercus semecarpifolia*, *Picea spinulosa*, and *Abies spectabilis*. The understory consists mainly of *Salix oritrepha* and *Rosa tibetica*, interspersed with steep slopes (45°–50°), cliffs, and alpine meadows. These habitats are typically located at an elevation range of 3800 to 4000 meters (Xiaochun *et al.*, 2011) and sometimes prefer cultivated area, neglecting forest, shrubland, herbaceous vegetation or bare landscape (Soldatini *et al.*, 2010).

The Himalayan monal, a species that is consumed locally as a food source, encounters significant risks primarily from hunting and trapping. These threats are particularly pronounced during the winter season when the bird descends to lower altitudes closer to human settlements (Yonzon and Lelliott 1980; Baral, 2009). Local hunters, herders, and collectors of medicinal plants have been actively engaging in these activities for many years in the mountainous region of the country. The species is severely threatened by the trade in its flesh and crest feathers, both of which fetch high prices (Kaul *et al.*, 2004).

The bird has been well established in the mythology of several Himalayan civilizations (Delacour, 1977). Feathers are considered significant in rituals and local celebrations throughout Asia (Kumar *et al.*, 1997; Ramesh, 2003; Inskipp *et al.*, 2016). In addition, pheasants possess aesthetic beauty that captivates people's admiration, while also serving as a dependable food resource. Unfortunately, due to human expansion and development leading to habitat degradation, pheasant populations have suffered significant declines across most of their natural (McGowan and Gillman, 1997). Changes in forest cover, a decreasing trend in grassland area, overgrazing, burning, and human activities such as hydroelectricity development, as well as criminal activities, all threaten the species' survival (Ahmed *et al.*, 2016 ; Inskipp *et al.*, 2016).

The Himalayan monal exhibits a heightened sensitivity to human disturbances and actively avoids areas where human presence is prominent. The interference caused by human activities is detrimental to the pheasant populations in the Himalayan region, leading to negative impacts on their numbers (Sharief *et al.*, 2022).

Pheasants rank among the most extensively hunted avian species in Nepal. Conservation concerns for this group of birds often intersect, encompassing illegal hunting, trapping for meat consumption, the utilization of body parts in traditional medicinal practices, and the keeping of pheasants as pets. The direct threats to pheasants also encompass deforestation

and forest fires, recognized as significant factors impacting their population. Many pheasant species, including Himalayan monal, are classified as Least Concern on the IUCN Red List due to their widespread distribution (DNPWC and DFSC, 2018).

Many pheasant species do not have a desirable conservation emphasis because of their conservation status. There are little resources available for their research and conservation projects, resulting in a low degree of conservation awareness among a wide range of stakeholders. Consequently, the scientific investigation into the distribution patterns, habitat utilization, and prevailing challenges, along with its discoveries, can be utilized to address the requirement for comprehensive research and efficient conservation strategies for pheasant species in Nepal in the long term.

1.2 Research objectives

1.2.1 General objective

The general objective of this study was to explore the habitat preferences of Himalayan Monal in Langtang Valley of Lamtang National Park, Nepal.

1.2.2 Specific objectives

The specific objectives were:

- To determine the spatial distribution pattern of Himalayan monal in Langtang Valley of Lamtang National Park
- To determine the habitat preference of Himalayan Monal in Langtang Valley of Lamtang National Park, Nepal
- To determine the threats to Himalayan monal in Langtang Valley of Lamtang National Park

1.3 Significance of the study

Pheasants are large ground-dwelling birds found across Nepal, from the lowlands to the high mountains. Eight species of pheasants are recorded in Nepal (McGowan and Garson, 1995; Fuller and Garson, 2004; Poudyal, 2008).

Recognized for its captivating presence, the Himalayan monal has been officially designated as Nepal's national bird according to the country's Constitution. Additionally, the NPWC (National Park and Wildlife Conservation) Act of 1973 has classified the Cheer Pheasant, Himalayan monal, and Satyr Tragopan as protected species, including them in Schedule I of

Nepal's list. Although, Himalayan monal is our national bird declared many years ago, so far no species specific scientific field study has been carried out. This study therefore is the first field study focused on this nationally important bird.

Despite being designated as protected birds, pheasants face substantial hunting pressure and are among the most targeted avian species in Nepal. The conservation risks affecting this group often intersect and involve activities such as illegal hunting, trapping for meat consumption, the utilization of body parts in traditional medicinal practices, and the keeping of pheasants as (Yonzon and Lelliott, 1980; Baral, 2009). Deforestation, forest fires, and overgrazing have also been identified as direct threats to pheasants, notably Himalayan monal (Miller, 2010; Ahmed et al., 2019). The unlawful killing of Himalayan monal for their body parts, primarily their feathers, is a particular threat so far.

Because of their widespread distribution, many pheasant species are classified as Least Concern on the IUCN Red List. Pheasant species, like the Himalayan monal, do not have a desirable conservation emphasis because of their conservation status (DNPWC and DFSC, 2018). There are little resources available for their research and conservation projects, resulting in a low degree of understanding about conservation among a wide range of stakeholders.

Pheasants are widely recognized birds in Nepal, yet there is a notable lack of comprehensive knowledge regarding their ecology and population status among scientists and conservationists. Although a few sporadic research efforts have been undertaken, numerous potential areas for investigation remain unexplored and untapped. There is still a lack of scientific and evidence-based population data on Himalayan monal. Thus, a detailed investigation on population, ecology, and habitat modelling of pheasant communities is required, implying the need for long-term studies. Thus, this study will aid in assessing the population, abundance, habitat preferences, and existing threats of Himalayan monal in Lamtang National Park, as well as establishing a relationship between habitat predictors and occupancy of the species within the study area.

2. LITERATURE REVIEW

2.1 Distribution of Himalayan monal

Several studies have reported the presence of Himalayan monal in all Himalayan protected areas, including Afghanistan, Pakistan, India, Nepal, Bhutan, China, and Myanmar (Yin, 1970; Johnsgard, 1986; Bhuju, 2001; Bhuju *et al.*, 2007; Miller, 2010; Xiaochun *et al.*, 2011). According to (Sathyakumar *et al.*, 2011) in the study of Galliformes in the Khangchendzonga Biosphere Reserve of Sikkim, India, it was observed that Phasianids, a family of birds that includes pheasants, are most prevalent in the valleys of the middle and high altitudes of the Himalayan range. Additionally, a significant proportion of these species are exclusive to the Himalayas, showcasing their endemic nature.

Based on numerous additional studies, the Himalayan monal is known to occupy the montane ecosystems of the Himalayan region, spanning from eastern Afghanistan and extending through Pakistan, India, Nepal, Bhutan, China, and Myanmar (Sathyakumar and Kaul, 2007; BirdLife-International, 2023).

Grimmett *et al.* (2016) observed that the Himalayan monal primarily occupies upper temperate forests consisting of coniferous and oak trees, along with open grasslands, within an elevation range of 2400 to 4500 meters. Study on the ecology and conservation status of pheasants in the Great Himalayan National Park, Western Himachal Pradesh highlights the seasonal migration pattern of the Himalayan monal along the altitudinal gradient. It was noted that the species demonstrates a preference for sub-alpine oak forests during spring and conifer-dominated forests during winter (Ramesh, 2003). Altitudinal movements by the species have been observed to avoid harsh winter circumstances in highly seasonal climates, according to the Pheasants Conservation Action Plan for Nepal (DNPWC and DFSC, 2018).

The Himalayan region in Nepal provides an ideal environment for many species (Liu *et al.*, 2017; Nie *et al.*, 2017). The Himalayan monal benefits from legal protection by the government and is included in CITES Appendix I. It holds a national classification of near threatened, as reported by (Inskipp *et al.*, 2016), and is listed under the least concern category by the IUCN, according to (Inskipp and Baral, 2013). It is a fairly common distributed resident in Nepal, prone to vertical fluctuations ranging from 3300-4750m in summer to 2500m in winter. The Himalayan monal has been recorded in various protected areas of Nepal, including Makalu Barun, Sagarmatha, Langtang, Shey Phoksundo, Khaptad, and Rara National Parks, as well as Dhorpatan Hunting Reserve. It has also been

documented in the Kanchenjunga, Gaurishankar, Manaslu, Annapurna, and Api Nampa Conservation Areas, as discussed in the study by (Inskipp *et al.*, 2016).

The research conducted on the alteration of habitat distribution for the national bird, the Himalayan monal, in the Gandaki River Basin (GRB), revealed that the central region of Nepal's Himalayas offers a favorable habitat for various bird species, including the Himalayan monal. The study indicated that the habitat of the Himalayan monal is projected to diminish within the elevation range of 1750 m to 3750 m, while expanding between 3750 m and 4500 m (Rai *et al.*, 2020). Sharief *et al.* (2022), using their investigation into the distribution and occupancy of the Himalayan monal in Uttarkashi district, researchers discovered that the species occupies an elevation range of 2000 to 4067 meters within the study area. Notably, they tend to concentrate predominantly within a narrow strip spanning from 2400 to 3400 meters.

Earlier studies have identified favorable habitat ranges for the Himalayan monal between 2500 meters and 4750 meters in the Himalayan barren land and open forests of Nepal (BCN, 2013). The higher Himalayan region, which encompasses the northern portion of the Gandaki Basin, has witnessed a notable acceleration in temperature increase, leading to habitat shifts for several vulnerable species, including the Himalayan monal, as highlighted in the investigation on the alteration of habitat distribution for the national bird in the Gandaki River Basin of the Western by (Rai *et al.*, 2020).

2.2 Habitat preferences of Himalayan monal

Extensive research conducted on the distribution and habitat utilization of the Himalayan monal has conclusively established its native occurrence in Afghanistan, Pakistan, India, Nepal, Bhutan, China, and Myanmar. (Yin, 1970; Johnsgard, 1986; Bhujju, 2001; Bhujju *et al.*, 2007; Xiaochun *et al.*, 2011; Miller, 2013). It can be found in a wide range of altitudes, depending on habitat, location, and season. Grimmet *et al.* (1998) investigated The Himalayan monal is known to inhabit upper temperate forests consisting of oak and conifer trees, as well as sub-alpine oak forests that are interspersed with open grassy slopes, cliffs, and alpine meadows. Its presence is typically observed within elevations ranging from 2400 to 4500 meters, with a significant concentration of individuals occurring within a narrow band between 2700 and 3700 meters.

The ecological study on pheasants in the western Himalayan Great Himalayan National Park by Ramesh (2003) has indicated that the Himalayan monal demonstrates a preference for

steep southern slopes and sizeable boulders as roosting sites, providing them with protection against predators like martens and foxes. This species exhibits migratory behaviour, descending to lower elevations during the winter, with recorded sightings as low as 2000 meters. During the breeding season, it shows a preference for high-altitude woodlands and is known to venture beyond the tree line, exploring grassy slopes. The study also revealed that during the winter, the Himalayan monal occupies coniferous and mixed forests characterized by a substantial presence of rhododendrons and bamboo, which offer shelter from inclement weather conditions.

Similarly, Ramesh *et al.* (1999) investigated recent changes in pheasant populations in the Great Himalayan National Park and discovered that its diet varies depending on location, but it typically consists of seeds, tubers, shoots, berries, terrestrial insects, and their larvae. During the snow-free winter months, the Himalayan monal dedicates a significant portion of its day to foraging for tubers, roots, and insects by skillfully utilizing its beak to probe and excavate the surface of the ground. Throughout the remaining seasons, its diet primarily consists of roots, leaves, tender shoots, acorns, seeds, and various types of berries.

A study of the Himalayan monal in Tibet, China discovered that birds live primarily in rocky forests with dominating tree species such as *Quercus semecareifolia*, *Picea spinulosa*, and *Abies spectabilis*. At an elevation of 3800-4000 m, the shrub layer consists of *Salix oritrepha* and *Rosa tibetica* intermingled with steep slopes, rocks, and alpine meadows (Xiaochun *et al.* 2011). Another study conducted in Sagarmatha National Park, Nepal, by Soldatini *et al.*, (2010) found that Himalayan monal prefers cultivated regions, whereas forest and shrublands are significantly neglected. The bird was not found in herbaceous vegetation or bare landscape, and the prominent species in its environment were *Betula utilis*, *Abies spectabilis*, *Rhododendron*, *Juniper spp*, *Berberis*, and others.

2.3 Conservation threats of Himalayan monal

As indicated by a study examining the potential impact of climate change on range-restricted Andean birds, numerous species inhabiting mountainous regions may experience substantial reductions in their ecological ranges in the coming years, influenced by both natural and human-induced (del Rosario Avalos and Hernández, 2015). According to the studies of (Baral, 2009; Miller, 2010; BirdLife International, 2023), Based on predictions, the habitat range of the Himalayan monal is estimated to span approximately 20,000 square

kilometres globally, including regions such as Nepal, India, Bhutan, Afghanistan, Pakistan, Tibet, and Myanmar.

In a study conducted by Inskipp *et al.*, (2016), the presence of the Himalayan monal was confirmed in high-altitude regions characterized by steep slopes, rocky slopes, cliffs, meadows, and timber patches. While a comprehensive assessment of the global population has not been conducted, it is estimated to range between 3500 and 5000 individuals in Nepal. Notably, a previous study conducted by Bird Conservation Nepal (BCN, 2013) reported the detection of 26 individuals during winter and 51 individuals during spring within the Annapurna Conservation Area.

In a comprehensive research overview of the status, distribution, and habitat of protected birds in Nepal, (Baral, 2009) discovered that hunting and trapping have long been prevalent practices among local hunters, herders, and collectors of medicinal plants in the mountainous regions of the country.

In the pheasant research in the Annapurna Himal, (Yonzon and Lelliott, 1980) the study identified hunting and trapping as the most significant threats to the Himalayan monal, primarily driven by local consumption. These activities are particularly prominent during the winter season when the birds descend to lower altitudes in close proximity to human settlements. Shepherds and poachers cannot be overlooked when hunting and trapping during and after rainy seasons.

According to a report to the World Pheasant Association by (Kaul *et al.*, 2004), this bird's migration pattern often takes it into neighboring farmlands, where it becomes a target for illegal killing due to the high value placed on its crest feathers and flesh. This activity poses a grave threat to the species' survival.

Another investigation, conducted by (Inskipp *et al.*, 2016), reported that the bird is targeted for its plumes, which are sought after for crafting crowns used by shamans. Additionally, the practice of capturing these birds alive for aviaries is prevalent. The species is also vulnerable to threats such as forest fires, nest and egg destruction, and the use of its tail feathers for arrow production in certain regions.

As per the findings of a study conducted by (BCN and DNPWC, 2011), alterations in forest cover, grassland areas, human activities, and illegal practices pose significant risks to the persistent existence of this species in Nepal. According to (Inskipp *et al.*, 2016), the diminishing trend of grassland area owing to overgrazing and burning has created a worst-

case situation in which no substantial acreage remains outside of the country's protected areas, which might be regarded as a significant threat to Pheasant species.

In the Survey of Western Tragopan, Koklass Pheasant, and Himalayan monal populations conducted by Miller, (2010) in the Great Himalayan National Park, Himachal Pradesh, India, it was highlighted that human disturbances, primarily attributed to livestock grazing, along with natural disruptions, were recognized as significant factors contributing to the degradation of habitat within the park.

In a study conducted by Ahmed *et al.*, (2019) on the distribution and population status of the Himalayan monal pheasant in Salkhala Game Reserve, Neelum valley Azad Jammu and Kashmir (Pakistan), it was found that the combination of livestock grazing and extensive mushroom collection from the forest has led to a decline in the condition of various species in the western Himalayan region of Pakistan. Furthermore, the study's findings projected a 5% decrease in forest coverage between 2010 and 2050.

A study conducted in the temperate forests of the Western Himalaya, India, a study examining the effects of human disturbance on the population of Himalayan pheasants reached a significant finding that the Himalayan monal is threatened due to poaching and other anthropogenic factors, and the population reacted negatively to anthropogenic disturbance caused by the development of hydroelectricity (Jolli and Pandit, 2011).

3. MATERIALS AND METHODS

3.1 Study area

Lamtang National Park (LNP) is situated in Bagmati Province in Himalayan region of Nepal (28°15'0.00" N 85°30'0.00" E) connecting Chinese border in the south. The park was established on 22nd March of 1976 with an aim to protect and conserve the unique flora and fauna of the region. The park has a total area of 1,710 sq. km extending in Rasuwa, Nuwakot and Sindhupalchowk districts of Nepal. It has mosaic landscape along the altitude range between 1000 m and 7245 m. the LNP is third most popular trekking destination among protected areas of Nepal. The park is named after the Langtang Valley, which is a popular trekking destination for visitors. The valley is surrounded by high peaks, including Langtang Lirung (7,227 m asl), which is the highest peak in the park. The park is also home to the sacred Gosainkunda Lake, which is an important pilgrimage site for Hindus.

The park supports highly diverse life forms. The park is home to 347 species of birds including Himalayan monal, Satyr tragopan, Yellow-rumped honeyguide, Wood snipe, etc. and a total of 46 species of mammals has been recorded including endangered Red Panda, Snow Leopard, Himalayan thar, Himalayan black bear, Asiatic black bear, Langur monkey, Musk deer and Pika (DNPWC 2022). The park is known for its diverse vegetation, which includes sub-tropical forests, temperate forest, alpine forest, shrub lands and high altitude grass lands. The park is also home to over 1000 different species of plants including rhododendrons, oaks, and maples belonging to variety of family. The park is also home to several medicinal plants, which are used by local communities for traditional medicine. belonging to variety of family.

The traditional Sherpa and Tamang communities that live in the park have a unique culture and way of life. The communities rely on agriculture, livestock and tourism for their livelihoods, and have developed sustainable farming practices that help to preserve the park's natural resources. The communities also have a rich cultural heritage, with traditional festivals and dances that are unique to the area.

The park is a popular destination for trekking and mountaineering, with several peaks in the area that are accessible to climbers. The park is also home to several trekking trails, including the Langtang Valley Trek and the Tamang Heritage Trail. These trails offer visitors the opportunity to experience the natural beauty of the park, as well as the traditional culture and way of life of the local communities. The park has faced several challenges in

recent years, including deforestation, illegal poaching, and overgrazing by livestock. These issues have threatened the park's biodiversity and the traditional way of life of the local communities. To address these challenges, the park has implemented several conservation programs, including community-based conservation and eco-tourism.

The area between Ghodatabela (3000 m) and Kyanjin Ri peak (4300 m asl) Lat. 28.199372 Lon. 85.458031 West, Lat. 28.217542 Lon. 85.570959 East, was explored along Langtang Valley trek, a total of 16 km trail. Three types of habitats were observed with in the study area. The area between Ghodatabela and Thangsyap was characterised by forest composed of rodhodendron, pine trees, sea buckthorn, etc., shrubland and grassland. Moving further from Thangsyap, there were no forest but majority of shrub land followed by grassland at higher elevations.

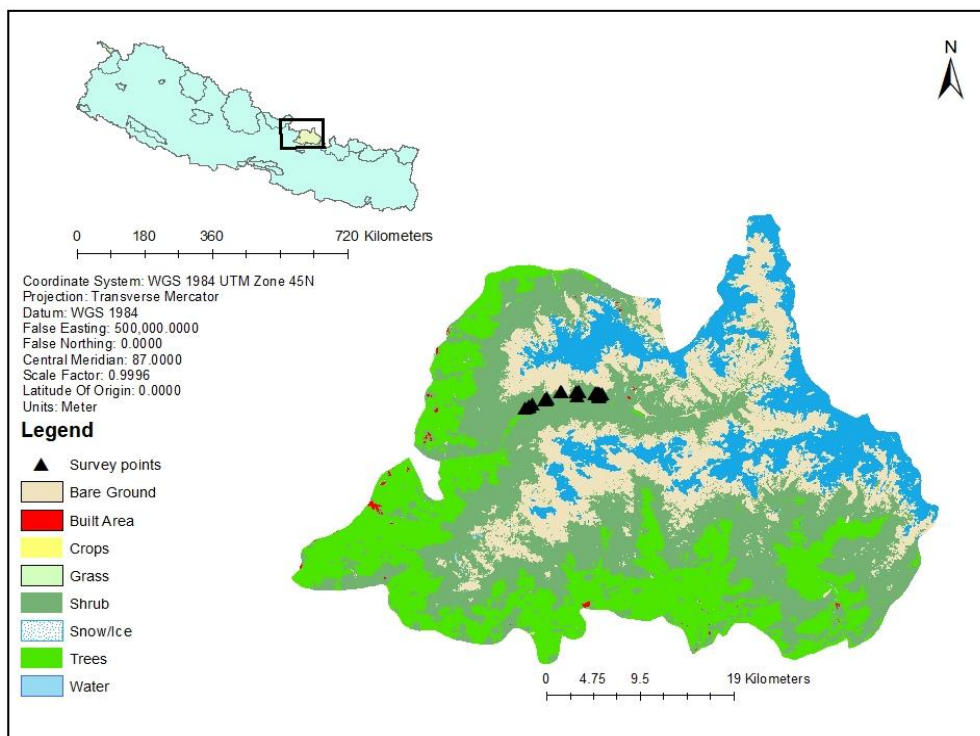


Figure 1. Map of Lamtang National Park showing the study area

3.2 Bird survey

The method used for bird survey was Route Census method (Ranta *et al.*, 1995). This method was highly suitable for the study area with varied geographical character. Altogether a total of 44.5 km trail was survey, further divided into 11 trails of varied length depending on slope and accessible vegetation. A total of 14 days was spent collecting data in the month

of November. Once the bird species was sighted, coordinate of the occurrence point and the environmental variables along with topographic data such as elevation, slope, aspect, etc., and was recorded. The environmental variables such as vegetation type, ground cover, distance from water, walking trail and village were estimated and recorded.

Normalised Differential Vegetation Index (NDVI) mean of each occurrence sight was calculated using Landsat image from USGS in ArcGIS. Number of individual of the HM bird species at each occurrence sight was also recorded.

To access the threats to HM, a semi structured questionnaire survey was done. A total of 50 individuals of age group between 20-50 years were interviewed (Male=32 and Female=18).

3.3 Mapping land cover and land use of study area

Supervised image classification was done to calculate the land cover area by forest, shrub land and grassland using Landsat 8 image downloaded from USGS and processed in ArcGIS. Image classification was done in UTM Zone 45N Projection system. The land use and land cover of the study area was classified in to 4 categories (barren and built up land, forest, grassland and shrub land) on the basis maximum likelihood. A minimum of 25 training (Pixel) were chosen to classify each land use and land cover type. Kappa accuracy method was used to estimate the reliability of categorisation, showed 92% accuracy. The raster map was then converted in to polygon to estimate the land use and land cover area.

3.4 Data analysis

All the recorded and estimated data were put into excel sheet and structured well to analyse. Once the data was ready for analysis, R-studio was used to analyse the data. Since, the objective of the research was to understand the habitat preference of Himalayan monal, thus Generalised Linear Modelling (GLM) was performed. Prior to Generalised Linear Mixed Modelling (GLMM), Generalised Linear Modelling (GLM) was performed to select the environmental variables that has statistical significant with number of individuals and distribution of HM with lowest AIC value. A correlation test was performed among the predictor variables and the variables with high correlation (above -0.8 and +0.8), were excluded during GLMM. Then the best fitted model in GLMM was selected that explains the habitat preference of HM in their natural habitat. The number of individuals of HM was taken as response variable and other topographic and environmental variables were taken as predictor variables. GLM and GLMM with Poisson distribution was used for the obtained data as the data was in discrete form. Different models were fitted using variables in

combination in GLMM. The model with lowest AIC value and marginal and conditional R-squared values was selected to interpret the habitat preference of HM.

Coefplot2 and Sjplot package were used to estimate standardized coefficient and conditional and marginal values respectively. The categorical data of vegetation type was analysed in relation to number of sighting of HM individuals using box plot in r-studio. Similarly, ggplot was used to draw boxplot graph in r-studio for statistically significant variables (NDVI mean, distance from walking trail and distance from water) to show its influence on Himalayan monal occurrence.

4. RESULTS

4.1 Distribution of Himalayan monal in Langtang Valley

A total of 86 individuals of Himalayan monal (HM) were identified from 30 occurrence sites on the basis of direct observation (Figure 2). Out of 86 individuals, 51 were sighted in shrubland at 12 different sites while 34 individuals were sighted in grassland at 17 different sites followed by the least one individual in forest land.

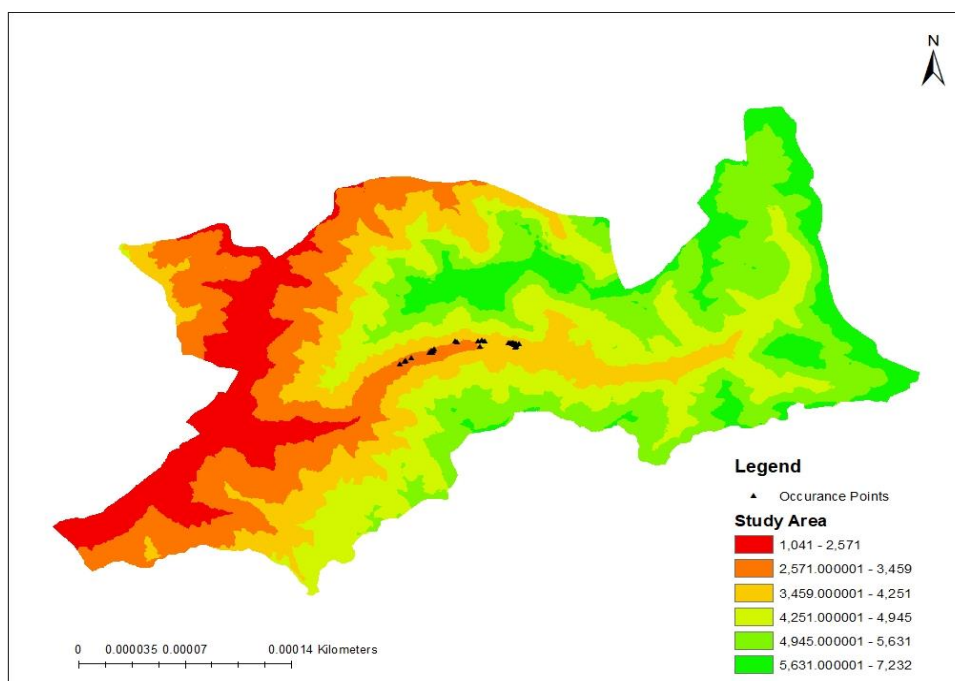


Figure 2. Map showing the occurrence of Himalayan monal in study area at different elevations.

The distribution of HM was higher in shrubland (SL) in comparison grassland (GL) (Figure 3). The mean value of HM number in shrubland is close to median value with only one data that has high variance, while in case of grassland the mean value is close to first quartile with two data having high variance represented by the circle above each plot. Forest land had least number of HM (n=1). This plot clearly explained that shrub land is the highly preferred habitat of HM within the study area.

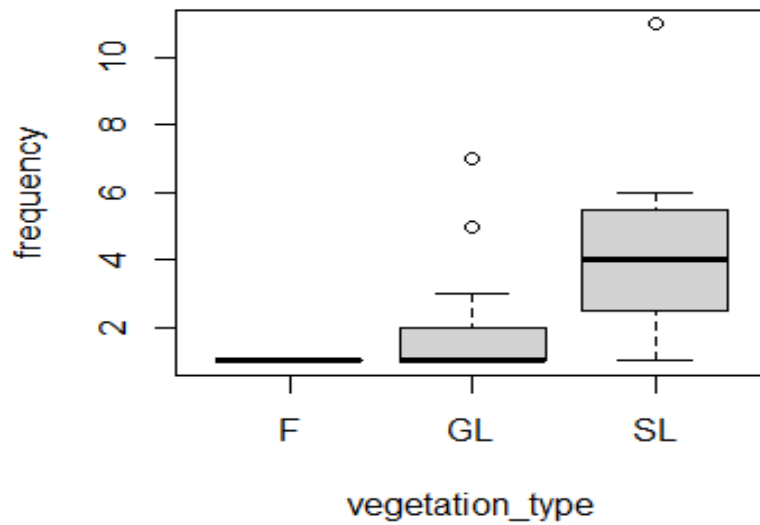


Figure 3. Distribution of Himalayan monal in different habitat types.

The number of Himalayan monal individuals was found to be higher in an elevation range of 3100-3300 m which then decreased from 3300- 3500 m around the region of Langtang Valley (Figure 4). There was gradual increase in the number of individuals from the elevation of 3500-3800 m and finally dropped to zero in the barren and rocky area beyond 3900 m.

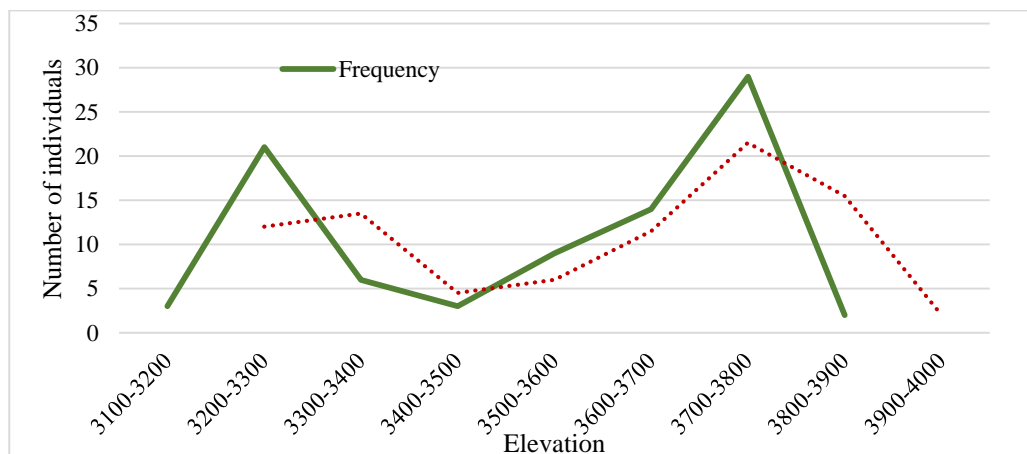


Figure 4. Line graph showing distribution of Himalayan monal along elevation.

Majority of the sightings of HM was on the southwest face of the slopes in study area followed by the southeast (Figure 5). Though the aspect did not show statistical significance in GLMM, yet HM were found to prefer sunny slopes on southwest aspect.

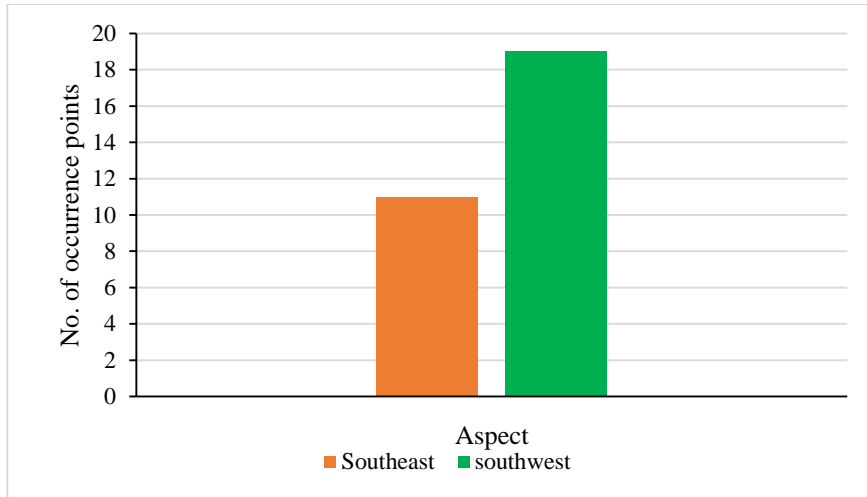


Figure 5. Bar graph showing the distribution of Himalayan monal along the aspect.

As the slope increases gradually, the number of occurrence points of HM also decreases gradually. There was a gradual linear decrease in number of sightings as slope increases indicates negative correlation between occurrence points and the slope (Figure 6).

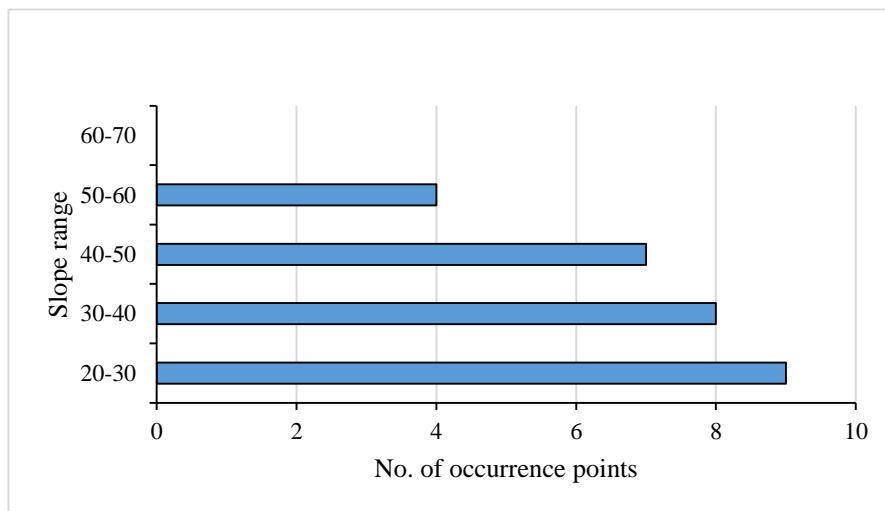


Figure 6. Bar graph showing distribution of Himalayan monal along slope range.

The ground cover value between 50-60 percent and 80-90 percent contributes to equal number of sighting of HM while the least is contributed by 30-40 percent in the study area (Figure 7).

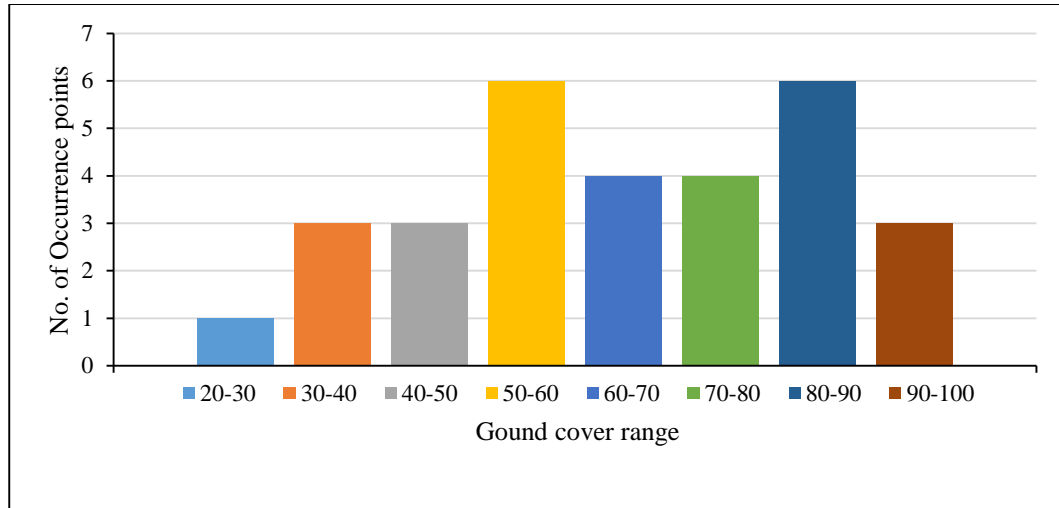


Figure 7. Bar graph showing the distribution of Himalayan monal along the ground cover range.

4.2. Habitat preference of Himalayan monal

Four categories of land cover and land use were observed in the study area (Figure.8). The total area occupied by forest, shrub land and grassland within the study area was estimated to be 3574 m². Among that, forest occupied 150 m² (4.84%), shrub land 604 m² (16.13%) and grassland 2820 m² (79.03%).

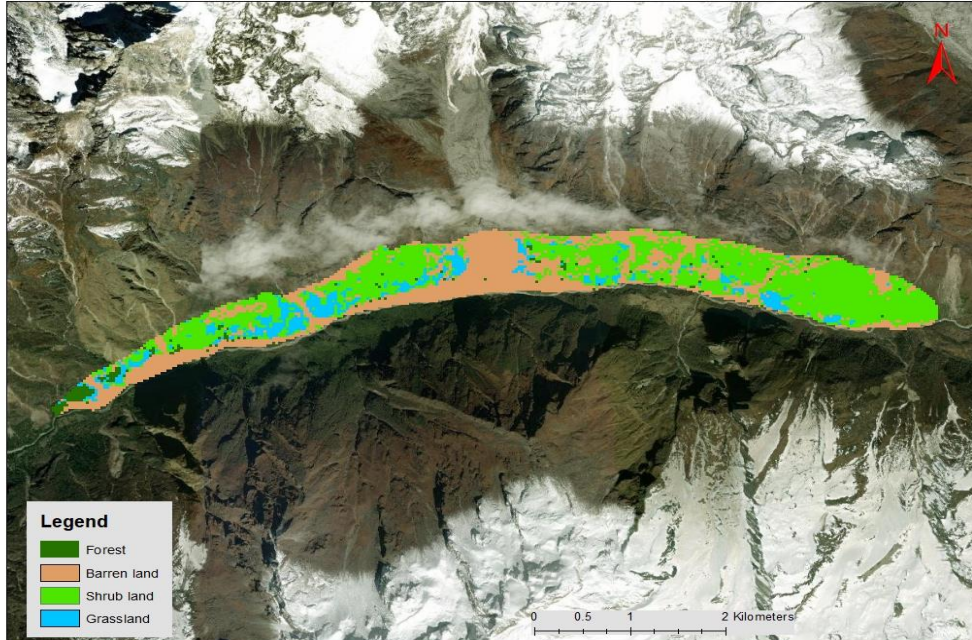


Figure 8. Map showing land cover classification of the surveyed area.

The occurrence ratio for forest was estimated to be 0.03226667, grassland was estimated to be 0.90798013 and shrub land estimated to be 1.42926596 (Table.1). The occurrence ratio of shrub land represents high preference of shrub land by Himalayan monal.

Table 1. Occurrence ratio of Himalayan monal in different habitat types.

S.N.	Habitat	Number	Area (m ²)	Area (%)	Occurrence ratio
1	Forest	1	150	4.84	0.03226667
2	Grassland	34	604	16.13	0.90798013
3	Shrub land	51	2820	79.03	1.42926596

The Himalayan monal was found to prefer shrub land over grassland while it preferred forest land the least (Figure 9).

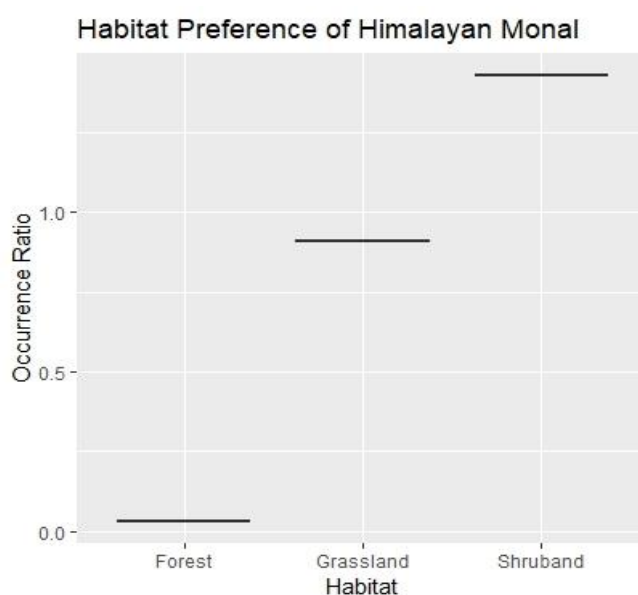


Figure 9. Habitat preference of Himalayan monal.

The Poisson regression model of GLMM suggested that NDVI and distance from walking trail were significant predictor variables determining the distribution of the HM. Other predictor variables did not show a significant effect (Table 2).

Table 2. Coefficients of response variable in relation to predictor variables.

Fixed effects:				
	Estimates	Std. Errors	Z value	Pr(> z)
(Intercept)	0.90629	0.13131	6.902	<0.001***
Slope	-0.07154	0.13539	-0.528	0.5972
Aspect	-0.07411	0.22581	-0.328	0.7428
NDVI_mean	-0.66737	0.26337	-2.534	0.0113 *
Dist_from_water	0.50121	0.25849	1.939	0.0525
Dist_from_walking_trail	-1.04343	0.26360	-3.958	<0.001***

Habitat use (R^2_m -0.459, R^2_c -0.459)

In the model, NDVI and distance from walking trail showed highly negative correlation with the response variable (frequency of HM) (Table 1). The estimated coefficient -0.66737 of response variable indicates that there will be increase in HM number by 0.66737 with unit decrease in NDVI at $P < 0.05$. Also, the estimated coefficient -1.04343 indicates that the number of individuals of HM will increase on unit decrease in distance from walking trail by 1.04343 times at $p < 0.001$. Similarly, distance from water is marginally statistically significant at $p = 0.0525$ suggesting that there is increase in number of HM with increase in distance from water source. This model best fit the habitat preference model of HM as it has lowest AIC value which is 121.8. The marginal and conditional R-squared values indicate that the model explains a significant amount of the variation in the data.

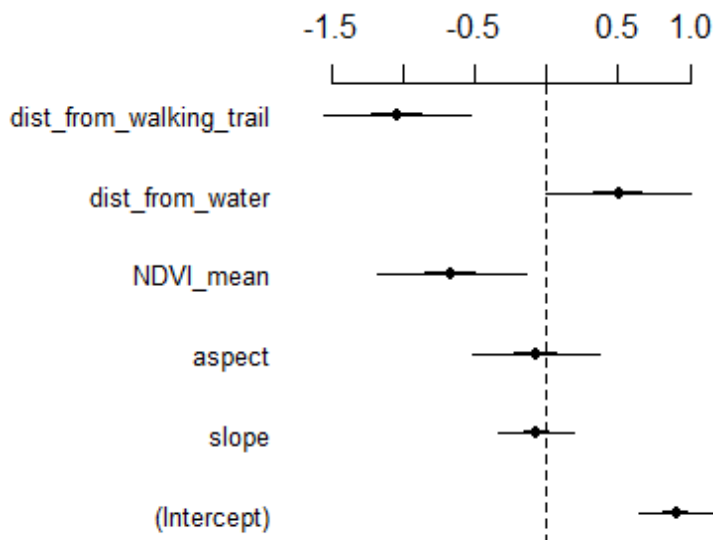


Figure 10. Plot representing the standardized coefficient of predictor variables in relation to response variable.

The generalized linear mixed model analysis showed that the frequency of occurrence of the studied species was significantly influenced by the mean NDVI, the distance from the walking trail, and the intercept. The incidence rate ratio (IRR) for the intercept was 2.48, which means that the frequency of occurrence was 2.48 times higher when all other variables were held constant. The IRR for mean NDVI was 0.51, indicating that a one-unit increase in mean NDVI was associated with a 0.51 times lower frequency of occurrence. The IRR for the distance from the walking trail was 0.35, suggesting that a one-unit increase in the

distance from the walking trail was associated with a 0.35 times lower frequency of occurrence.

Table 3. Table showing the numeric value of incident rate ratio between predictor variables and response variable.

Frequency			
Predictors	Incidence Rate Ratios	CI	p
(Intercept)	2.48	1.91 – 3.20	<0.001
Slope	0.93	0.71 – 1.21	0.597
Aspect	0.93	0.60 – 1.45	0.743
NDVI mean	0.51	0.31 – 0.86	0.011
Dist from water	1.65	0.99 – 2.74	0.053
Dist from walking trail	0.35	0.21 – 0.59	<0.001

ICC= 0.00

The random effects analysis revealed that the variance of the random intercept for the elevation group was 0.01, while the variance for the random intercept of the occurrence point group was 0.00, and the intra cluster correlation coefficient (ICC) was 0.00, indicating that there is no correlation between the random effects (Table 2).

The line graph (Figure 11, 12, and 13) shows the influence of statistically significant variables on Himalayan monal in the study area.

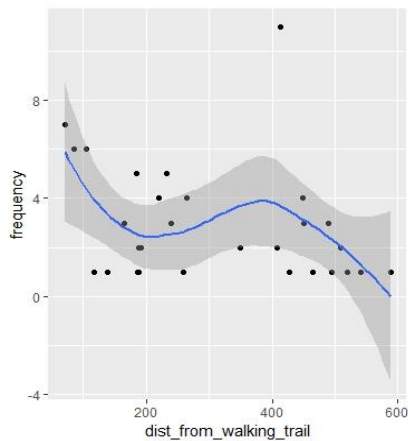


Figure 13. Change in occurrence of Himalayan monal along distance from walking trail.

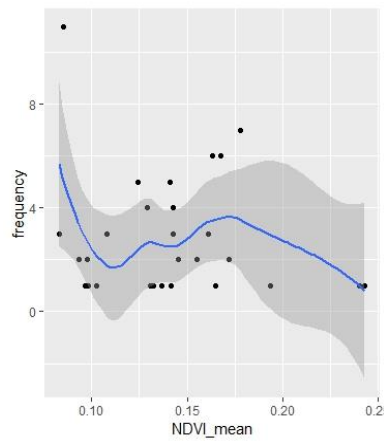


Figure 11. Change in occurrence of Himalayan monal along mean NDVI.

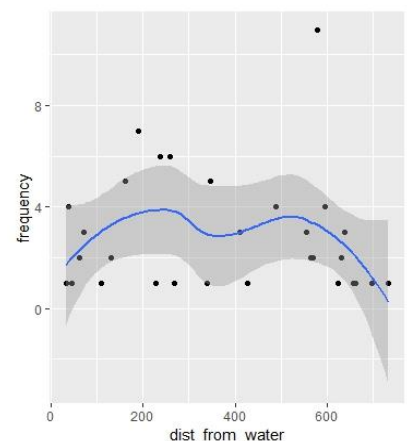


Figure 12. Change in occurrence of Himalayan monal along distance from water.

4.3 Conservation threats to Himalayan monal

Among 50 people, 45 responded to poaching, 31 responded to free livestock grazing, 28 responded to anthropogenic pressure and 11 responded to settlement. The Pie chart (Figure 10) shows the percentage of threat factors to HM in the study area. The threat assessment using semi structure questionnaire survey reveals that poaching is the major threat to HM followed by livestock grazing and anthropogenic pressure.

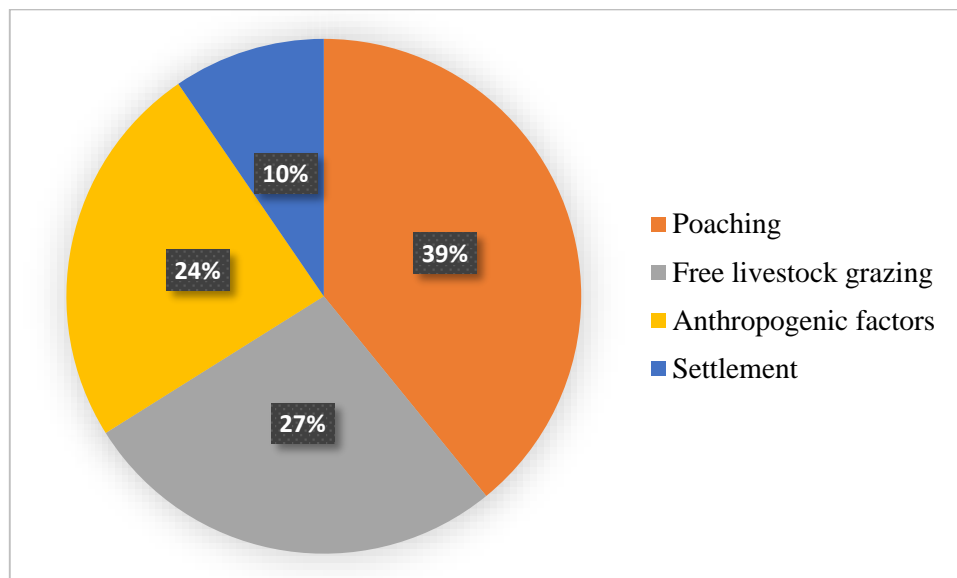


Figure 14. Pie-chart showing threats to Himalayan monal in study area.

5. DISCUSSION

5.1 Distribution of Himalayan monal

Having adequate information on the distribution and habitat preferences of a species is vital for effective conservation and management strategies. Regrettably, the Himalayan monal (HM) remains one of the least studied species in Nepal, with available knowledge primarily derived from short-term surveys and status reports. There is a significant data gap in Nepal regarding distributional modeling and understanding the habitat preferences of this species, especially in Lamtang National Park.

The present study has revealed the presence and distribution pattern of HM in parts of Lamtang National Park. The species was recorded from Ghodatabela to Sindum region of the National Park area from an elevation range of 3100m to 3900m. The distributional pattern along elevation showed the most suitable and preferred habitat of HM around elevation of 3100m to 3300m and 3500m to 3800m.

Previous studies have revealed that the Himalayan region of Nepal, characterized by arid regions and open forests, provides suitable habitat for the HM within an elevation range of 2500 m to 4750 m (Inskipp *et al.*, 2016). The findings of a recent study conducted by (Rai *et al.*, 2020) align with these observations, indicating that elevations between 3750 m and 4500 m are also considered suitable habitat for the species. However, the model employed in the study predicts potential losses in forest cover, grassland, and shrub land within these elevation ranges, posing future challenges to the habitat availability for the HM.

The findings of Sharief *et al.*, (2022) further corroborated the elevational distribution of the HM, which was observed to inhabit the range of 2000 to 4067 m in Uttarkashi district, Uttarakhand. The study highlighted that the species predominantly concentrated within a narrow belt of 2400–3400 m. However, in contrast to these findings, the HM was also found to occupy upper temperate oak-conifer forests and subalpine oak forests, alongside open grassy slopes, cliffs, and alpine meadows, with a higher concentration observed within a narrow belt of 2700–3700 m (Grimmett *et al.*, 1998). Also, HM appear to migrate to lower elevations in the winter, sometimes as low as 2000 m (Ramesh, 2003). These slight changes in the elevational distribution pattern of HM could be attributed to variation in topography, slopes, aspects, vegetation types etc. which impose ecological impact on species distribution and occupancy (Sharief *et al.*, 2022). In the Tibetan region, the bird's elevation range during the summer spans from 3800 m to 4300 m, while during the winter, it ranges from 3200 m to

3500 m (Xiaochun *et al.*, 2011). Similarly, according to Shrinivasan *et al.*, (2018), one of the main factors limiting the range of birds in the Himalayan region is the temperature variability.

Our findings are supported by other studies (Beebe, 1922; Hussain and Sultana, 2013), which have demonstrated that the species' habitat preference varies based on the landscape slope at different elevational ranges.

In accordance to the findings of present study, the higher number of species found in 3100m to 3300m and 3500m to 3800m elevation could be attributed to the suitable habitat with sloppy landscapes and vegetation types rather than Langtang Valley (3500m). Human settlement, livestock grazing and other anthropogenic factors are the major reasons for the low distribution of the species in Langtang valley. Due to anthropogenic disruption in its environment, the monal, a sensitive species, avoids these areas. Our findings support previous research showing the species' sensitivity to human-caused disturbances. Therefore, species may have evolved a behavioural tendency to avoid areas with anthropogenic disturbances (Jolli and Pandit, 2011; Bhattacharya *et al.*, 2009; Ramesh, 2003).

In addition to the altitudinal distribution, the present study demonstrated that among the major habitat types within the study area (Grassland, Shrub land and Forestland), species occupancy was found higher in Shrub land and very low in forest area. This result of high preference of shrub land by HM contradicts other findings of habitat use and occupancy. The distribution of the species was found to be significantly influenced by variables related to vegetation and habitat. The proximity to forests, forest-grassland mosaics, and forest-grassland edges were identified as important factors reflecting the species' preference. Studies have also indicated that areas with greater spatial variability tend to have higher bird diversity (Maskell *et al.*, 2019). Additionally, the species is known to feed on open grasslands (Soldatini *et al.*, 2010) and seek shelter in forests (DNPWC and DFSC, 2018), HM requires both habitat types. These factors could explain HM's affinity for grassland and woodland mosaics.

However, in contrast to findings of present study, Himalayan Monal was found to prefer cultivated areas while forest and shrub lands were considerably neglected in Sagarmatha National Park (Soldatini *et al.*, 2010). The bird was absent from herbaceous vegetation and barren land habitats. Higher distribution in shrub land in Lamtang National Park might be due to reasons like shelter, nesting, protection of eggs and young ones and to avoid

predators. Thorny shrubs around the study area and occurrence sites may possibly provide species with safety against different threats including human and livestock grazing. In some cases, the species preferred alpine and sub-alpine areas in steep grassy and open rocky slopes to avoid predators and disturbances (Lelliott, 1981).

5.2 Habitat use by Himalayan monal

In this study, the GLMM showed that predictor variables (NDVI and distance to walking trail) were statistically significant with the response variable (number of Himalayan monal) i.e. there was strong negative correlation between the predictor and response variables. The NDVI within the study area and study period was found to be low and negatively correlated with the presence of the HM because the NDVI index of shrub land was lower in comparison to grassland habitat in the month of November. The fact that the HM prefers dry area for feeding may be the cause of the larger number of HM in the months with low NDVI. Also, HM tries to avoid habitat overlapping with other notable herbivores (such as Himalayan thar, Himalayan langur, and wild boar) in the area with high NDVI.

Similarly, number of HM was found to be negatively associated with distance to walking trail i.e. as the distance from walking trail increases the number of HM decreases and vice versa. This shows that within the study area the HM were found to utilize habitats near walking trails because as the distance from the trail increases the suitable habitat of HM gradually decreases characterized by rocky and barren land with low vegetation on the slopes.

Other variables like slope and its correlation with number of species was statistically insignificant and suggest low impact in species occupancy. In contrast to these finding, the landscape slope was found to be positively influencing factors for habitat preference of the species in Uttarakhand (Hussain and Sultana, 2013; Sharief *et al.*, 2022). Since steeper slopes are free of anthropogenic disturbances, it is quite plausible that Himalayan Monal prefer them for roosting in order to avoid being preyed upon by carnivores. This is supported by the findings of (Ilyas, 2022) that monal prefer areas of medium to high altitude with steep slopes and dense vegetation.

Another predictor variable, distance from water was found to be marginally statistically significant suggesting that there is increase in number of HM with increase in distance from water source. The low water requirements of the Himalayan monal could be the cause of their preference for areas far from water sources. Another possible explanation for HM

utilizing habitats far from water resources is to avoid human disturbances and other predators in the vicinity of those areas with water resources.

5.3 Conservation threats to Himalayan monal

Hunting or poaching of HM for food and feather trade by local population in protected area has increased risk for decline of HM especially in winter season when HM migrates to lower altitude. Similarly, free livestock grazing and anthropogenic pressures such as fodder, herd, mountain trekking, etc., are also major threats to HM. These actions disturb the HM habitat and thus forcing HM to hide and seek shelter in dense shrub lands. Langtang Valley is one of the most favourite places for mountain trekkers. The local tourist seems to be unaware of HM habitat and make loud noise while trekking producing unnecessary disturbance. Similar results were observed by (Garson *et al.*, 1995; Ahmad *et al.*, 2019) where they found that anthropogenic pressure and hunting of HM for food trade are major threats to HM, over exploitation of habitat of HM by fodder, mushroom collection, destruction of nests of HM in breeding season and habitat destructions has forced HM to find safer habitat far from the settlement area and walking trails. In addition (Shansaz *et al.*, 2021) suggest similar threats finding in Brein Conservation reserve, Kashmir, India with high anthropogenic pressures and hunting of HM forcing the bird migrate to safer place. A study by (Bhattacharya *et al.*, 2007) suggest lower abundance of HM during summer season when there is high presence of humans near the HM habitat, due to high visit of free livestock grazing accompanied by herders and shepherd dogs. This study also suggests population clumped of pheasants in some undisturbed area of study area similar to present study. A study by (Chhetri *et al.*, 2021) on impact of climate change on Himalayan pheasants predicts that the core zone habitat of Himalayan pheasants would shift towards higher elevation and latitude gradient due to intensification of greenhouse gases. This model suggests that the shifting of suitable habitat of Himalayan pheasants in near future could be a serious threat to HM.

6. CONCLUSION

This study concluded that the distribution of Himalayan monal (HM) differs along the elevation along the Langtang River in Lamtang National Park. HM preferred shrubland habitats over forests and grasslands. In most of the places the walking trail passed through core habitat area especially in Thansyap region and Langtang Valley causing various threats to HM, poaching being the most and followed by free livestock grazing and anthropogenic pressure. Free livestock grazing and anthropogenic pressure can cause damage to its nesting sites. Although, the species is protected but the status of population and its habitat preference needs more study to understand the real population status and suitable habitat of HM. Further study during breeding period may help towards formulating conservation actions to manage this species.

7. RERERENCES

- Ahmad B, Noor F, Awan M, et al. 2019. Distribution and population status of Himalayan Monal pheasant (*Lophophorus impejanus*) in Salkhala game reserve, Neelum valley Azad Jammu and Kashmir (Pakistan). *The Journal of Animal Plant Science* , **29**(4): 1150–1159.
- Baral H. 2009. Protected birds of Nepal: A review of their status, distribution and habitat. *The Initiation* , **9**: 66–80.
- Baral, S. 2022. Modelling habitat suitability of the Himalayan monal (*Lophophorus impejanus*) and its connectivity in the Himalayas. *Nepalese Journal of Zoology*, **6**(1): 1–9.
- BCN. 2013. Important bird areas in Nepal deliver vital ecosystem services to people. Kathmandu: Bird Conservation Nepal. BCN, DN
- PWC. 2011. The state of Nepal's Birds 2010. Kathmandu: Bird Conservation Nepal and Department of National Parks and Wildlife Conservation.
- Beebe, W. 1922. A monograph of the pheasants-4 volumes. – New York Zoological Society by Witherby & Co., pp. 1918–1922.
- Bhattacharya, T. et al. 2009. Distribution and abundance of galliformes in response to anthropogenic pressures in the buffer zone of Nanda Devi Biosphere Reserve. – *International Journal of Galliformes Conservation.*, **1**:- 78–84.
- Bhujju U.R. 2001. Nepal Biodiversity Resource book. Protected areas, Ramsar sites and World Heritage site. International Center for Integrated Mountain Development, 128 pp.
- Bhujju, U. R., Shakya, P. R., Basnet, T. B., and Shrestha, S. 2007. Nepal biodiversity resource book: protected areas, Ramsar sites, and World Heritage sites: International Centre for Integrated Mountain Development (ICIMOD).
- Chhetri, B., Badola, H. K., and Barat, S. 2021. Modelling climate change impacts on distribution of Himalayan pheasants. *Journal of Ecological Indicators*, **123**: 107368.
- Del Rosario Avalos V., Hernández J. 2015. Projected distribution n shifts and protected area coverage of range-restricted Andean birds under climate change. *Global Ecology and Conservation*, **4**: 459–469.

- Delacour, J. 1977. Pheasants of the world: Food and Agriculture Organisation of the United Nations. Spur Publications. Published in conjunction with the World Pheasant Association." 1st ed. published in 1951, by Country Life. Bibliography: p. 383–388.
- DNPWC and DFSC. 2018. Pheasant Conservation Action Plan for Nepal (2019–2023). Department of National Parks and Wildlife Conservation and Department of Forests and Soil Conservation. Kathmandu, Nepal.
- Fuller, R.A. and Garson, P.J. (Eds.) (2000). Pheasants. Status and Conservation Action Plan 2000-2004. WPA/Birdlife/SSC Pheasant Specialist Group. IUCN, Gland. Switzerland and Cambridge, UK and the World Pheasant Association, Reading, UK.
- Garson P.J., McGowan P.J.K. 1995. Action Plan for Pheasants. WPA/IUCN, Geneva Switzerland.
- Gaston, A. J. 1980. Census techniques for Himalayan pheasants including notes on individual species. *Journal of World Pheasants Association*, **5**: 40–53.
- Grimmett, R., Inskipp, C., Inskipp, T. and Baral, H.S. 2016. *Birds of Nepal (Revised Edition)*, Christopher Helm Field guide, Bloomsbury USA, 368 pp.
- Grimmett, R., Inskipp C., Inskipp T. 1998. *Birds of the India Subcontinent*. Oxford University Press, Delhi, p–888.
- Hussain, M. S. and Sultana, A. 2013. Ecological separation of habitat variables among five rare pheasant species of the Himalayas, India. *Zoology and Ecology*, **23**(2), 97–103.
- Ilyas, O. 2022. Status, distribution and aspects of ecology of monal (*Lophorus impeyanus*) in Garhwal Himalayas, Uttarakhand, India.
- Inskipp, C., Baral, H., Phuyal, S., Bhatt, T., Khatiwada, M., Inskipp, T. et al. 2016. The status of Nepal's birds: the national red list series. *Zoological Society of London*, UK, p–628.
- Inskipp, C. and Baral, H. 2013. Bird Conservation Nepal. Danphe–A nationally threatened species. *Bird Conservation Nepal*, **22**: 1–12.
- Johnsgard, P. A. 1986. *The pheasants of the world*: Oxford University Press.
- Jolli, V. and Pandit, M. 2011. Influence of human disturbance on the abundance of Himalayan pheasant (Aves, Galliformes) in the temperate forest of western Himalaya, India. *Vestnik Zoologii*, **45**: 40–47.

- Kaul, R., Jandrotia J., and McGowan P. J. 2004. Hunting of large mammals and pheasants in the Indian western Himalaya. *Oryx*, **38** (4): 426–431.
- Kumar, S.R., Rawat, G.S., Sathyakumar, S. 1997. Winter habitat use by Himalayan Monal (*Lophophorus impejanus*) in Kedarnath Wildlife Sanctuary, Western Himalaya. *Journal of the Bombay Natural History Society*, **103**: 49–56.
- Lelliott, A.D. 1981 Survey of cheer pheasant near Dhorpatan west Nepal 1981 In C.D.W. Savage & M.W. Ridley (Eds.) *Pheasants in Asia* 1982. pp. 58–61. Reading UK: WPA
- Lelliott, A.D. and Yonzon, P.B. 1980. Pheasant studies in the Annapurna Himal II: field studies. Pages 56–62 in Christopher Savage (ed) *Pheasants in Asia 1979: Proceedings of the First International Symposium on Pheasants in Asia*. World Pheasant Association, Exning, UK.
- Maskell, L. C., Botham, M., Henrys, P., Jarvis, S., Maxwell, D., Robinson, D.A. et al. 2019. Exploring relationships between land use intensity, habitat heterogeneity and biodiversity to identify and monitor areas of High Nature Value farming. *Biological Conservation* **231**:30–38. <https://doi.org/10.1016/j.biocon.2018.12.033>
- McGowan, P.J.K., and Gillman, M. 1997. Assessment of the conservation status of partridges and pheasants in South East Asia. *Biodiversity and Conservation*, **6**: 1321–1337.
- McGowan, P.J.K. and Garson, P.J. 1995. Status survey and conservation action plan 1995 – 1999. Pheasants. IUCN and World Pheasant Association, Switzerland and U.K. Pp 116
- McGowan, P.J.K. 1994. Family: Phasianidae (pheasant and partridges). In: Del Hoyo J, Elliot A, Sargatal J (Eds) *Handbook of the Birds of the world*. Volume 2. New World Vultures to Guinea fowl. Lynx Edicions, Barcelona, pp 434–552.
- Miller, J. R. 2010. Survey of Western Tragopan, Koklass Pheasant, and Himalayan Monal populations in the Great Himalayan National Park, Himachal Pradesh, Indian Birds, **6**(3):, 60–65.
- Nie, Y., Sheng, Y., Liu, Q., Liu, L., Liu, S., Zhang, Y. et al. 2017. A regional-scale assessment of Himalayan glacial lake changes using satellite observations from 1990 to 2015. *Remote Sensing of Environment*, **189**: 1–13.

- Poudyal, L. P. 2008. Distribution and habitat use of pheasants in the headwater forests of Seti Khola, Annapurna Conservation Area, Nepal. Thesis for the Degree of Master of Science in Natural Resource Management and Rural Development. Tribhuvan University, Institute of Forestry, Pokhara, Nepal.
- Rai, R., Paudel, B., Changjun, G. and Khanal, N. R. 2020. Change in the Distribution of National Bird (Himalayan Monal) Habitat in Gandaki River Basin, Central Himalayas. *Journal of Resources and Ecology*, **11**:223–231. <https://doi.org/10.5814/j.issn.1674-764x.2020.02>.
- Ramesh, K., Sathyakumar, S. and Rawat, G. S. 1999. Ecology and conservation status of the pheasants of Great Himalayan National Park, Western Himalaya. Wildlife Institute of India, Dehradun.
- Ramesh, K. 2003. An ecological study on pheasants of the Great Himalayan National Park, western Himalaya. Wildlife Institute of India, Dehradun.
- Ranta, E., Lindstrom, J. and Linden, H. 1995. Synchrony in tetraonid population dynamics. *Journal of Animal Ecology*, 767–776. <https://doi.org/10.2307/5855>
- Sathyakumar, S., Poudyal, K., Bhattacharya, T. and Bashir, T. 2011. Galliformes of Khangchendzonga Biosphere Reserve, Sikkim, India. – In: Biodiversity of Sikkim – exploring and conserving a global hotspot. Government of Sikkim, pp. 301– 315.
- Sathyakumar, S. and Kaul, R.. 2007. Galliformes of India. ENVIS Bulletin. Wildlife and protected areas. – In: Sathyakumar, S. and Sivakumar, K. (eds), Pheasants. Wildlife Inst. of India, pp. 33– 52.
- Shansaz, U. H., Fazili, M. F., and Bhat, B. 2021. Distribution and threats to two threatened pheasants in the Brein Nishat Conservation Reserve, Kashmir, India. *Uttar Pradesh Journal of Zoology*, **42**(9): 88–94.
- Sharief, A., Singh, H., Joshi B.D., Singh, I., Mukherjee, T., Chandra, K. et. al 2022. Understanding distribution and occupancy of Himalayan monal in Uttarkashi district, Uttarakhand for conservation and management planning. *Wildlife Biology* **2022**: e01013. <https://doi.org/10.1002/wlb3.01013>.
- Soldatini, C., Albores-Barajas, Y. V. and Pellizzi, B. 2010. Habitat preferences of high-altitude Galliformes in Sagarmatha National Park, Nepal. *Italian Journal of Zoology*, **77**:347–353. <https://doi.org/10.1080/11250000903337909>.

- Srinivasan, U., Elsen, P. R., Tingley, M. W. and Wilcove, D. S. 2018. Temperature and competition interact to structure Himalayan bird communities. *Proceedings of Royal Society B* **285**:20172593. <http://dx.doi.org/10.1098/rspb.2017.2593>.
- Xiaochun, M., Junfeng, G., and Xiaoping, Y. 2011. Himalayan Monal (*Lophophorus impejanus*): Distribution, habitat and population status in Tibet, China. *Journal of Avian Research*, **2**(3): 157–162.
- Yin, T. 1970. Record of Himalayan Monal (*Lophophorous impejanus*) in Burma. *Journal of Bombay Natural History Museum*, **67**: 328.

Photo plates



Himalayan monal in different habitat types, slopes, aspects and elevation.

Variables collected

S.N.	Environmental variables	Topographic variables	Response variable
1.	NDVI	Co-ordinates	Number of Himalayan monal
2.	Ground cover	Slope	
3.	Distance from water	Aspect	
4.	Distance from trail	Elevation	
5.	Distance from village		
6.	Vegetation type		

Semi-structured questionnaire

Name: _____

Occupation: _____

Age: _____

Gender: _____

1. What is your level of awareness about the Himalayan monal and its conservation status?
2. Have you observed or heard about the illegal hunting or trade of Himalayan monal in your area?
3. How frequently do you encounter Himalayan monal in your area?
4. What do you think are the major threats to the survival of Himalayan monal in your area?
5. Do you know about any conservation programs or initiatives that aim to protect the Himalayan monal?
6. Have you ever witnessed or heard about the destruction of Himalayan monal habitat in your area?
7. How important do you think Himalayan monal is for the local ecosystem and biodiversity?
8. Have you ever seen or heard about Himalayan monal being affected by pollution or climate change?
9. What do you think can be done to better protect and conserve the Himalayan monal in your area?
10. How do you think local communities can be involved in Himalayan monal conservation efforts?