

**Distribution and Habitat Use of Himalayan goral  
(*Naemorhedus goral*) in Lamtang National Park, Nepal**



By

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Environment**

**Central Department of Zoology  
Institute of Science and Technology,  
Tribhuvan University  
Kathmandu, Nepal  
March 2023**

## DECLARATION

I hereby declare that the work presented in this thesis “**Distribution and Habitat Use of Himalayan goral (*Naemorhedus goral*) in Lamtang National Park, Nepal**” has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).



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This is to recommend that the thesis entitled “**Distribution and Habitat Use of Himalayan goral (*Naemorhedus goral*) in Lamtang National Park, Nepal**” has been carried out by Ranjit Kumar Sharma for the partial fulfillment 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 my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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**LETTER OF APPROVAL**

On the recommendation of supervisor Laxman Khanal, PhD this thesis submitted by Ranjit Kumar Sharma entitled “**Distribution and Habitat Use of Himalayan goral (*Naemorhedus goral*) in Lamtang National Park, Nepal**” is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master’s Degree of Science in Zoology with special paper Ecology.

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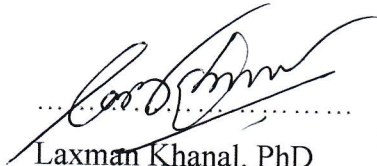
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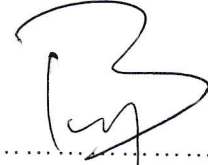
  
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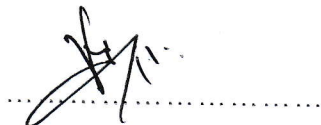
  
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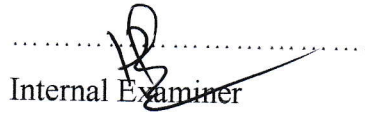
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## **ABBREVIATIONS AD ACRONYMS**

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DNPWC	Department of National Parks and Wildlife Conservation
IUCN	International Union for Conservation of Nature
GIS	Geographic Information System
GLM	Generalized Linear Model
GPS	Global Positioning System
HR	Hinting Reserve
LNP	Lamtang National Park
NP	National Park
WLR	Wildlife Reserve
WS	Wildlife Sanctuary

## ABSTRACT

Mountains are the sensitive ecosystems towards global climate change and human disturbances. Ungulates are the major indicators of mountain habitat which are under the pressure of human threats. The investigation of Himalayan goral is very low in Nepal where status is still unknown. The main aim of conducting the current study was to assess the distribution status and habitat utilization of Himalayan goral (*Naemorhedus goral*) in Lamtang National Park, Nepal in 2019 and 2021. Line transects each of 100 m were laid on the field which were spaced 100m-200m with random start to investigate the distribution status of goral. Direct observation of goral, fecal pellet counts in various type of habitat and records of other ecological variables were recorded to evaluate the distributions and habitat utilization. Informal interviews with locals were used to assess level of threats to Himalayan goral. A total of seven individuals of goral were sighted in five sites and 137 fecal groups of gorals were counted from 2124m to 2717m asl. Out of four habitat types within the study area Himalayan goral dominantly preferred the rocky cliff followed by grassland, Pine Forest and Quercus Forest. The distribution of goral had negative relation with the livestock on the basis of Generalized Linear Model. South facing slope was most used followed by south-east facing slope where very steep and steep terrain were used more by goral. Habitat destruction, fragmentation and various human activities such as road construction, cattle grazing, timber collection and fuel wood collection were the threats to goral in LNP.

# 1. INTRODUCTION

## 1.1 Background

The biodiversity of the earth changes with the change in global environment (Chen et al. 2011) so regular monitoring of status of wildlife is crucial for its conservation and management (Lindenmayer and Fischer 2013). The collection of database from small scale studies can be used to generate the large-scale database of species which provides baseline for effective conservation practices (Boitani et al. 2007). The formulation of scientific and evidence-based conservation efforts requires the database of distribution of species (Jetz et al. 2012). Ecological research is essential for cost-effective means of population assessment of an organism and formulation of effective management policies (De Garine and de Garine-Wichatitsky 1999).

Himalayan ecosystems are some of the most sensitive ecosystems to global warming in the world (Hirzel and Le Lay 2008). The low density of the species and difficult topography of mountain has limited the study of mountain species (Gibson et al. 2004). Ungulates are the key indicators for determining the quality of mountain habitat as they play a great role in influencing the vegetation structure and nutrient cycling (Bagchi and Ritchie 2010, Zafar et al. 2014). The distribution of mountain ungulates appear to be healthy in steep rugged areas far from roads and settlements (Fox et al. 1991). The threats like habitat destruction, illegal hunting, overgrazing, human disturbance, competition and diseases are the major cause for decline in the population and range of mountain ungulates (Mishra et al. 2004, Berger et al. 2013).

Himalayan goral is a gray or brown colored ungulate having white spot in throat, black color at tip of tail, dark stripe on back of hind leg and possess parallel horns (Mead 1989). It is listed in Appendix I i.e., threatened with extinction in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Near Threatened in International Union for Conservation of Nature (IUCN) Red List of Threatened Species (Amin et al. 2018, IUCN 2019). Four goral species are included in the IUCN's Red List: *N. caudatus*, *N. griseus*, *N. baileyi*, and *N. goral* (Duckworth and MacKinnon 2008) but the recent study shows additional two species of goral i.e., *N. cranbrooki* and *N. evansi* (Joshi et al. 2020, Li et al. 2020).

*N. goral* is with two valid sub-species and they are Himalayan gray goral; *N. goral goral* and Himalayan brown goral; *N. goral bedfordi* (Groves 1985, Wilson and Reeder 2005). Out of two sub-species of *N. goral*, Himalayan Brown goral (*N. goral bedfordi*) is distributed in India, Nepal, China and Bhutan whereas Himalayan Gray goral (*Naemorhedus goral goral*) is distributed in Nepal, Pakistan, India and Thailand (Pocock 1908, Green 1978, Cavallini 1992, Abbas et al. 2015). Himalayan goral occurs in nine National Parks in Nepal i.e., Shey-Phoksundo, Khaptad, Bardia, Rara, Lamtang, Sagarmatha, Makalu-Barun, Parsa and Chitwan as well as Dhorpatan Hunting Reserve, and six Conservation Areas i.e., Gaurishankar, Annapurna, Kanchenjunga, Gaurishankar, Manaslu and Api-Nampa (Duckworth and MacKinnon 2008). Gorals are also widely distributed in different districts outside the protected areas of Nepal like Nawalparasi, Tanahun, Dailekh and Taplejung (Thapa 2010, Paudel and Heinen 2015, Adhikari et al. 2021, Karki 2021).

The elevation range of goral ranged from 200m to 4000m (Green 1987) whereas it is recorded between 200m to 3400m in steep slope with low canopy in Nepal (Paudel 2012). The most suitable slope was recorded above 50° in Geospatial Modelling for goral Habitat Evaluation (Kushwaha et al. 2000). Goral prefers solitary life which is influenced by their selective feeding behaviour and high metabolic rate (Pendharkar, 1993) whereas it also occurs in pair or in small herd of 4 to 12 individuals (Mead 1989). The mean group size ranged from 1.6 to 1.8 within different study areas of Pakistan and India (Pendharkar and Goyal, 1995, Bhattacharya et al. 2012, Ashraf et al. 2017). The association of wild goat is significant with steep slopes and rocky terrain holding sufficient sources of water and has negative relation with roads and settlements (Esfandabad et al. 2010).

The local extinction of Himalayan goral was reported in Thailand and decline in population was reported in different habitat of Pakistan and India where drivers were interspecies competition, habitat loss, hunting and predator's pressure (Bhattacharya et al. 2012, Abbas et al. 2015). The dependent of people on forest resources has increased the problem of human-wildlife conflicts nowadays (Ahmad et al. 2020). The method to be incorporated for the study of species is directly affected by its ecological behaviour (Marques et al. 2001) so appropriate method of finding population density and distribution is necessary (Cairns and Telfer 1980).

Dung/Pellet group count method (Bennett et al. 1940) of monitoring distribution and habitat of ungulate species is most commonly used method (Plhal et al. 2014) which has been used for more than fifty years (Neff 1968). The dung count method has also been used for interpretation of the population of species (Eggert et al. 2003). The information on distribution and habitat of ungulates can be assessed through direct observation method and indirect method like pellet sampling (Edge and Marcum 1989, Campbell et al. 2004, Hemami and Dolman 2005). Global Positioning System (GPS) helps to provide information on distribution of an animal (Johnson et al. 2002). Mountain ecosystem is highly affected by human activities and their consequences so to find distribution and habitat use of goral, this study was conducted in Lamtang National Park by line transect sampling method (Buckland et al. 2001, Buckland et al. 2004) and pellet sampling method (Bennett et al. 1940) which can aid for its conservation practices.

## **1.2 Research objectives**

### **1.2.1 General objective**

The major objective of this study was to explore the distribution and habitat use of Himalayan goral in Langtang National Park, Nepal.

### **1.2.2 Specific objectives**

The specific objectives were:

1. To explore distribution of Himalayan goral in study area of LNP.
2. To identify the habitat features of Himalayan goral in the study area.

## **1.3 Significance of the study**

Low investigation of goral has been reported in Nepal (Adhikari et al. 2021) where the status is still unknown. There are huge gaps in scientific researches and many areas, floras and faunas still need to be explored so the study is expected to fill the gaps on information. The result from this research will help to analyze the status, distribution and habitat of Himalayan goral in focused area of Langtang National Park which may emphasize for the management of the species and its habitat. The gorals distributed in these areas are threatened by habitat degradation due to illegal hunting, overgrazing and

other human disturbance. Gorals are major indicators of mountain ecosystem so this study contributes to for its conservation practices and resource management and wildlife conservation in Himalayan region.

#### **1.4 Limitations of the study**

1. Difficulty in studying the animal for longer period due to fluctuation of environmental conditions.
2. Difficulty in sighting of goral due to its shy nature.
3. Lack of proper devices for proper scoping.

## 2. LITERATURE REVIEW

### 2.1 Himalayan goral (*Naemorhedus goral*)

The original naming of genus *Naemorhedus* was given by Hamilton Smith which is said to be etymologically incorrect and would be *Nemorhaedus* if properly formulated as recognized by Hodgson (Hodgson 1841)) and supported by Ellerman and Morrison-Scott (Ellerman and Morrison-Scott 1951). The original spelling of the genus was retained and family-group names was kept Naemorhedinae after several emendations (Grubb 2001). The rapid uplift of the Qinghai-Tibetan Plateau and Hengduan Mountains from the early Pliocene to the Pleistocene has close relation with speciation of goral (Li et al. 2020). *Capricornis* and *Naemorhedus* are independent monophyletic sister taxa (Li et al. 2020). The genus *Nemorhaedus* refers to goat like animal as its generic name ‘nemoris’ has latin meaning ‘a young goat’. The species name ‘goral’ is originated from north eastern India where it is a local name for goral. It is also called as ‘PijPijur’ in Pakistan and ‘Ghoral’ in Nepal (Cavallini 1992, Bhattacharya et al. 2012).

The valid number of species of goral was not recorded before 1930, one species of goral was reported until 1985 that was split into three species: the long- tailed goral *Naemorhedus caudatus*, the red goral *Naemorhedus bailey* and the brown goral *Naemorhedus goral* (Groves 1985). The grey goral *Naemorhedus griseus* was split from *Naemorhedus caudatus* forming six species of goral where the studies were based on morphological evidence only (Groves 1985). The International Union for Conservation of Nature’s Red List has included four goral species: *Naemorhedus caudatus*, *Naemorhedus griseus*, *Naemorhedus baileyi*, and *Naemorhedus goral* (Duckworth and MacKinnon 2008, Jnawali et al. 2011). Although, the two clades of Chinese gorals *N. caudatus* and *N. griseus* have some similarities with *N. goral* but the sub-species of *N. goral* were addressed with genetically diverged lineage from goral species reported from other regions (Joshi et al. 2020). Phylogenetic analysis based on the mitogenome sequences using the Bayesian inferences method showed that *N. goral* was closely related to *N. griseus* and *Naemorhedus* and *Capricornis* formed a monophyletic group (Liu and Jiang 2017). The study of phylogenetic reassessment of gorals in Myanmar concluded and there are five species of goral forming two major

distinct phylogenetic clades (Li et al. 2020): Clade 1: *Naemorhedus caudatus* and *Naemorhedus goral* whose synonym was taken as *Naemorhedus griseus*; Clade 2: *Naemorhedus evansi*, *Naemorhedus baileyi*, and *Naemorhedus cranbrooki* (Liu and Jiang 2017, Li et al. 2020). The phylogeny group study distinguished gorals into six clades i.e., clade 1: *N. caudatus*, clade 2: *N. griseus*, clade 3: *N. baileyi*, clade 4: *N. cranbrooki*, clade 5: *N. evansi* and clade 6: *N. goral* (Joshi et al. 2020). Himalayan goral; *Naemorhedus goral* is with two valid sub-species and they are Himalayan gray goral; *Naemorhedus goral goral* and Himalayan brown goral; *Naemorhedus goral bedfordi* ((Groves 1985, Wilson and Reeder 2005, Joshi et al. 2020).

The animals in sub order Ruminantia possess horns which is born on bony structure where males are with larger horns than females. The grinding of food occurs by selenodont teeth with a sideway motion in gorals and digestion occurs by regurgitation of partially digested food and cud-chewing in a multi chambered stomach (Mead 1989, -i-Abbas et al. 2012). Himalayan goral is closely related with serow but lack depression on skull due to absence of pre-orbital gland below their eyes (Pocock 1908). It possesses smooth premolar surface in upper jaw and small teeth but both premolars and molars are almost similar to the serow (Allen 1930). The long and coarse guard hairs cover the short wooly undercoat in gorals where males are with semi erect manes. The coloration of different species of goral varies from dark gray to brown, bright red to tawny from which *N. goral* appears gray or brown color. The summer coat is shorter and sparser but the winter coat is composed of 25 to 30mm underfur guarded by 67mm long hairs (Zahidullah et al. 2016). Goral is gray or brown in color with white patch on the throat, a dark stripe on back of hind leg and black colour at tip of tail (Mead 1989). The length of the body in average is about 95cm in female and 130cm in male where weight varies from 35 kg to 42 kg (Prater 1965). The condylo basal length of skull was recorded to be 164 to 230mm, zygomatic breadth was 90 to 102mm, width across molars was 58 to 63mm and length of upper molar row was 62 to 71mm. The diameter of horn core varies from 15mm to 21mm with length of 83.3mm in goral (Mead 1989). The number of teeth in goral was recorded 30 where dental formula was recorded as; I 0/3, C 0/0, P 3/3, M 3/3 (Mead 1989). The ears of goral are broad and bell-shaped and females possess four mammae (Pocock 1908).

The study on rutting behavior of goral in Northern India was concluded with 27 qualitatively different visual, auditory and olfactory behavior patterns which are approach threat, body and head shake, chase threat, croup touch, dynamic head down, flank stroke, following female during mating and twenty others (Lovari and Apollonio 1994). It was conducted behavioral study on goral maintained in semi captive conditions suggested that the sub-adult spends 33.48% on sleeping, 22.16% on feeding, 20.24% on resting, 12.22% on ruminating, and 7.92% on agnostic activities where as adults spend 26.48% on ruminating, 24.88% on sleeping, 14.09% on resting, 13.42% on agnostic behavior and 8.06% on feeding. goral is mainly dependent upon camouflaging and threat behavior for its defense and are vigilant to environmental changes while feeding, ruminating and resting. goral migrates towards lower altitude during winter season to escape from hunters, predators, low temperature and in search of food. goral migrates upward the hills during summer and in winter returns downward and also migrate far sometime. The camera traps for goral confirmed that it can be found during daytime as well as at night where the early morning activity peak at 04:00 to 06:00 (Bhattacharya et al. 2012). and they prefer running water than stagnant water (Abbas 2006).

## **2.2 Distribution of Himalayan goral**

The annual rainfall and climatic conditions are the main factors which highly affecting the distribution of Himalayan goral (Ahmad et al. 2020). Caprids originated in Asia during the Miocene where the earliest caprids were like rupicaprid and widely distributed in Eurasia and North Africa (Groves 1985, Valdez 2011). The Long-tailed goral *N. caudatus* is distributed in North China, Korean peninsula and East Russia (von Dolan 1963). The red goral *N. bailey* is distributed in North Myanmar, North East India and South China. The Burmese goral *N. evansi* is distributed in Myanmar and Thailand. The Red goral *N. cranbrooki* is distributed in India, Myanmar and Burma ((Pocock 1908, Mori et al. 2019). The Chinese goral *N. griseu* is distributed in East- Central China, Myanmar and Thailand (Teng et al. 2021). The Himalayan goral *N. goral* is endemic to Asia and is distributed in middle slope or along the southern foothill of Himalayas in Nepal, India, Pakistan, Bhutan, Burma and Thailand (Groves 1985, Mead 1989, Zhiwotschenko 1990, Cavallini 1992, Joshi et al. 2020, Singh et al. 2021).

Out of two sub-species of *N. goral*, Himalayan Brown goral *N. goral bedfordi* is distributed in India, Nepal, China and Bhutan whereas Himalayan Gray goral *N. goral goral* is distributed in Nepal, Pakistan, India and Thailand ((Pocock 1908, Groves 1985, Green 1987, Zhiwotschenko 1990, Cavallini 1992, Joshi et al. 2020, Suraprasit et al. 2020). In China, *N. goral* is distributed throughout central and eastern part and many other provinces of the country (von Dolan 1963). In India, *N. goral* is distributed in Jammu-Kashmir and Himachal Pradesh, Uttaraanchal, Uttaraanchal Pradesh, Arunachal Pradesh and Sikkim, Kedarnath Wildlife Sanctuary, Binsar Sanctuary, Majhatal Arsang Wildlife Sanctuary, Kajinag National Park, Haryana and other regions of western Himalayas (Green 1987b, Cavallini 1992, Pendharkar 1993, Kushwaha et al. 2000a, Ilyas and Khan 2004, Junaid et al. 2012, Dar et al. 2020, Singh et al. 2021). In Pakistan goral is widely distributed and occurs in Jammu-Kashmir, Hazara Region, North-West Frontier Province, Margalla Hills National Park and Kohistan (Fakhar- i- Abbas et al. 2008, Farzana and Anzela 2013, Abbas et al. 2015). In Thailand, *N. goral* was reported in five Wildlife Sanctuary and two National Parks and they are Mae Lao-Mae Sae WS, Doi Chiang Dao WS, Lum Nam Pai WS, Mae Tuan WS, Om Koi WS, Doi Inthanon NP and Mae Ping NP (Chaiyarat et al. 1999). In Bhutan Gorals were reported in four national parks and they are Jigme Singye Wangchuk NP, Royal Manas NP, Thrumingla NP and Jigme Dorji NP (Green 1987).

*N. goral* occurs in nine National Parks of Nepal i.e., Lamtang NP (Groves 1985), Rara NP, Sagarmatha NP, Khaptad NP, Chitwan NP, Parsa NP, Bardia NP, Makalu-Barun NP, Shey-Phoksundo NP as well as five conservation areas i.e., Kanchenjunga CA, Annapurna CA, Gaurishankhar CA, Manaslu CA, Api Nampa CA and Dhorpatan Hunting Reserve (Shackleton 1997, Duckworth and MacKinnon 2008). Gorals are also widely distributed in different districts outside the protected areas like Nawalparasi (Thapa et al. 2011), Tanahun (Adhikari et al. 2021), Dailekh (Karki 2021), and Taplejung (Poudel 2009). The *N. goral* is unevenly distributed and mostly clumped in Mahabharat goral Conservation Area in Nawalparasi district (Thapa et al. 2011). A total of 34 *N. gorals* were reported in steep slope of Seti River basin in Tanahun district (Adhikari et al. 2021). Four *N. gorals* were encountered and distribution pattern was found to be clumped on the basis of pellet (Karki 2021).

The elevation range of goral in Nepal is recorded between 200m to 3400m within different protected areas and districts. Gorals were reported between elevation of 525m to 1421m in Tanahun (Adhikari et al. 2021), 700m to 1250m in Dailekh (Karki 2021), 1115m to 3400m in Api-Nampa NP (SHERPA 2016), 964m to 1591m in Nawalparasi (Thapa et al. 2011). Himalayan goral was recorded between elevation of 1400m to 1929m out of which 1500m to 1800m was preferred more in Thailand (Chaiyarat et al. 1999). In India, Himalayan goral is found to be distributed from 200 to 4000m above sea level in India with significant population in Jammu- Kashmir, Bengal, Himachal Pradesh, Uttaranchal, Sikkim and Arunachal Pradesh (Johnsingh 1992). It is also found between 1200m - 3700m of Khangchendzonga Biosphere Reserve (Bhattacharya et al. 2012) and between 240m to 1293m in Chilla Sanctuary (Kushwaha et al. 2000a). In Pakistan, goral was recorded within elevation of 773 to 3447 m a.s.l (Fakhar- i- Abbas et al. 2008). In China the most preferred habitat of goral was recorded with a mean altitude of  $1444.54 \pm 56.79$  m (Yang et al. 2013).

The observation of goral is mostly in steep slopes with low canopy. IUCN red list category categorize *N. goral* as Near 'Threatened', and *N. caudatus*, *N. bailey* and *N. griseus* as 'Vulnerable' (Duckworth and MacKinnon 2008). The illegal trade of any body parts of goral is prohibited as they are categorized into Appendix I of CITES. The observation of most solitary goral was reported in a study of Thailand where juvenile:adult ratio was 1:4 and herd of more than two individual was sighted very less (Chaiyarat et al. 1999). The group size of 1.6 to 1.8 were reported in this study area of Pakistan and India (Pendharkar and Goyal 1995, Bhattacharya et al. 2012, Ashraf et al. 2017). The selective feeding and high metabolic rate are the reasons that supports goral for its solitary life (Pendharkar 1993). The adult sex ratio and young to adult ratios were recorded as 49:94 and 29:143 respectively where mean group size was 1.7 in Pakistan (Fakhar- i- Abbas et al. 2008).

### **2.3 Habitat preference of Himalayan goral**

The land-cover data have the most diverse influence on ecological niches and they may represent food, shelter, breeding sites, disturbance, presence of competitors, etc. (Schadt et al. 2002). The result of occupancy modeling concluded that distant sites from the regularly used trails were best occupied by goral (Bhattacharya et al. 2012). The safe place from the natural predators and human for goral is steep slope (Thapa et al.

2011). Himalayan goral's habitat lies far from human habitation especially in steep terrain with slope greater than 30° in open forest consisting of sufficient grassy areas (Kushwaha et al. 2000). The suitable habitat of goral is rocky areas and hill's top with steep terrain having sufficient ground cover and palatable plant (Cavallini 1992). The most suitable slope was recorded above 50° in Geospatial Modelling for goral Habitat Evaluation (Kushwaha et al. 2000). The multi-species occupancy modeling suggested that the mean marginal occupancy probability of goral was negatively influenced by distance to the village and positively influenced by West Himalayan sub-alpine birch/fir forest where activity overlap of goral was found very less with sambar and barking deer (Singh et al. 2022).

The Geospatial Modelling for goral habitat evaluation showed that the most suitable habitat was the mixed forest with forest density range from 30%-50% where permanent drainage was within one km and at least 1.5 km far from roads or settlements (Kushwaha et al. 2000). Gorals prefers Open plant community with less shrub understory and are capable of running sideways in escape terrain (Mishra and Johnsingh 1996). The microhabitats selected by gorals was recorded with greater tree canopy and shrubs which can supply them better hiding habitat (Wei et al. 2018). The preference of grassland followed by rocky base areas and forest along deep valley was reported in Thailand (Chaiyarat et al. 1999). The use of forest cover was observed more by gorals followed by Cliff, open gullies, rocky areas and they were mostly recorded at steep slope in open pine community with less shrub and good grass cover in India (Mishra and Johnsingh 1996). The wide range of habitat of goral is recorded in India that includes alpine meadows, subalpine regions, forest of temperate zone, 1 pine forests of sub-tropical region, deciduous forest of Shiwaliks, and wet temperate Montana forest and evergreen forest (Sathyakumar 1994).

In Mahabharat goral Conservation Area of Nawalparasi district, *N. gorals* were distributed dominantly in the rocky cliff area, followed by Mixed Forest of Shorea, Schima Forest, grasslands and Qurecus mixed forest mostly on steep slopes of southern aspect. In Api-Nampa Conservation Area, *N. gorals* were found to be distributed mostly in grassland followed by cliff and gullies with good canopy cover and moderate ground cover (Sherpa 2016).

In Dailekh District, *N. goralis* were encountered mostly at steep slope mostly in the cliff areas followed by Quercus Forest, Sal-Terminalia Forest, Mixed-hardwood Forest and least in Pine Forest (Karki 2021). In Seti River basin of Tanahun district, *N. goralis* were distributed in steeped and rugged rocky terrain (Adhikari et al. 2021). The relation of goral was seemed to be positive with rhesus monkey and occurrence of rhesus monkey sometimes indicate goral presence in the respective vicinity (Zahidullah et al. 2016). *N. goral* migrates during winter season towards lower populated areas, to escape from cold temperature, predators, hunters or in search of food and if it migrates due to predators, then it will never return to its native habitat (Perveen et al. 2013). The occupancy-based model of goral showed its equal distribution in subalpine and temperate habitats (Bhattacharya et al. 2012). *N. goral* has the normal distribution range of distribution between 900 m to 4,000 m above sea level.

The Himalayan goral is found to be predominantly grazer ((Zhiwotschenko 1990, Mishra and Johnsingh 1996, Ilyas and Khan 2004, Ashraf et al. 2017) but proportion of grazing and browsing vary with area and season (Mead 1989) and somewhere is observed as browser (Dar et al. 2020). A total of 17 plant species belonging to nine different families from 2454 identified plant fragments were recorded by fecal analysis of *N. goral bedfordi* where 1463 represented browse species and 709 represented graze species (Dar et al. 2020). The study of goral's diet in Machiara of Pakistan reported that summer diet of the grey goral is composed of 44.96% of forbs, followed by 8.94% of grasses and 23.56% of shrubs (Ashraf et al. 2017). The diet analysis of goral in India concluded that the feeding occurred at sunrise and before sunset where minimum of ten species were found to be consumed specially on leaves and softer parts of plants with ratio of 12:27:53 for relative consumption of trees, shrubs and forbs or herbs (Junaid et al. 2012). The diet analysis of Himalayan goral concluded 28 plant species; herb, shrub, and trees appearing in the ratio of 1:36:63 where species mainly subsets on six species of grasses that provided 4.440 kcal of energy and 5.45 l of water per day to the adult goral (Fakhar- i- Abbas et al. 2008). The goral's diet during the pre and post monsoon revealed browse to grass ratio of 3:22 and 3:97 during pre- and post-monsoon seasons respectively. Tree, shrub and forb species in diet of goral was recorded as ratio of 1:5:11 and 2:1:6 during pre and post monsoon respectively (Ilyas and Khan 2004).

The consumption of 14 plant species from six families was recorded in food of goral in Thailand where dominant species were *Paspalum longifolium* followed by species of Gramineae, *Heteropogon contortus* and *Thysanolaena maxima* (Chaiyarat et al. 1999). The major threats of Nepal's mammals are habitat loss, degradation and fragmentation, poaching and illegal trade, chemical poisoning, reduction in fodder or prey, human-wildlife conflict, disease, disturbance, linear structures and hydro power, intensification of agriculture, climate change, small or fragmented population, limited conservation measures, inadequate knowledge and lack of research (Amin et al. 2018). The fragmentation of habitat, poaching for meat, disturbance of human and change in pattern of land use are the major cause of population decline of goral in Himalayas (Zahidullah et al. 2016). Gorals are easily hunted by the hunters as they suddenly stops while running to check the predators following it where hunter get time for shooting them (Zahidullah et al. 2016). The chief predator of goral in Pakistan is Human followed by wolf, jackal and others (Perveen et al. 2013). The habitat modeling showed that habitat range of goral shifts through the disappearance of this species in future because it has narrow ecological niches so it is more sensitive to climate change and pressure of human (Ahmad et al. 2020). Himalayan ecosystems are some of the most sensitive ecosystems to global warming in the world according to documented study of effects of climate change in different ecosystems and species (Schemnitz 1980, Hirzel and Le Lay 2008, Ahmad et al. 2020).

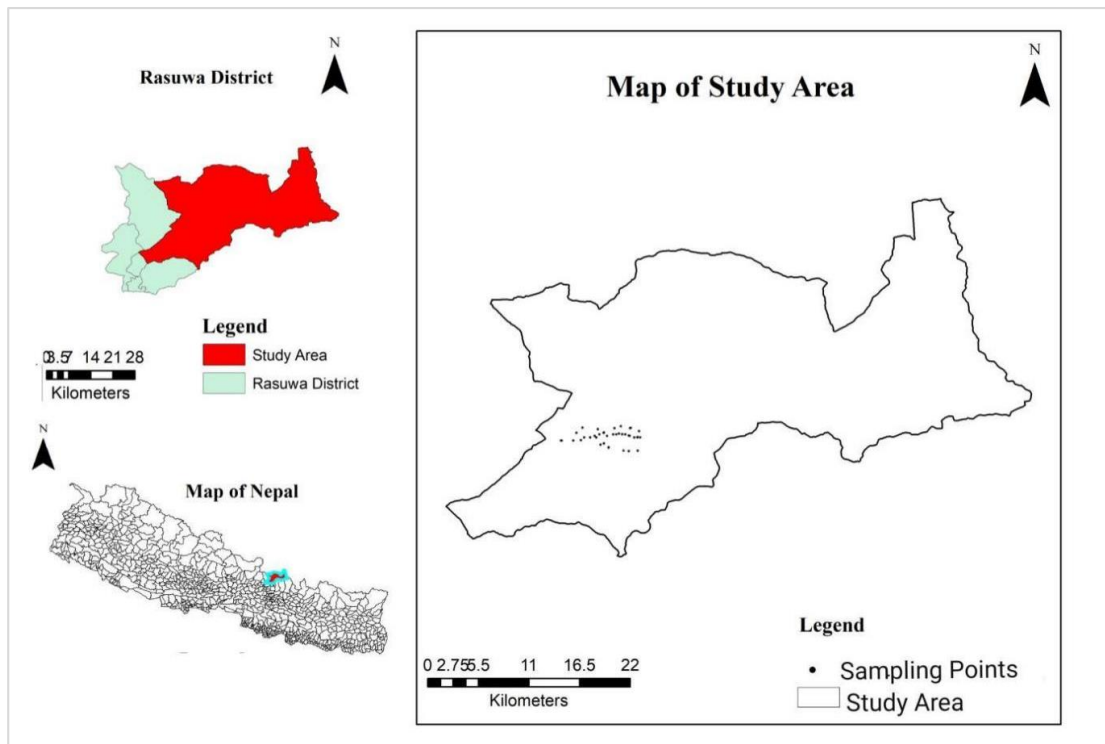
Wildlife trade is a major threat to biodiversity conservation as it can diminish species' populations, cause extinctions, and ultimately threaten ecosystem function (Challender et al. 2015). Gorals are heavily poached for the local consumption of meat, for demand of its fur/hides and horns (Duckworth and MacKinnon 2008, Yang et al. 2013). In Thailand, gorals are hunted for their meat, medicine and horns for decoration where occasional burning of grassland was most used method to kill goral (Chaiyarat et al. 1999). Himalayan goral is classified as endangered worldwide and vulnerable in Pakistan due to high hunting and trapping pressure where frequently used trapping of goral includes camouflage in which clothes of white and yellow color were used according to season, whistling by mouth and hunting by trained dogs (Perveen et al. 2013). N. goral are attacked by a disease during winter which kills many of them as eyes are affected badly by the disease so food could not be found and other could hunt easily (Perveen and Husain 2012).

The examination of carcasses of goral in Arunchal Pradesh of India revealed that Goatpox virus affected goral and domestic goat where probability of transmission between them was observed more as well as nodular pox-like eruptions was observed in the skin of both (Bora et al. 2021). The shrinking habitat size due to fast degradation caused by logging of trees, grazing and erosional subsidence of slopes has threatened the survival of goral which needs conservation program. The Himalayan goral is natural prey for predators such as the snow leopard, *Panthera uncia*, common leopard, *P. pardus*, and Eurasian lynx, *Lynx lynx* (Shakeel et al. 2015). The chief predator of goral in Pakistan is Human followed by wolf, jackal and others (Perveen et al. 2013). The chief predator of goral in Thailand was reported as tiger, *Panthera tigris* but the success rate was less due to rocky and steep terrain (Chaiyarat et al. 1999). The competition of goral was observed with serow; *Capricornis sumantesis*, barking deer; *Muntiacus muntjak* and domestic cattles for forage species, living space, escape cover, water resources and salt licks (Chaiyarat et al. 1999). The sympatric competition between Musk deer and goral was observed very less because of the differences in their feeding habits (Green 1987). The consumption of parasites on skin of goral by two bird species, the lesser coucal; *Centropus bengalensis* and white-headed bulbul; *Hypsipetes thomsoni* was observed in Thailand (Chaiyarat et al. 1999).

### 3. MATERIALS AND METHODS

#### 3.1 Study area

Himalayan goral was studied from syafrubesi to Numthang from where potential habitat was found from Syafrubesi to Lama Hotel along Sherpa village route. Lamtang National Park (LNP) is the first mountain national park in Nepal established in 1970. LNP is with an area of 1710 km<sup>2</sup> and additional buffer zone of 420 km<sup>2</sup>. The longitude of 85° 33' 98" 4" E and latitude of 28° 12' 47" 4" N is approximate geographical location of LNP (Khatiwada 2002).



**Figure 1.** Study area of Himalayan goral in LNP

LNP lies within the territory of Rasuwa, Sindhupalchowk and Nuwakot districts of Bagmati Province. There are more than fifteen lakes in LNP from which Gosainkunda is popular. The elevation of LNP ranges from 792m at Bhote Koshi to 7245m at the peak of Lamtang Lirung. The location between the Latitude 28° 09.598' to 28° 10.312' N and Longitude 85° 21.299' to 85° 24.959' E of LNP was focused in current study (Champion and Seth 1968, Chaudhary 1998).

The elevation range of focused study area was from 1974 m to 3650 m. Banjyang, Khamjing, Sherpa Village, Rimche and Lama Hotel were the main sites for this study which lies in ward 3 and 4 of Gosainkunda Rural Municipality of Rasuwa district.

### **3.1.1 Drainage, Topography, Geology and Soil**

Lamtang National Park consists of rivers like Lamtang and Bhotekoshi which are fed by glaciers and rivers like Trishuli, Phalanga and Tadikhola which are without glaciated origin. The discharge of river is highly affected by the monsoon. The typical feature of LNP is rugged and steep terrain. The great Himalayan Range with Himal like Lamtang, Jugal, Langsisa, Yala peak and Nayakhyang along with Lamtang valley are the main features of LNP. Lamtang river flows through inner curving of Langsisa range and Lakpa dorje range from northeast to southwest and meets Bhotekoshi at Syafrubesi. The local soil patterns are greatly affected by vegetation, topography and aspect. The lower forested regions contain mature soil and fertile Loams. Solis are acidic with pH 5-6 where large proportion is occupied by rocks in upper Lamtang valley. Soil transportation is carried out at lower forested elevations due to foraging, wood cutting activities, heavy rains with high run off and low evaporation during the monsoon. The increased human pressure and deforestation are the main causes of landslide or erosion (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

### **3.1.2 Flora**

The vegetation zones of Lamtang National Park are categorized below:

#### **i. Tropical Zone**

The elevation of this zone ranges from 792m to 1000m. The lower region of Bhote Koshi consist of *Shorea robusta* forest is found in lower region of Bhote Koshi which is associated with *Bombax ceiba*, *Semecarpus anacardium*, *Adina cordifolia*, *Terminalia temontosa*, *Bauhina vahlii*, and *Butea monosperma*. This zone corresponds to wet-hill sal forest but it is different from Southern Terai Sal forests. This zone is under the pressure of various activities of human (Champion and Seth 1968, Chaudhary 1998).

## ii. Sub - Tropical Zone

The elevation of this zone ranges from 1000m to 2000m. *Schima wallichii* and *Lagerstroemia parviflora* mixed forest is found in the wettest areas of lower elevation. *Schima wallichii* and *Castanospsis indica* are dominant species distributed in the damper areas of the lower Bhote Koshi. *Pinus roxburghii* is found to be mixed with *Schima wallichii* along the Bhote Koshi and Lamtang Khola. *Pinus roxburghii* is dominant species in the forest found on drier slopes, mainly in the upper Bhote Kosi (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

## iii. Temperate Zone

The elevation of this zone ranges from 2000m to 3000m. *Quercus lamellosa* is found in the wetter parts of the Bhote Kosi. *Quercus lanata* occurs on south-facing slopes together with *Rhododendron arboretum* and *Lyonia ovalifolia* forest is found in upper Bhote Koshi, lower Lamtang and other valleys the forest of *Pinus excelsa*, *R. arboretum* are dominant with small number of *P. excelara*. The intensive collection of fuel wood and fodder had degraded the forest of this region. *Berberis*, *Rubus* and *Lonicera spp* are some shrubs and species with grazing resistant are *Anaphalis*, *Anemone*, *Potentiala* and *Lantana* species. *Q. semicarpifolia* are the main feature of upper temperate zone. In south-facing slope, *Abies spectabilis* and *Quercus semicarpifolia* is found with some scrub species of *Berberis concinna*, *Rubus*, *Lonicera* and *Rhododendron* (Chaudhary 1998, Khatiwada 2002).

## iv. sub-Alpine Zone

The elevation of this zone ranges from 3000m to 4000m. The dominant coniferous forest composed of *Tsuga dumosa*, *Abies. spectabilis*, *Rhododendron barbatum* in association with *Acer campbelli* is characteristics feature of this region. *Juniperus recurva* is dominant in dry land which is associated with *R. lepidotum*, *R. campanulatum*, *Larix himalaica* and *Caragana sukiensis*. The *Rhododendron* occurring in *Abies* forest is limited to *R. barbatum*, *R. campanulatum* are found with *Abies* forest whereas endemic *R. cowanianum* and *Betula utilis* occur in few places. *Abies-Rhododendron* Forest lack broadleaves trees and bamboo species are *Himalayacalamus falconeri*, *Arundinaria sp.* and *Thamnocalamus aristatus*. The south-facing slope of

this region has dense thickets of *Caragana nepalensis* is found which is associated with *Berberis concinna*, *Rosa macrophylla* and *Rhododendron lepidotum*. The south-facing slope is dry area contains *Rhododendron* species in association with *Juniperus* species whereas the damp region contains *A. spectabilis* tree in less number. The forest of *B. utilis* and *R. companulatum* is found on north-facing slopes (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

#### **v. Alpine Zone**

The elevation of this zone extends above 4000m. *Rhododendron spp.*, *Lonicera spp.*, *Cotoneaster spp.* and *Juniperus spp.* are the scrub species that are present in lower part of this region. In south-facing slopes scrubs like *Cotoneaster microphylla*, *Ephedra gardiana*, *Juniperus wallichiana*, etc are found to be dominant in drier slopes whereas *R. anthopogan*, *R. setosum* etc in damper habitat and forbs is common. Forbs is common with abundance of tussocks of grasses and sedges. *Carex*, *Calomogrostis*; *Agrotis micantha* and *Festnia leptogonum* are dominant grass species of upper part of this region and it holds number of alpine flowering plants which belongs to the families of Primulacea, Rosacea, Gentianacea and Polygonacea. The lichens and mosses on exposed rocks are some vegetation in higher region above 5000m in this region as it is permanently covered with snow and ice which is characteristic features of this region (Chaudhary 1998, Khatiwada 2002).

#### **3.1.4 Fauna**

LNP consist of diverse fauna where there are 46 species of mammals (Khatiwada 2002), 345 species of bird, 11 herpeto-fauna species, 30 fish species, 10 species of spiders, (Khatiwada 2002) and 70 butterfly species (Karki et. al 2002). Some common primates of this region includes Assamese monkey (*Macaca assamensis*), Rhesus macaque (*Macaca mulatta*) and Common Langur (*Semnopithecus entellus*) (Chalise 2003). Fox, wild dog, Himalayan black bear, red panda, Martins, Leopard cat, Common leopard, Clouded leopard, snow Leopard are the carnivores, the common ungulates are wild boar, Himalayan musk deer, barking deer, Ghoral, Himalayan Tahr and small animals are Royal's pika, Himalayan marmot, Himalayan squirrel, and Indian porcupine. Eagle, Honey guide, Redstarts, Vultures, Dark rumped rose finch, Satry tragopan, golden eagle, Tibetan snow cock, Blood Pheasant, Ibis bill, Snow pigeon, honey guide, spotted

dove, snow partridge, Yellow-billed blue magpie etc are some notable birds. The reptiles include Green Pit viper, Himalayan Keel-back snake, Rock agama, Himalayan rock lizard, Himalayan matrix, mountain Pit viper, large toad viper etc. and amphibians includes Frog, Himalayan toad etc. Besides these, in the lower parts of Lamtang Khola, blunt snow trout is found in lower part of Lamtang river and Mahaseer occurs in Trisuli river. (Champion and Seth 1968, Chaudhary 1998).

### **3.1.5 Socio - Economic Aspects**

15 Rural Municipality lies within the buffer zone of LNP from which eleven lies in Rasuwa district, three lies in Nuwakot and one lies in Sindhupalchowk. The majority of Sherpas people is found in LNP, followed by Lamas and Tamangs. People have conserved their traditions and customs where LHOSAR is biggest festival celebrated for 15 days with other festivals are Nehra, Tohrpu, etc. but the change in their cultural, social, political and economic life has begun with modernization and change in global environment. Lamtang people have major occupation of livestock farming followed by Tourism, Agriculture, and different services like teaching, foreign employment etc. My study area lies in Ward 3 and Ward 4 of Gosaikunda Rural Municipality of Rasuwa district as potential habitat of goral was observed in these areas during preliminary survey. The villages within my study area are Banjyang, Khamjing, Briddim, Sherpa village, Rimche and Lama Hotel (Champion and Seth 1968, Chaudhary 1998, Khatiwada 2002).

## **3.2 Methods**

### **3.2.1 Preliminary Survey**

The preliminary survey was carried out between June 2 to June 13 of the year 2019. A total of 45 Km trail was walked, 30 Km long walking trail along Lamtang river from Syafrubesi to Numthang and 15 Km long walking trail from Rimche to Syafrubesi along Sherpa village. River, stream, gullies and ridges the natural features that were found as separating features for different types of vegetation. The primary information on the sighting of Himalayan goral was obtained through discussion with herders, forest staff, villagers and other concerned people. Direct observation of goral and presence of pellets were identified for study of distribution pattern. The major vegetation was also

identified through interaction with local people, herders, guides, hotel staff and google search. The potential habitat of Himalayan goral was observed from Banjyang village to Lama hotel along the Sherpa Village route. Secondary data was collected through articles, thesis, journals, books and google.

### 3.2.2 Line transect survey

The abundance of wild animal populations can be estimated by Line transect sampling (Buckland et al. 2001, Buckland et al. 2004). The lines or set of equally spaced lines are placed at random in the survey region in line transect sampling. An observation is carried out along each line and the shortest distance of animal or fecal pellet from line is recorded by using simple trigonometry (Buckland et al. 2001). The mean distance between trail and centres of the fecal pellet group or herd of animals is measured. Systematic random designs are usually preferred to designs in which each transect is independently located at random and lines are equally placed with random start (Buckland et al. 2001).

**Table 1.** Schedule of field time spent in LNP study area 2019-2022

S.N.	Field duration	Working days	Working hours	Remarks
1	2 <sup>nd</sup> –7 <sup>th</sup> June 2019	5	25	Preliminary survey and trail design
2	21 <sup>th</sup> – 27 <sup>th</sup> September 2019	7	35	Trail transects survey and vantage point selection
3	6 <sup>th</sup> – 15 <sup>th</sup> May 2022	9	45	Vantage point study, Pellet sampling and vegetation sampling
<b>Total</b>		21	105	

Some key assumptions for survey of fecal pellet group of Himalayan gorals are as follows:

1. The herd or individual of goral whose centers are on line or very near to the line are encountered with certainty.
2. The independent movement of goral is slow relative to observer's speed.
3. The distances from the line to the centre of each detected herd or individual is measured accurately.
4. There is an adequate sample of randomly-distributed lines in the survey region.

5. Group sizes of goral or pellet are accurately recorded, at least for groups on or near the line.

For the study of the distribution and habitat preference of Himalayan goral, the walking trails of Lamtang valley was chosen along Sherpa village. A total trail of 15 Km from Bhotekoshi to Lama Hotel was chosen. A total of 50 survey transects each of 100 m length were laid and 20m wide area was scanned for pellet and 200 to 1Km area was scanned for animal. The distance between two transects ranged from 100m to 200m and transects were laid on random starting points. The transects were laid at different altitude from 1974m to 3650m for covering the maximum area of probable habitat of Himalayan goral. The transects were scanned from 6:30 am to 10:00 am in the morning and from 2:30 pm to 5:00 pm in the evening. The sighting of Himalayan goral and encountering of other animals were recorded and pellets sampling was also incorporated to gather further information. A 100m rope was taken for pellet sampling.

Vegetation was identified with the help of local people, articles and books and major vegetation was noted. Binocular was used for scanning of wide area of about 500m to observe the goral directly. Camera was used to take photograph and GPS device was used to find location and elevation. Mobile Canopy app was used to find canopy cover. The data was collected for two seasons i.e., autumn and spring. The site was also visited in different seasons and data was collected as per requirements. The habitat composition, structure and variability that was preferred by goral were also collected. The general disturbances factors like distance to village, distance to road, distance to water source, number of livestock, human, predators were noted to assess the threats to Himalayan goral.

The presence of goral along with other wild animals, terrain type, slope, aspect and other variables were noted in goral sighted area and fecal groups observed locations within each transect. Informal Interviews was performed with key informants for knowing perception towards Himalayan goral.

### **3.2.3 Fixed point count/vantage point count**

The method detailed by Jackson and Hunter (Jackson and Hunter 1996) was used to count the Himalayan goral from vantage points. The wide scanning of study area for

proper identification of animal is easy from the vantage points (Ashraf et al. 2015). The wait and observe method were conducted at good vantage points. Observations were carried out in five different vantage point spending an hour for each point from where animals could be scanned easily using 10x40 binoculars. Observation of goral was carried out from 6:00 to 9:00 or 15:00 to 17:00 and records of group size, sex, age, time were noted. Individuals were classified into different groups when the distance between two individuals or groups was more than 200m. The male, female and juvenile were categorized on basis of size of body and presence or absence of manes was used to classify male and female. The physical structure of nearby animals was also noted and human disturbance was recorded. GPS locations and elevations were measured by visiting the grazing site by using GPS device. The slope angle, terrain type, aspect and vegetation type noted. The distance to village, road and water source were measured by using measuring tape. Gap Light Analysis Mobile app was used to measure canopy cover at the goral's grazing sites.

#### **3.2.4 Distribution of Himalayan goral**

The potential habitat of Himalayan goral and five vantage point were established on the basis preliminary survey and local people knowledge. The population composition was observed from the points. The presence or absence of Himalayan goral was verified in each transect and locations were recorded using GPS device. The human disturbance like road construction, tree cutting, farming, tourist flow and different ecological variables were noted at each potential site. ArcGIS-10.2.1 software were used to produce a Himalayan goral distribution map based on the distribution identified during current study.

#### **3.2.5 Habitat use**

The habitat parameters were collected from the field by using Random sampling. The strong indirect evidence of habitat use by the species was presence of pellet. The pellet group count method to find habitat use was first described by Bennet et al., 1940 has first described the pellet sampling method which has been used by several investigators (Anderson 1976, Burnham et al. 1980, Hedley et al. 1999, Hedley and Buckland 2004, Fewster et al. 2005, Buckland et al. 2010). Pellet sampling was done in 50 transects where each transect was of 100m length and 20m wide where distance between two

transects ranged from to 100m to 200m. Parameters including slope, altitude, aspect, other fauna, vegetation type, canopy cover, land features, distance from nearest village, distance from trail and distance from nearest water source were recorded for these plots and goral observed site. Habitat suitability was studied on basis of availability of Himalayan goral. Habitat utilization was determined by dividing habitat as rocky cliff, grassland, pine mixed forest and Quercus mixed forest.

### **3.2.6 Data analysis**

Microsoft Excel was used for processing the data collected during the study. It was also used to tabulate the data with necessary parameters and for making bar graphs, pie charts, line graphs, tables etc. It was also used for different mathematical calculations. Generalized Linear Model (GLM) was used to find the significant variables that affect the distribution and habitat uses of Himalayan goral. ArcGIS-10.3 software was used to generate the distribution map of goral distribution noted during current study.

Generalized Linear Model (GLM) was performed using Past program to find the significant habitat of Himalayan goral in response to variables like elevation, distance to water source, distance to village, distance to road, number of livestock and number of humans for the observed groups of Himalayan gorals. The field experiences and the models developed for the similar species used the similar environmental variables in different documented species-habitat associations. Generalized linear model (GLM) is a flexible generalization of ordinary linear regression that allows for response variables that have error distribution models other than a normal distribution. Habitat utilization is determined according to number of Himalayan goral or its pellet group recorded in a particular habitat. Habitat usage is a surrounding of a species which it prefers for better survival and how it interacts with its habitat. Habitat utilization of Himalayan goral for each habitat type was calculated as (Zhao et al. 2013)

$$U_i = N_i / N$$

Where,  $U_i$  is the utilization rate of the specific habitat type by Himalayan goral.

$N_i$  is the number of signs of Himalayan goral in the specific habitat type.

$N$  is the total number signs of Himalayan goral in all habitat types.

Population and Pellet data was analyzed under different parameters.

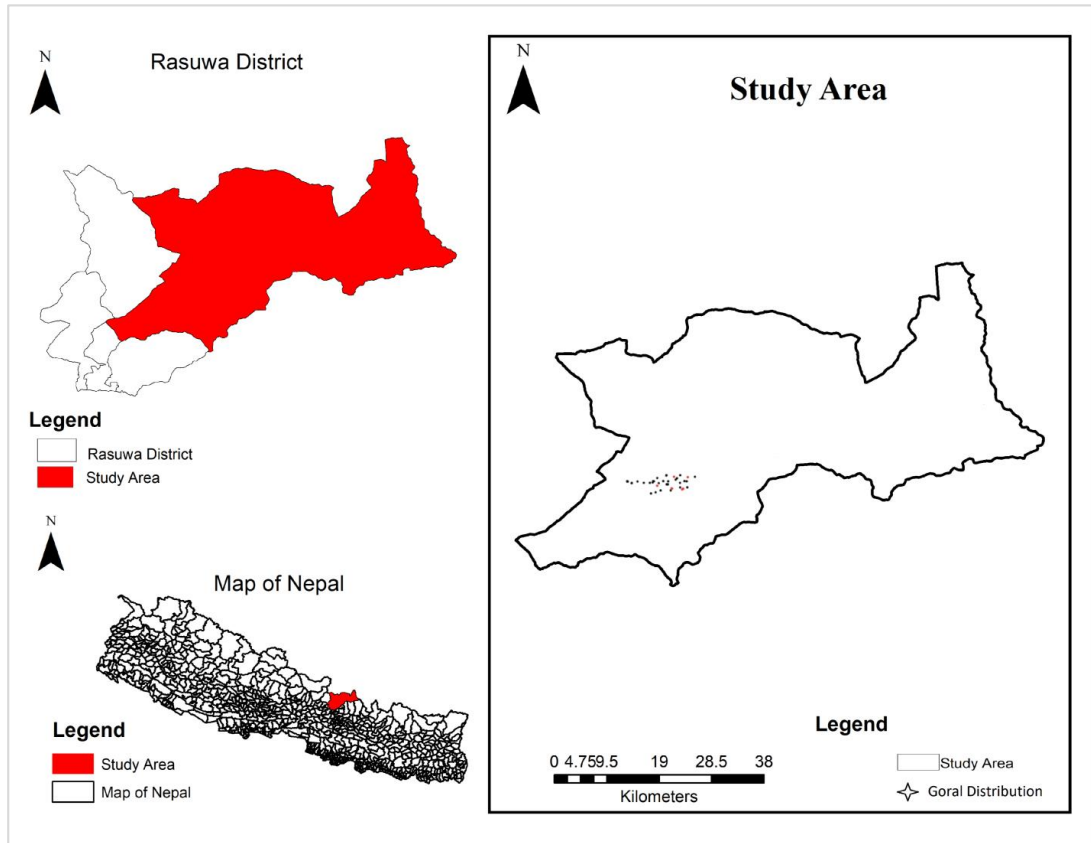
$$\text{Density of Pellet} = \frac{\text{Total number of Pellet group}}{\text{Total Sampled area}}$$

$$\text{Sex ratio} = \frac{\text{Total number of Male}}{\text{Total number of Female}}$$

$$\text{Young to adult female ratio} = \frac{\text{Total number of young}}{\text{Total number of females}}$$

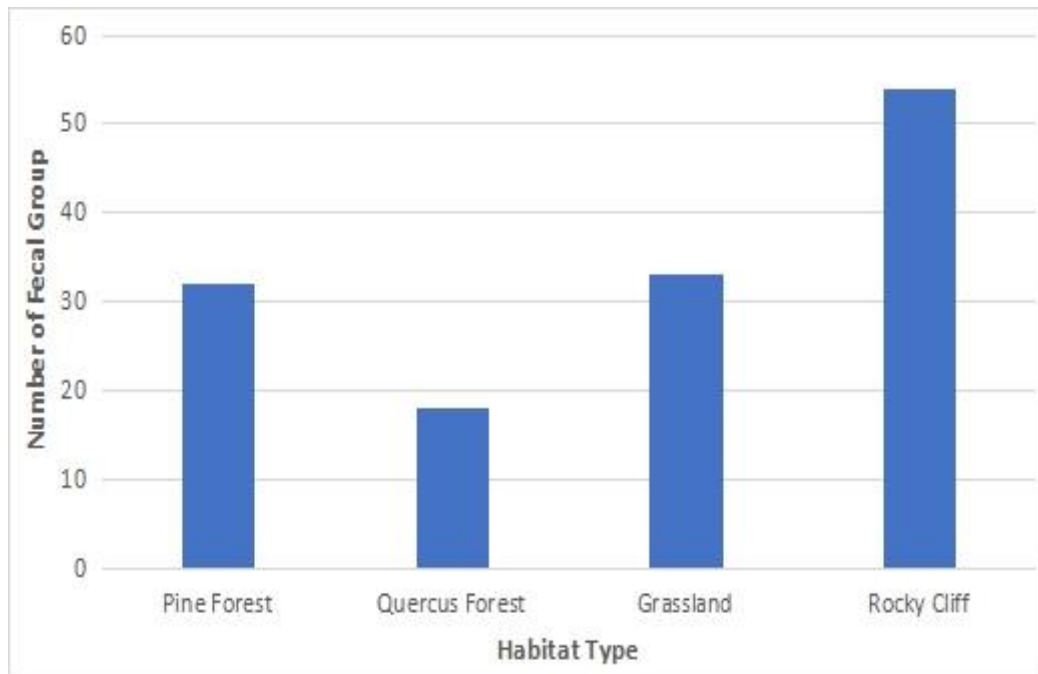
## 4. RESULTS

### 4.1 Distribution of Himalayan goral in Lamtang National Park



**Figure 2.** Distribution goral (Red mark) and its Pellet group (Black Mark) in study area

The density of goral observed in my study area was found to be 0.47 individuals  $\text{km}^2$ . A total of 137 fecal groups were recorded in 27 transects out of sampled 50 transects during the study period where total pellet group was 1370 pellet group. Gorals were found mostly in the cliff areas followed by Grassland, Pine Forest and least in Quercus Forest (Figure 2). The observation of fecal groups of gorals and its direct observations was recorded between the elevation of 2124 m to 2716 m above sea level from  $28^\circ 10.312' \text{ N}$  and  $85^\circ 21.299' \text{ E}$  to  $28^\circ 09.348' \text{ N}$  and  $85^\circ 25.209' \text{ E}$ .

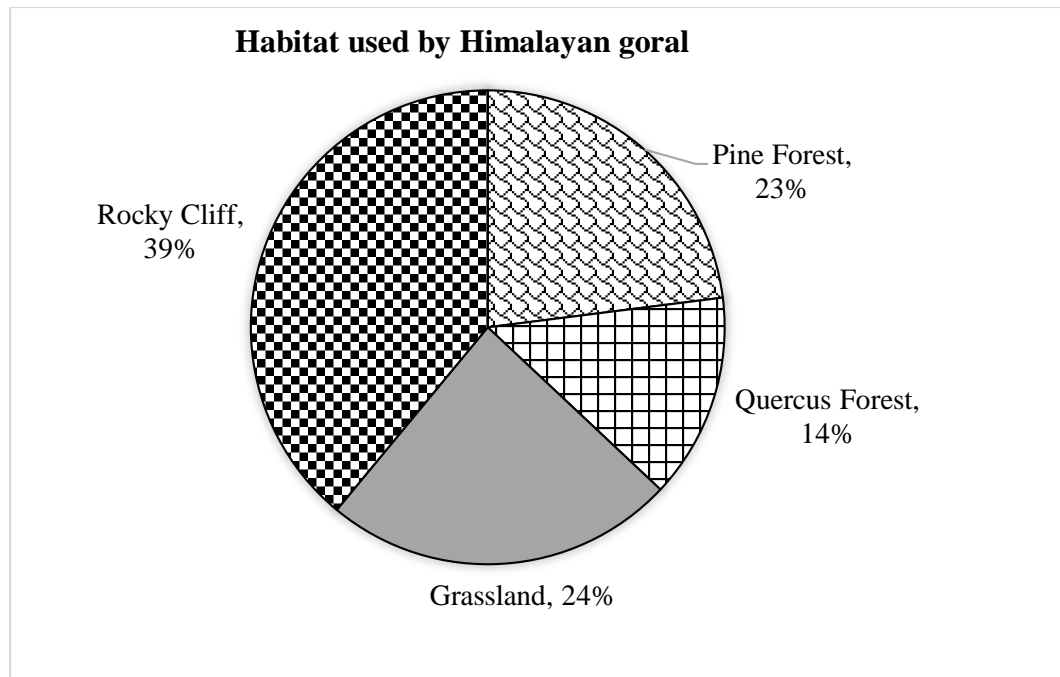


**Figure 3.** Fecal groups of Himalayan gorals recorded with different habitats

A total of seven Himalayan gorals were reported in five vantage points near Sherpa village. Three types of herds were observed where three were solitary i.e., two male and one female, one was female- juvenile herd and one was male-female herd. The sex ratio of Himalayan goral was found to be 1:1 and Juvenile-Female ratio was 1:1.

#### **4.2 Habitat used by Himalayan goral**

Himalayan goral preferred Rocky cliff followed by Grassland, Pine Forest and Quercus Forest.



**Figure 4.** Habitat utilization by Himalayan goral.

**Table 2.** Generalized Linear Model (GLM) Between the presence of goral with different habitat and disturbance variables. Here, DS=Distance to settlement, DW= Distance to water source, DR= Distance to road, CC=Canopy Cover, PL= Presence of livestock.

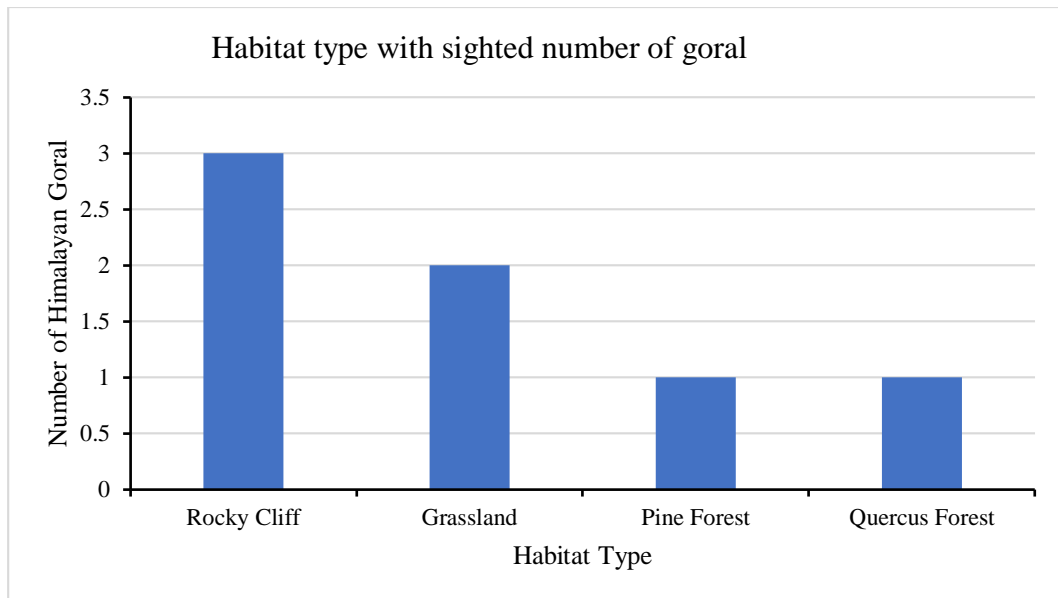
Model Parameters	Slope	Intercept	P Value	Significance
Elevation	-0.005	19.53	0.286	
DS	27.64	1644.9	0.589	
DW	-47.07	947.59	0.373	
DR	-0.06	5.8231	0.671	
CC	-0.2607	29.84	0.825	
PL	-0.242	2.23	0.043	*

Significance Code: '\*' 0.05

The GLM performed in Past-program showed that the distribution of Himalayan goral has negative relation with the presence of livestock.

#### 4.2.1 Habitat type

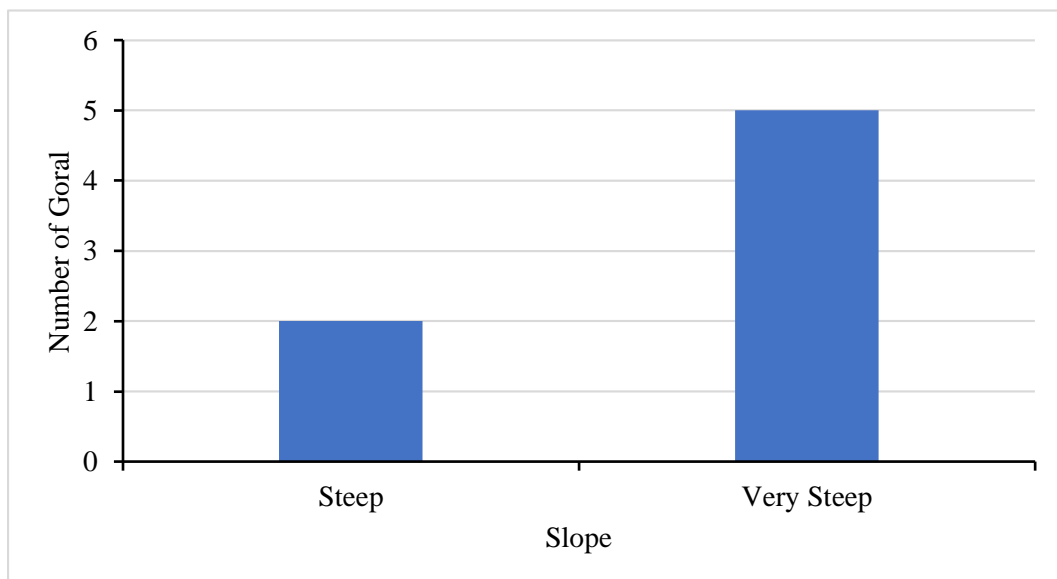
The direct observation of goral was high in Rocky cliff followed by Grassland and less in Pine and Quercus Forest.



**Figure 5.** Himalayan goral presence in different habitat types of LNP

#### 4.2.2 Slope type

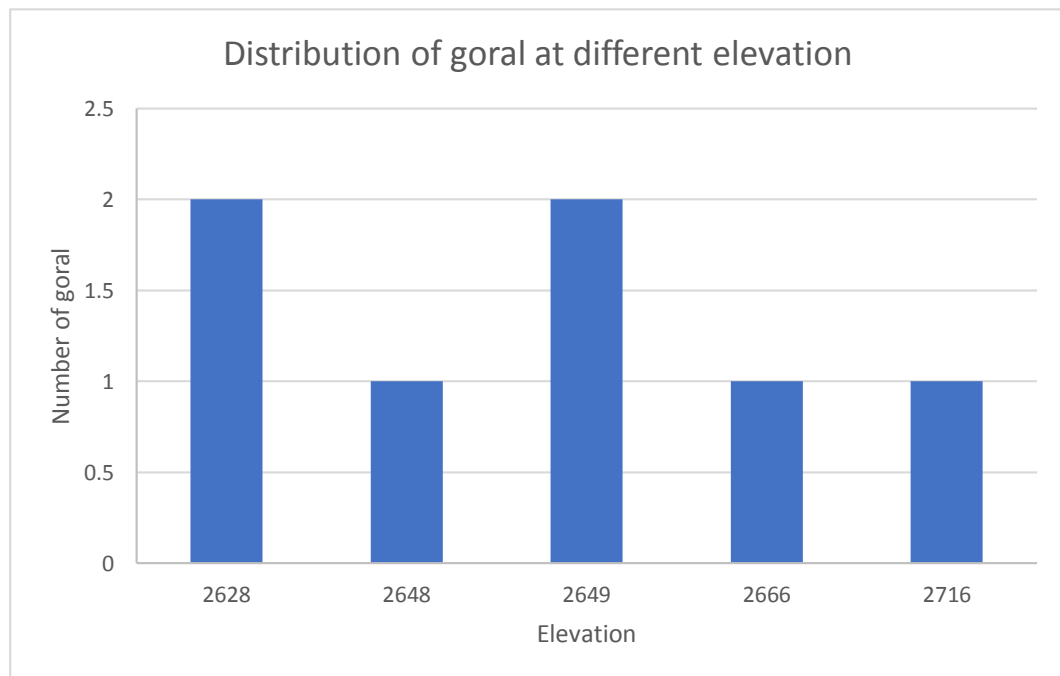
Slope angle was categorized into "flat"  $<15^{\circ}$ , "moderate"  $15^{\circ}-40^{\circ}$ , "steep"  $40^{\circ}-65^{\circ}$  and "very steep"  $>65^{\circ}$  where most chosen slope was steep slope 50% and there was least observation of goral in flat land. The result shows that Himalayan goral preferred very steep (70%) and steep slope (30%). There was no observation of Himalayan goral in flat areas.



**Figure 6.** Slope preferred by goral in the LNP

### 4.2.3 Elevation

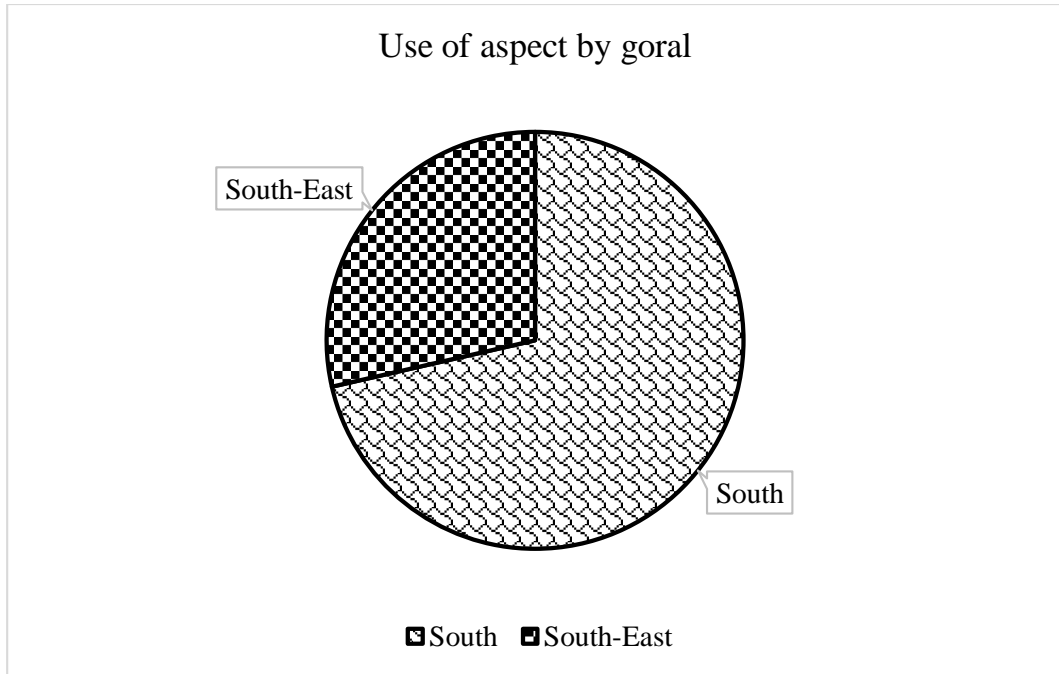
The distribution range of entire population of Himalayan goral was between 2124m-2831m found from Syafrubesi to Lamtang based on fecal pellet sampling. The direct observation of goral was from 2628m to 2716m a.s.l.



**Figure 7.** Distribution of Himalayan goral at different elevation of LNP

### 4.2.4 Aspect

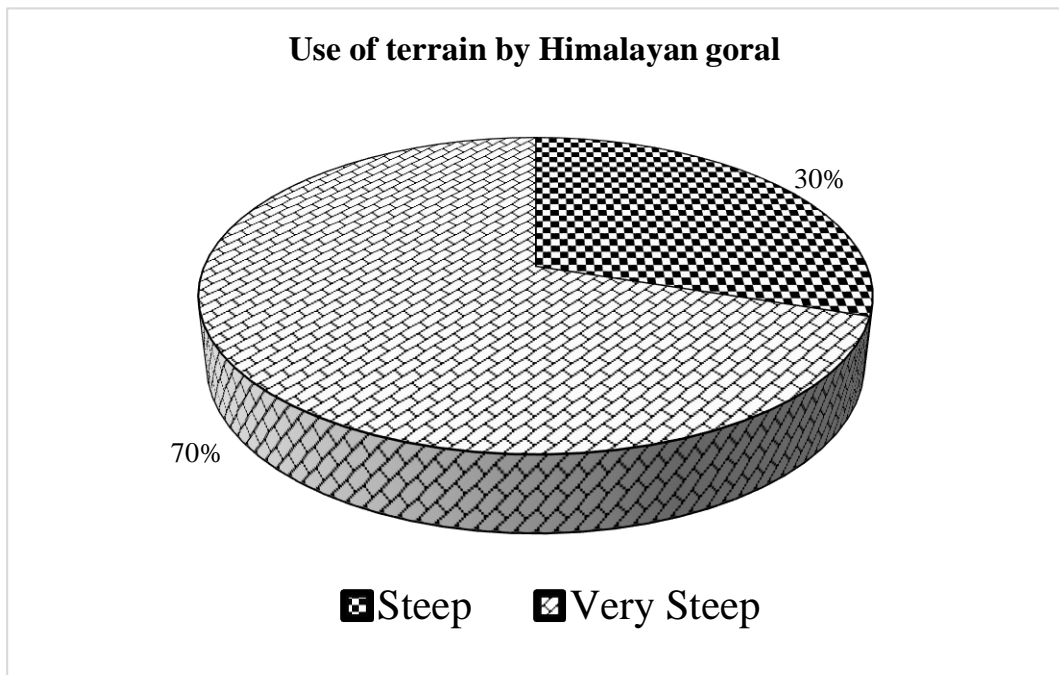
The habitat preferred by goral is distributed throughout the study area but sighting of goral occurs mainly in the south and the South-East aspect of the study area.



**Figure 8.** Distribution of Himalayan goral by aspect of the study area

#### 4.2.5 Terrain type

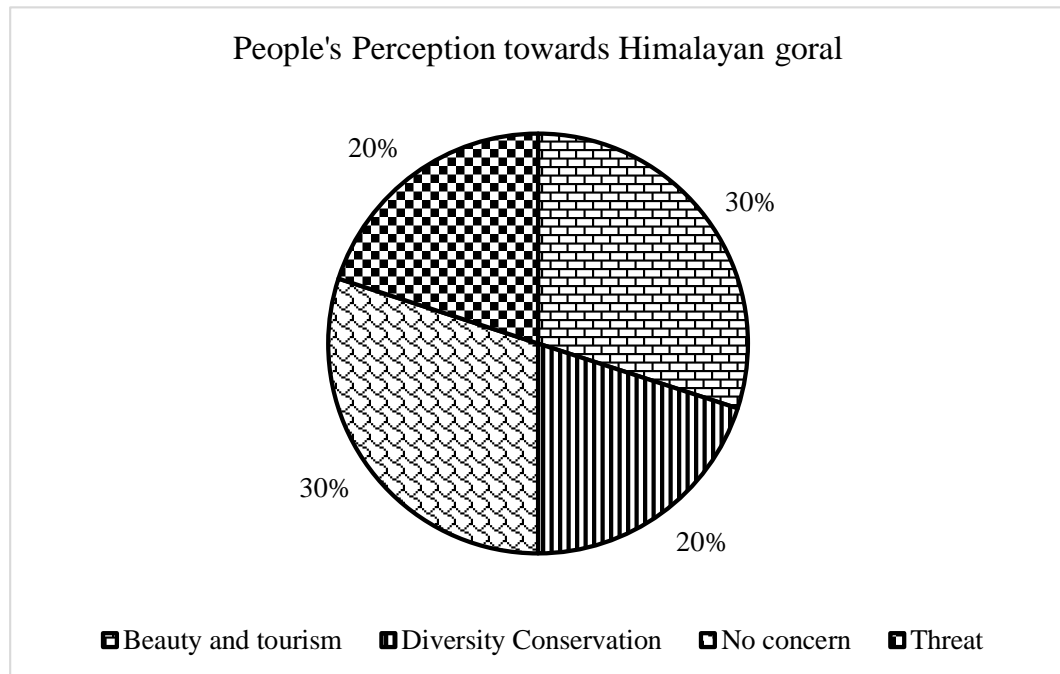
Himalayan goral was observed in areas with a highly rugged and steep terrain. The observation of goral was not recorded in less steep terrain.



**Figure 9.** Preference of terrain by Himalayan goral

### 4.3 People's perception towards Himalayan goral

20 local people were randomly selected and informal interview was performed to know their perception towards Himalayan goral from which 20% talked about threats of goral. The poaching of goral is especially by the workers from other districts using net traps. 30% people do not have any concern about goral and its conservation.



**Figure 10.** People's perception towards Himalayan goral

## 5. DISCUSSION

### 5.1 Distribution of Himalayan goral in Lamtang National Park

Himalayan goral was distributed from 2124m to 2716m in my study area where distribution was high in Rocky cliff followed by Grassland, Pine Forest and Quercus Forest. The elevation range of goral in Nepal is recorded between 200m to 3400m within different protected areas and districts. Gorals were reported between elevation of 525m to 1421m in Tanahun (Adhikari et al. 2021), 700m to 1250m in Dailekh (Karki 2021), 1115m to 3400m in Api-Nampa NP (Sherpa 2016), 964m to 1591m in Nawalparasi (Thapa et al. 2011b). Himalayan goral was recorded between elevation of 1400m to 1929m in Thailand (Chaiyarat et al. 1999). Himalayan goral is distributed from 200 to 4000m above m.s.l, in the states of Himachal pardesh, Jammu and Kashmir, West Bengal, Uttaranchal, Arunachal pardesh and Sikkim in India. Goral was detected over the broadest elevation range between 1200m to 3700m of Khangchendzonga Biosphere Reserve (Bhattacharya et al. 2012), between 240m to 1293m in Chilla Sanctuary (Kushwaha et al. 2000), In Pakistan, goral was recorded within elevation of 773 to 3447 m a.s.l (Fakhar- i- Abbas et al. 2008). In China the most preferred habitat of goral was recorded with a mean altitude of  $1444.54 \pm 56.79$  m (Yang et al. 2013). My study is in line with most studies and showed that goral has wide range of distribution.

The density of Himalayan goral in my study area was 0.47 individuals per square kilometre which is lesser in comparison with the study in India, Pakistan and Thailand (Chaiyarat et al. 1999, Bhattacharya et al. 2012, Ashraf et al. 2017). Three solitary goral, one Maternal herd and one Male-Female herd was observed in the study area with mean group size of 1.4. The sex ratio was found to be 1:1 and juvenile-adult female ratio was 1:3 in my Study area. The observation of most solitary goral was reported in a study of Thailand where juvenile:adult ratio was 1:4 and herd of more than two individual was sighted very less (Chaiyarat et al. 1999) which is very much similar with our study. 172 unique gray goral individuals were recorded in a study of Pakistan where adult: subadult ratio was 143: 29 and adult sex ratio was 49:94 and mean group size was 1.7 (Fakhar- i- Abbas et al. 2008).

The group size of 1.6 and 1.8 were reported in this study area of Pakistan and India (Pendharkar and Goyal 1995, Bhattacharya et al. 2012, Ashraf et al. 2017). The groups of four to 12 gorals were also recorded in different study which is not in line with our study (Lydekker 1907). The prevalence of solitary animals was dominant however grey goral were observed in herd of two, three, four, five and six in Pakistan with mean group size of 1.99 which is also in line with our study (Ashraf et al. 2017). The high metabolic rate and selective feeding are the reasons that favor for the solitary life of Himalayan goral (Pendharkar, 1993). During our study the gorals were encountered in less disturbed area. The increase in population size increases the group size of an animal (Borkowski 2000), so the smaller herds observed today might reflect the decline in population from a century ago. Two Himalayan goral with single calf were encountered in a study in Nawalparasi (Thapa et al. 2011). The smaller group sizes of animals at present could reflect decrease in risk of predation (Hamilton 1971) or distribution of resources (Jarman 1974).

## **5.2 Habitat use of Himalayan goral**

The GLM showed the significance relation between presence of livestock and goral pellet group in current study which reveals that the livestock number has negative impact on distribution of goral. The GLM showed significance relation between signs of human and number of goral signs showing negative impact of settlements and sign of human presence on Himalayan goral of Dailekh District (Karki 2020). Similar negative relationship between goral and Human was reported in Thailand (Chaiyarat et al. 1999). The GLM showed a significance relation between slope and number of goral fecal pellet (Karki 2020) but current study was not in line with it.

Himalayan goral preferred Rocky cliff followed by Grassland, Pine forest and Quercus forest. The study in Dailekh showed that the higher number goral presence is in cliff rock area and *Quercus* forest followed by, *Sal-Terminalia* forest, mixed hardwood forest and pine forest (Karki 2020). *N. gorals* were The distribution of goral was highest in the rocky cliff area followed by Shorea mixed forest, Schima mixed forest, grasslands and the least was noted in Quercus forest in Nawalparasi District (Thapa et al. 2011). In Api-Nampa Conservation Area, *N. gorals* were found to be distributed mostly in grassland followed by cliff and gullies (Sherpa 2016).

The Geo-spatial Modelling for goral habitat evaluation showed that the most suitable habitat was the mixed forest with forest density range from 30%-50% where permanent drainage was within one km and at least 1.5 km far from roads or settlements (Kushwaha et al. 2000) which was also similar to this study. The preference of grassland followed by rocky base areas and forest along deep valley was reported in Thailand (Chaiyarat et al. 1999). In India the wide range of habitat is noted for goral from alpine meadows to Montana wet temperate and evergreen forest (Sathyakumar 1994) which is also in line with our study.

The direct observation of goral was from 2628m to 2716m in the study area whereas pellet was found to be distributed from 2124 m to 2716 m which was due to dense forest in the lower region that caused difficulty in sighting of goral. 70% observation of goral was on south facing slope and 30% on south-east facing slope in the study area. goral of Nawalparasi used south facing slope only (Thapa et al. 2011). The use of southern and northern was reported in Dailekh (Karki, 2020). Very steep terrain was habitat with high preference by Himalayan goral followed by steep slope, moderate slope and flat land in my study area where slope angle ranged from  $20^{\circ}$  to  $70^{\circ}$  with mean slope angle was  $51^{\circ}$ . The most suitable slope was recorded above  $50^{\circ}$  in Geo-spatial Modelling for goral Habitat Evaluation (Kushwaha et al. 2000). The slope of  $30^{\circ}$  or more and cliffs, open forests with sufficient grass cover and far from settlements are preferred by goral which is similar to current findings (Kushwaha et al. 2000). Similar observation was reported in Seti River basin in Tanahun district and Dailekh district where Fecal pellets were collected from the steep landscapes (Adhikari et al. 2021). Gorals are cliff dwelling mountain ungulates as reported in different studies (Prater 1971, Mead 1989). The animals can keep them safe from predators and different human activities by existing in steep slopes (Thapa et al. 2011). The suitable habitat of goral includes high degree of slope angle as goral mostly preferred steep slopes, rocky areas and top of hills having sufficient cover and food plant (Cavallini 1992). The steep grassy slopes, which are the most preferred habitat of goral (Cavallini 1992, Mishra 1993, Mishra and Johnsingh 1996). The steep and rocky areas with sufficient cover and palatable plants are mostly used by gorals (Lovari 1986). The occupancy-based model of goral showed its equal distribution in sub-alpine and temperate habitats (Bhattacharya et al. 2012).

The canopy of the pellet group observation site in my study area ranged from 0 to 60% with an average of 29%. Goral prefers Open plant community with less shrub under-story and shows tendency to run sideways in escape terrain (Mishra and Johnsingh 1996). Similar habitat with good canopy cover and moderate ground cover was recorded in western Nepal (Sherpa 2016). Our study was different from the micro habitats selected by goral in China which have greater tree canopy and more trees and shrubs which can supply them better concealment conditions (Wei et al. 2018). The conservation status of carnivores and ungulates is declining since 40 years and has been accelerated afterwards where key challenges are prevention of the extinction of species and decreasing the extinction risk of threatened (Di Marco et al. 2014). Human causes damages of wildlife which increases the human-wildlife conflict (Angelici 2016).

The key component of the Himalayan mammalian fauna are ungulates and they form the main prey base for the large mammalian predators (Vinod and Sathyakumar 1999). The damage of crop, predation of livestock, damage of property, human injury and casualties are the main reasons associated with human-wildlife conflict in Nepal (Bajimaya 2012). The status of goral was reported as vulnerable and the increase in means of transportation, wood cutting and extended communication links are predicted to be major threats for goral in Pakistan in future which shows that LNP is also on pressure of human towards the goral (Abbas et al. 2015). The increased hunting and trapping pressures on goral was reported in Pakistan and implementation of new wildlife rules and regulations was suggested (Perveen et al. 2013). The evidence of possible transmission of the infection of goat pox to and from domestic goats and gorals was reported in India (Bora et al. 2021). Similar threats were observed in wildlife of Nepal (Thapa and Maharjan 2015) so proper strategies should be implemented for threat assessment and their solutions. Awareness programme and direct conservation action should be implemented for species conservation (Fitter and Fitter 1987, Marco 2013). Wildlife management can be made succeed by scientific use of wildlife resources by mankind and improvement of natural ecosystem (Ovfleke O. 2015). About 36% of carnivores and ungulates of world threatened with extinction (IUCN 2019) so the monitoring of status of ungulates is crucial for wildlife management as it directly affect the carnivore population (Gray et al 2012).

## **6. CONCLUSION AND RECOMMENDATIONS**

### **6.1 Conclusion**

The distribution of Himalayan goral was recorded in Lamtang National Park between 2124 m and 2716 m above sea level from 28° 10.312' N and 85° 21.299' E to 28° 09.348' N and 85° 25.209' E. A total of seven Himalayan gorals were observed during single season observation with density of 0.47 individuals per km<sup>2</sup>. One goral was sighted in upper region of Khemjing village in Rocky cliff near Quercus Forest. A Female goral with a juvenile was observed in Grassland towards west of Sherpa Village. A total of four Himalayan gorals were sighted in the Rocky cliff towards east of Sherpa Village in which two were solitary adult and one was male female herd. The density of pellet was 1370 pellet group per km<sup>2</sup>. As the climate of the Himalaya is changing rapidly, we expect species to adjust their distributions. Unusual patterns of precipitation and temperature have already been observed in the Himalaya and such patterns are predicted to become more severe in the future.

### **6.2 Recommendations**

- The detail study on distribution, habitat preference and threat assessment of wildlife should be monitored regularly for their conservation.
- Large scale study on distribution status of goral and other wildlife should be performed in the Lamtang National Park.

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## PHOTOGRAPHS



**Photo 1.** Himalayan goral on steep terrain



**Photo 2.** Old fecal pellet of goral



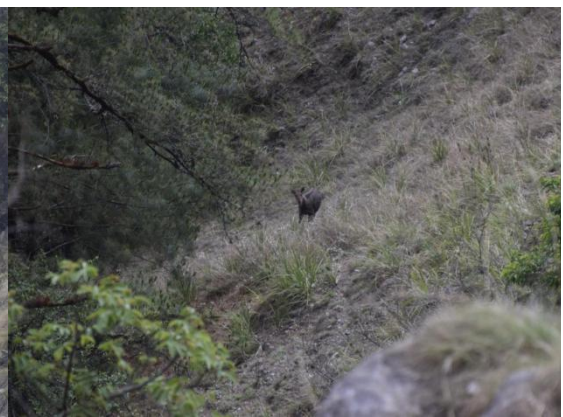
**Photo 3.** Grazing adult male and female goral



**Photo 4.** New fecal pellet of goral



**Photo 5.** Himalayan goral in rocky cliff



**Photo 6.** Himalayan goral in pine mixed forest