

**Distribution, Habitat Utilization and Threats of Himalayan Goral
(*Naemorhedus goral*) in Nawalpur District, Nepal**



Entry 86

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Submitted to:

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

May 2023

DECLARATION

I hereby declare that the thesis entitled "**Distribution, Habitat Utilization and Threats of Himalayan Goral (*Naemorhedus goral*) in Nawalpur District, Nepal**" has been done by me under the guidance of Associate Professor Dr. Laxman Khanal and no part of this work has been submitted for any other degree to any institution or University. All the sources of information have been acknowledged by giving citation and references to the author/s.

Date: 02 May 2023

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This thesis work submitted by Anish Paudyal entitled “**Distribution, Habitat Utilization and Threats of Himalayan Goral (*Naemorhedus goral*) in Nawalpur District, Nepal**” has been accepted as a partial fulfillment for the requirements of Master’s Degree of Science in Zoology with special paper Ecology and Environment.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
HGG	Himalayan Grey Goral
NP	National Park
MGCA	Mahabharat Goral Conservation Area
GLM	Generalized Linear Model
MBCCS	Mahabharata Biodiversity Conservation Concern Society
ASL	Above sea level
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature

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ABSTRACT

Himalayan gorals (*Naemorhedus goral*) are small sized shy natured cliff dwelling herbivorous mammals. They are widely distributed but less studied ungulates from Nepal. This study was conducted for determining the distribution, habitat utilization and conservation threats of Himalayan gorals from a part of the Mahabharata Goral Conservation Area in Nawalpur District, Nepal during December 2022 and March 2023. Observation of animals, fecal pellets, hoof marks in different habitat types along with topographic variables were recorded to find out the distribution and habitat utilization of Himalayan gorals. The study area was divided into three blocks each of 3km² (6km×0.5km) and a total of 34 line transects each of 0.5 km were surveyed. Additionally, questionnaire survey (n=21) and interviews with local people (n= 42) were done to assess the level of conservation threats. A total of 89 pellet deposits, two individuals of Himalayan gorals, and three hoof marks were recorded in the study area. The pellets of Himalayan gorals were distributed from the elevation of 925m to 1580m asl. Analysis of variance to mean ratio for transects revealed a clumped distribution pattern of pellets of Himalayan gorals. Four habitat types were used by the goral, where the highest number of fecal pellets deposits was recorded in rocky cliff area followed by *Shorea robusta* forest. Himalayan gorals preferred south facing steep slopes of 51°–75°. The major conservation threat of goral was found poaching. Regular monitoring of the Himalayan goral population and awareness programs should be conducted at local level for the conservation of Himalayan gorals in the Mahabharata Goral Conservation Area.

1. INTRODUCTION

1.1 Background

Himalayan goral (*Naemorhedus goral*, order Artiodactyla, sub-order Ruminantia, family Bovidae, class mammalia) is a small goat like animals (Figure 1). They are medium sized shy natured, cliff dwelling herbivores. They are dark grey or brown in color with dark dorsal stripes. They are found in the southern Himalayan foothills of East Pakistan, India, and Nepal as well as Bhutan and northernmost Burma and Thailand ranging from 200–4000m asl (Hayman 1961).

Goral has two recognized subspecies, *Naemorhedus goral goral* and *Naemorhedus goral bedfordi* (Wilson and Reeder 1993). Goral is diurnal animals and are most active in the early morning and late evening. They do not cause any harm to human beings. Males are typically solitary; they might be seen in pairs or small groups. They usually reside in small groups of 4–12 individuals. Goral likes grassy hills and steep rocky slopes to graze on. They graze on grass, leaves, twigs, fruits and nuts as food. With single births, the gestation duration is 170–218 days. Males and females achieve sexual maturity at three years of age, and they can live for up to 15 years (Prater 1971; Poudel 2009; Jnawali et al. 2011)

They are mountain hoofed animals that lives on cliffs, sexually monomorphic and is 65–70 cm in height and weighing about 25–30 kg (Prater 1980). The brown goral and grey goral of the western Himalayan serve as representatives of the Himalayan goral. They mainly select grasslands along a rock base area and woodland along a deep valley (Chaiyarat et al. 1999). They usually prefer open habitats at higher elevations, grassland, high topography and thick vegetation (Green 1985).

Himalayan gorals have been reported from eight Nepalese national parks (Khaptad NP, Rara NP, Langtang NP, Makalu-Barun NP, Bardia NP, Chitwan NP, Sagarmatha NP and Shey-Phoksundo NP (Wegge & Oli 1997), as well as the Annapurna Conservation Area, Dhorpatan Hunting Reserve and Parsa Wildlife Reserve. Himalayan gorals are also known to occur in the Taplejung area, beyond the Kanchenjunga Conservation Area (Poudel 2009). Due to lack of scientific investigations, the population and distribution of goral in Nepal is still unclear (Thapa et al. 2011).



Figure 1. Himalayan goral (*Naemorhedus goral*) individual observed in the Khalde Dada of Nawalpur, Nepal.

Himalayan goral is listed as Near Threatened in the IUCN Red list of Threatened Species (Duckworth & MacKinnon 2008). Because of increased human pressure on forests, wildlife has become a priority target, with just a little place for its resistance. The status of Himalayan goral populations is likely to be good. However, they are frequently hunted illegally for meat, both within and outside of protected regions. With ongoing trend of such actions, the Himalayan goral population is thought to decline in the habitat outside of the protected areas. Until now, scientific knowledge about Himalayan goral is limited within the nation (Shrestha & Jha 2015).

Most programs and conservation efforts are centered on distinctive large animals, but this initiative wants to start with one of the species that is currently neglected. The Magar people of Nawalparasi east's rural hills, who once killed gorals called "Sarsyaa" in their language for meat and entertainment, came together to work for the animal's conservation. The residents of Dhaubadi, Naram, Ruchang, Deurali and Hupsekot in Nawalparasi and Jhirubas in Palpa were inspired by this to regulate hunting and protected the endangered species (Shrestha & Jha 2015). Since 2008, those six local administrative bodies were designated as a Goral

Conservation Area and now are organized and actively working under the guidance of an NGO named the Mahabharata Biodiversity Conservation Concern Society (MBCCS). They focused on preserving vulnerable species as well as other living forms, with a primary focus on improving people's economic position through diverse possibilities for a living.

The environment that a species is most likely to select or that is best suited to these species is known as its habitat choice. Himalayan gorals prefer open habitat elevations, such as sub-alpine rhododendron bushes, alpine and grassland (Green 1985). They are extensively dispersed over the Mahabharat range. Furthermore, rocky mountainous locations outside of protected zones have also reported seeing Himalayan gorals. The primary indicator of an animal's habitat, distribution and utilization of the environment was a fecal pellet. Populations can be dispersed among three ways; uniformly, randomly, or clumped. According to a sign study in the area, Himalayan gorals were not uniformly dispersed and were found to be spread out between 964m and 1591m (Thapa et al. 2011).

Rapid human and livestock population growth in the Himalayan region has resulted in habitat loss, habitat degradation, poaching, trade and conflicts between wildlife and people. The main causes of Himalayan goral population decline were hunting, overgrazing, poaching, habitat loss, disturbance of different areas. As a result, several mountain species and their habitat are now seriously threatened.

The aim of this study was explore distribution, habitat utilizations, and current conservation threats of Himalayan goral in the region. The outcomes of this study will be key for the management of goral in Nawalpur District and locally created "Mahabharat Goral Conservation Area".

1.2 Research objectives

1.2.1 General objective

The major objective of study is to find distribution, habitat utilization and threats of Himalayan goral in Nawalpur District, Nepal.

1.2.2 Specific objectives

- i. To assess the distribution of Himalayan goral in the study area,
- ii. To explore the habitat utilization of Himalayan goral,
- iii. To investigate the conservation threats of Himalayan goral in the Nawalpur District.

1.3 Rationale of the study

The Himalayan goral is widely distributed to Asia, but its population is declining due to fragmentation, competition, and livestock habitat overlaps. As a result, goral conservation is a global problem. The Nepalese government is preserving endangered flora and animals, including Himalayan goral, which has been found in several sections of Nepal's mountains. However, due to lack of scientific investigations, the populations and distribution of goral in Nepal are unclear. There is little scientific research on the ecology of this species in Nepal. Therefore, this study was carried out to gather extensive information on the distribution and habitat utilization of goral in the studied area as well as the cause for the threats of this species. The study adds to the current database of knowledge about the distribution of Himalayan goral in Nepal. The findings of the study would be important for effective management of Himalayan goral population.

2 LITERATURE REVIEW

2.1 Distribution of Himalayan gorals

The Himalayan goral, *Naemorhedus goral* (Hardwicke) (Artiodactyla: Bovidae), are sharp cloven-hoofed mammals having slender legs (Roberts 1977). Goral, also known as Himalayan goral, is a closely related species that shares characteristics with a genuine goats, sheep, and antelope. They belong to subfamily Caprinae, characterized by species adapted for climbing on mountains. Gorals are mostly solitary animals (Green 1987), although groups can contain one to twelve individuals (Vinod & Sathyakumar 1990). Both sexes seem identical and are almost of same size.

Gorals are mostly an inhabitant and grazer (Ilyas & Khan 2003). The species has a short, black horn and are sexually monomorphic. Grey gorals are typically yellowish grey with black spots; yet, the upper lip, bottom of the jaws, and throat are white (Prater 1980). This species is currently distributed across the Churia and mid-hills between elevations of 300 m and 3,000 m. They graze on grass, leaves, twigs, fruits and nuts as food. With single births, the gestation duration is 170–218 days. Males and females achieve sexual maturity at three years of age, and they can live for up to 15 years (Jnawali et al. 2011).

There are six species under the genus *Naemorhedus* (Valdez 2011). However, according to Duckworth and MacKinnon (2008), the IUCN still only recognizes the four species: the Red goral (*Naemorhedus bailey*), the Chinese goral (*Naemorhedus caudatus* and *Naemorhedus griseus*), and the Himalayan goral (*Naemorhedus goral*).

Gorals are found in several provinces in China, although they are most common in the country's central and eastern regions (Dolan 1963). Goral are found in Doga National Park (NP), Royal Manas NP (Green 1987), Jigme Dorji NP (Johnsingh 1989), Black Mountains NP, and Thrumsingla NP in Bhutan. Gorals are found in Jammu and Kashmir, Himalchal Pardesh (Cavallini 1990), Uttar Pradesh (Singh & Singh 1986), the Kedarnath Wildlife Sanctuary (Green 1987), Sikkim, and Arunachal Pradesh (Sathyakumar 2003).

According to Duckworth and MacKinnon (2008), Gorals are found in eight National Parks in Nepal, including Khaptad NP, Rara NP, Langtang NP, Makalu-Barun NP, Bardia NP, Sagarmatha NP, and Shey-Phoksundo NP, as well as the Annapurna Conservation Area and Dhorpatan Hunting and Parsa Wildlife Reserve. In the Kanchanjunga Conservation Area, gorals are widely dispersed and locally numerous. They are also known to occur beyond the

KCA in the Taplejung area (Poudel 2009). According to local communities report, gorals are also found in the Mahabharata Range of the Nation and Mahabharata Goral Conservation Area (Thapa et al. 2011). In Pakistan, a nationwide survey was conducted from 2002 to 2004 in 98 locations spread out throughout the 4839km² of acceptable grey goral habit, 172 distinct grey goral including 143 adults and 29 sub adults were counted. The adult sex ratio was female-biased about 2:1 (Fakhar-I-Abbas et al. 2012).

2.2 Habitat utilization of Himalayan gorals

Himalayan goral is a goat antelope that is native to Asia and is found in the middle slopes of Himalayas (Singh & Singh 1986). They are found in the southern Himalayan foothills of India, Pakistan, and Nepal, Sikkim, Bhutan, and in northernmost Burma and Thailand (Hayman 1961; Schaller 1967).

In locally created Goral Conservation Area of Nawalparasi District, sightings of Himalayan gorals took place in early morning and the finding also revealed that goral was present in the region in an uneven but widespread manner. The Himalayan gorals were distributed from 1081–1552m asl. The Himalayan gorals were seen in herd sizes between 2 to 5 and were discovered more on grassland of south facing slopes as preferred habitat (Shrestha & Jha 2015). In the Majhatal Harsang Wildlife Sanctuary (MHWS) in the Indian Himalayan, Habitat selection, diet and escape behavior of grey goral was studied. Goral fed almost entirely on grasses (92% in cold season & 98.3% in warm season). They preferred open vegetation with good grass cover and avoided shrub-rich patches and have much broader elevation distribution from 200m to around 4000m. Goral do not seem to show any elevation migration (Mishra & Johnsingh 1996).

Anwar & Chapman (2000), in the Margalla Hills National Park (MHNP), reported Himalayan gorals at an elevation of 800m–1200m. They were usually observed either standing on the ridges or foraging on nearby vegetation and their droppings were found near the ridges. 28% of total park area was occupied by goral. According to Abbas & Rooney (2015), if the species is protected from human predation, the population, habitat, and species have the possibilities for the survival in the area. The Himalayan goral population is fragmented into 7–8 sub populations, is male biased in mortality and experiencing lack of males and genetic variety.

Himalayan gorals were located in steep grassy places, whereas muntjacs were found in various habitats and slopes. Nearer to the villages and highways, there was a low prevalence

of all species. Additionally, water supplies were essential in determining the distribution of animals since there was a greater number of mammals signals close to the water sources (Adhikari et al. 2019). Those species that favors flat, densely forested environments are affected by higher levels of human disturbances, and that adjusting to rugged places does not indicate reduced human disturbances. The abundance of all species was tested decreased with the number of settlements nearby and increase with distance to the nearest village (Paudel & Kindlmann 2012).

Himalayan goral was mostly found in subtropical sal woodland, subtropical pine broad-leaved forest, temperate broad-leaved forest, and rocky and grassy places. Topographic characteristics of these species were found more accurate indicators of the presence than distance to nearest village. It covered 67% of research area and widely distributed. The Churia hills in the southern section of the region, which is a remote place with a rich cover of grass, are only the location with high-quality habitats for Himalayan goral (Paudel et al. 2015).

It was confirmed that gorals were unevenly distributed in MGCA in Nawalparasi District. The distribution of species was found from the elevation of 964m to 1591m. The study suggested that the goral preferred steep slopes in southern aspect and rocky cliff as habitat the most (Thapa et al. 2011). According to Sherpa (2014), a total of five individuals and 31 pellet groups of goral were reported in ANCA, whereas the distribution of Goral were dispersed from the elevation 1150m to 3400m asl. The habitat preferred by goral was grassland followed by rocky cliffs, and the goral liked south facing steep slopes more in that area. The area's temperature and subalpine forests, the goat-antelopes, goral, and serow may have comparable food and cover requirements (Sathyakumar 1994; Awasthi et al. 2003). Karki(2021) found a total of five individuals and 122 fecal deposits of gorals in Dailekh District, Nepal. The gorals were distributed from 700m–1250 m asl and the preferred habitat by goral was cliff rock area the most. Goral preferred south facing steep slopes and top of cliffs.

In Om Koi Wildlife Sanctuary of Thailand, gorals mostly used chosen grasses near rock foundation region and forest near a deep valley. The age ratio of adults to newborns showed that the population was balanced. Goral were possible food sources for tiger and also due to hunting, the population of goral was on verge of being critically endangered (Chaiyarat et al. 1999). Pellet groups found within transect, along with direct sightings of individual animals

and signs of presence such as Hoof marks were collected. At each pellets sign, GPS coordinates, elevations, aspects, slopes, types of vegetations were recorded (Burnham et al. 1980).

In the Keoladeo NP, Bharatpur, India, several pellet-plot (sampling unit) designs were used to mitigate the underlying problems of the missed pellet groups on the larger plots. Different shapes and sizes of the sampling units, including the groups lying on the plot boundary were explored. Smaller plots and higher edge-to-area ratios were found to have higher density (Noor et al. 2022).

Bowkett et al. (2008), to investigate the ecology of forest antelopes in the biologically diverse Udzungwa Mountains, Tanzania, Camera-trapping was used. The link between camera trapping rates and vegetation was explored using generalized linear modeling. Over 630 pictures of antelope were taken, the camera trap rate showed the negatively associated to distance to the nearest village as expected for a species targeted for subsistence hunting.

According to Green (1987), in Kedarnath Sanctuary in Uttar Pradesh, India, the eating habitat of species differed according to faeces study. The musk deer is most similar to the goral in its utilization of shelter, although it feeds differently. The nutritional overlap between musk deer and goral is highest in the winter, when food supply is limited.

Cho et al. (2015), analyze the seasonal habitat utilization of reintroduced Long-tailed gorals in Woraksan (mountain) NP. A total of 10,721 goral were coordinated using transmitters and analyzed habitat utilization. Southwest slope was seen in spring, summer and autumn whereas northwest aspect was detected in winter. Furthermore, seasonal usage was higher in the summer and lower in winter and spring. Except in winter, the distance from the stream was typically 50m. The study investigates significant variations in the habitat utilization of reintroduced gorals in Woraksan (Mt.) NP.

During 2012-2013, the population traits of grey goral were studied in Machaira NP using direct visual observations of animals, indirect signals such as pellet groups. The Grey goral was found more in MNP than in Serli Sachi because of less disturbance of human. A total of 30 goral herds were recorded Machiara (21), Serli Sachi (9). The report concluded that the peak breeding of Grey goral is around Six months (Ashraf et al. 2015)

2.3 Conservation threats of Himalayan goral

According to the IUCN Red List category, three species of gorals: *Naemorhedus caudatus*, *Naemorhedus griseus*, and *Naemorhedus bailey* are classed as Vulnerable, while the Himalayan goral-*Naemorhedus goral* is classified as Near Threatened (Duckworth & MacKinnon 2008).

The Himalayan grey goral (*Naemorhedus goral bedfordi*), a caprinae species native to Asia and listed as Near Threatened on the Red List, lives on the Himalayan Mountains' southern slopes. The species is categorized as Vulnerable on the National Red List of Pakistan, although its range and abundance are poorly known.

Prey species for clouded and common leopard across the study found were red muntjac, wild boar, Himalayan serow, Himalayan goral, musk deer etc. The study showed that some prey species gets declined as elevation increases whereas Himalayan goral, musk deer did not showed any association with the elevation (Can et al. 2020). In Kohistan, Pakistan, locals and hunters detected goral by direct observations, fecal contents, noises, and footprints. The hunters hunted and trapped them for entertainment and food. The methods for hunting and trapping were mostly applied of camouflage, whistled by mouth and use of gunfire and bullet shoots (Perveen et al. 2013) .

The Azad Jammu and Kashmir Wildlife Department recorded illegal hunting of 24 goral between 2000-2011, of which nine were from protected areas and two from Machiara NP (Shakeel et al. 2015). The main risks to the preservation of the grey goral included habitat erosion, illegal hunting, poaching, overgrazing by cattle, and human disturbance despite the fact that goral is protected under the AJ&K Wildlife Act. Himalayan gorals are facing threats due to destruction of their habitat, degradation, habitat fragmentation, changes in land use pattern, and also due to others anthropogenic activities such as fire, fodder collection, fuel wood collection, overgrazing etc. (Yang et al. 2013).

3. MATERIALS AND METHODS

3.1 Study area

The study was carried out in the Mahabharat Goral Conservation Area (MGCA) established by local people. It is located in the Nawalpur and Palpa districts. The MGCA was founded in 2008 and covers the villages of Dhaubadi, Deurali, Ruchang and Naram in the former Nawalparasi District, as well as Jhirubas in the Palpa District (Acharya et al. 2008). The field survey was conducted on Hupsekot and Baudikali Rural Municipalities that are located between 27.77405° N 84.1145° E to 27.74172° N 84.1183° E(Figure 2). The study area's vegetation indicates a subtropical zone with elevations ranging from around 1000m to 2000m, with important vegetation including *Shorea robusta*, *Schima wallichii*, *Quercus* Forests (Oak). The other species found in these areas are *Panthera pardus* (leopard), *Canis aureus* (jackal), *Erethizontidae* (porcupine), *Panthera tigris* (tiger), *Chiroptera* (bat), birds, herpeto-fauna etc. The gorals that live in these regions are threatened by habitat deterioration caused by overgrazing, human disturbances, and poaching.

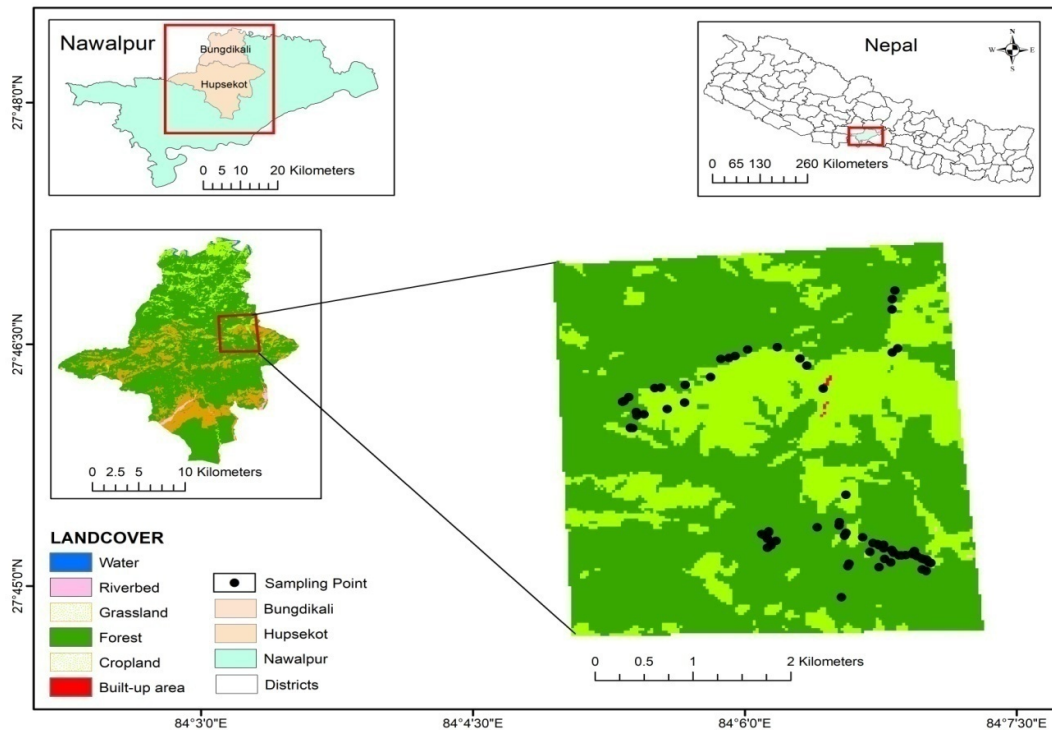


Figure 2. Map of the study area showing the GPS points of the records of Himalayan gorals and their fecal pellets.

3.2 Materials used

1. GPS (Garminetrex 10)
2. Camera (Canon 77D)
3. Zip lock Bags
4. Rope
5. Measuring Tape
6. Binoculars

3.3 Methods

3.3.1 Preliminary field Survey

The preliminary field visit was done to explore the potential habitats and threats of Himalayan goral during December 2022. Then the selection of study site was done in the study area.

3.3.2 Data collection

The data were collected in December 2022 and March 2023. The information on the distribution, habitat utilization and threats were carried out by direct observation, fecal pellets, footprints, and discussion with key informants and locals were done to obtain primary data from the field. Secondary sources such as books, papers, thesis, and journals were used to gather information on the current conditions, distribution, habitat utilization and dangers related to Himalayan goral. To identify expected goral threats, a field study was conducted which included questionnaire survey and interviews with local villagers and herders.

3.3.3 Block wise distribution of fecal deposits of goral

The study was carried out in Nawalpur District. Three blocks of each 3km² (6×0.5) km were created from the identified possible goral habitat area. They were named as Rudragadi Dada, Ramche and Khalde Dada. The sampling sites were chosen randomly. For data collection, roughly the same amount of time was spent in each block.

Further, based on the age of fecal matter, three kinds of fecal deposits have been identified. Wetness, coloring, scent and the look of pellets were the indicators of the age of fecal. Fecal matter less than two weeks were considered as fresh, fecal matter between two weeks and two month considered as old, fecal matter more than two months considered as very old.

3.3.4 Line transect survey

At intervals of 50 m along the matching lines on the topographic map, line transects of 0.5km in length were established. Pellet groups found within 5meters on either side of the line transect were collected, along with direct sightings of individual animals and signs of presence such as hoof marks. At each pellets sign, GPS coordinates, elevations, aspects, slopes, types of vegetations were recorded (Burnham et al. 1980).

3.3.5 Habitat utilization by Himalayan gorals

For analyzing the distribution of fecal pellets based on land use type, the study area's habitats were classified into four types of land categories: rocky cliff area, *Shorea robusta* forest, *Schima* and *Quercus* mixed forest and grassland. Significance difference of distribution of Ghoral pellets among different habitat type were recorded and tested.

To study the distribution of fecal pellets based on aspect, study area was categorized into eight categories namely South, South East, South West, East, West, North, North East and North West and distribution of pellets in each aspect was recorded.

For analyzing the distribution of fecal pellets based on slopes, the habitat utilization of goral was also studied according to the slope. One of the key elements in determining the existence of gorals in the study area was slope. On the basis of slope, study area was categorized into three categories. Slope Below 25° was taken as gentle slope, 26° – 50° as moderate slope whereas slope of 51° – 75° was taken as steep slope. Due to the greater steepness of the transect walk, faeces could not be captured above 75° .

To analyze elevation distribution of Himalayan gorals the field survey was done from the elevation of 461m to 1590m asl in the study area. The elevation of the study area was divided into four categories: <500 m, 500 –1000m, 1000– 1500 m and >1500 m.

3.3.6 Conservation threat assessment

Himalayan goral habitat disruptions have been predicted from general observations of its area's surroundings and also by conversations with local residents in the region. To construct the disturbance index, causes of habitat disturbance such as forest fire, livestock grazing, deforestation and other anthropogenic activities encountered along the transect were counted. To know the numbers of livestock, interviews with herders and villagers were undertaken. A

questionnaire survey was carried out in the area to understand the perception of people (n=42) about the goral and its threats. Interviews were held with the key people of the study area.

3.4 Data analysis

3.4.1 Distribution pattern

The distribution pattern was determined by using data on animals' location such as the number of individuals and pellets observed in each habitat of Himalayan goral. The distribution pattern of Himalayan goral was determined by using the variance-to-mean ratio (Odum 1971), which is based on the fact that in a Poisson distribution, the variance (S^2) is equal to the mean (\bar{x}).

If $S^2/\bar{x} < 1$, the distribution is uniform

If $S^2/\bar{x} = 1$, the distribution is random

If $S^2/\bar{x} > 1$, the distribution is clumped

Also, Chi square test, in R studio was done to determine the significance.

3.4.2 Habitat utilization

Direct observation of animals, fresh fecal pellets, and hoofmarks along with transects were used to evaluate the habitat utilization of the species (Joyon 1999). The number of individuals, footprints, and pellets seen in each habitat type were counted. According to Zhao et al. (2013), the habitat utilization by Himalayan goral for each habitat type was estimated as:

$$U_i = N_i/N$$

Where, U_i is the Himalayan goral's utilization rate of a certain habitat type.

N_i is the number of signs of Himalayan goral's in a certain habitat type

N is the total number of Himalayan goral's signs found in all habitat types.

Further, Chi square test, using R studio was done for significance test.

3.4.3 Environmental factors affecting Himalayan goral abundance

The different environmental variables such as slope, aspect, elevation, habitat types, distance to water resources, distance to road, canopy cover, ground cover and distance to human settlements were recorded. Based on the presence or absence of information, environmental

data were gathered. In the field, GPS mapping was used to identify the geographic coordinates of sites.

Using the R studio, the Generalized Linear Model (GLM) was executed. The GLM was done to find significance and relation between abundance of pellets with independent environmental variables including distance to the settlement, distance to road, slope, aspect and distance to water, nearest livestock, canopy cover and ground cover. GLM is a versatile generalization of conventional linear regression, which allows for response variables with error distribution models other than a normal distribution (Karki 2021).

4. RESULTS

4.1 Distribution of Himalayan goral in Nawalpur

During the field survey, a total of 89 fecal deposits were observed. Only two individuals, one at Ramche and another one at Khalde dada were sighted. Three hoof marks, one at Rudragadi Dada and two at Khalde Dada were seen. The field survey was done from elevation of 461m–1590m asl, where the indirect evidences of goral pellet were recorded in between 925m–1580m asl. As variance is greater than the arithmetic mean, the distribution pattern of goral fecal groups was clumped in the study area ($S^2/\bar{x} = 10.93 > 1$, $\chi^2 = 29.66$, $p \leq 0.05$).

4.1.1 Block wise distribution of fecal deposits of goral

Out of 89 fecal pellets deposits identified in the study area, the highest number of depositions were found in Khalde Dada (64.04%), followed by Ramche (19.10%) and Rudra Gadi (16.85%). The fecal pellet distribution was found to be significantly different among the blocks ($\chi^2 = 29.66$, $df = 2$, $p \leq 0.05$). In three blocks of research area, the fresh feces found were 58.42%, old fecal was 31.46% and very old fecal pellets was 10.11%. The highest amount of fresh fecal was found in Khalde followed by Ramche and Rudragadi. Among the old fecal depositions, the highest number was found in Khalde compared to other places. Rudragadi has the least amount of very old fecal deposition whereas Ramche has no evidence of very old fecal deposition.

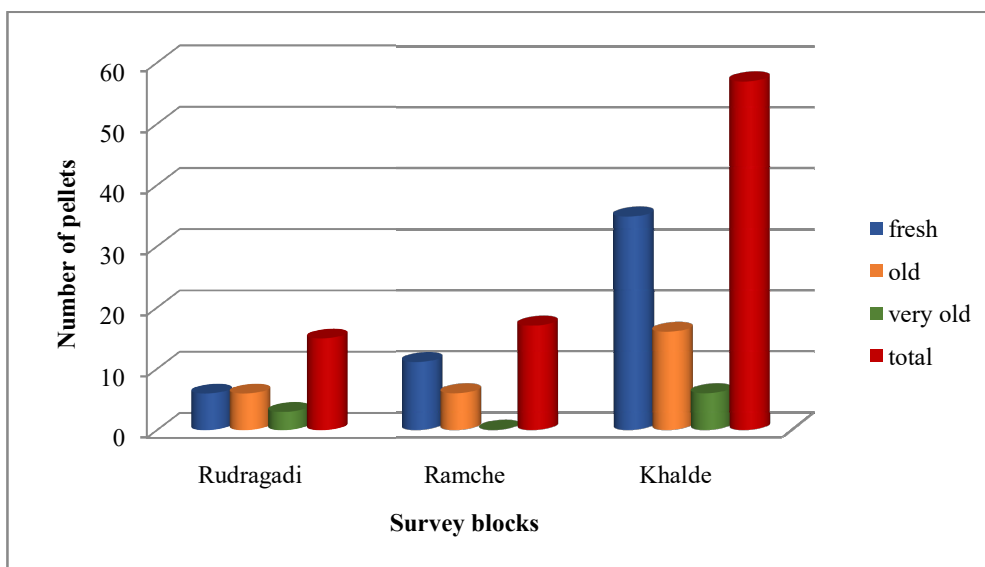


Figure 3. Fecal pellet deposits in different blocks of the study area

4.2 Habitat utilization by Himalayan gorals

4.2.1 Distribution of fecal pellets based on land use type

Highest percentage of pellets was observed from the rocky cliff habitat followed by the *Shorea robusta* forest. The finding indicated that Himalayan goral preferred rocky cliff areas the most as compared to others ($\chi^2=18.9$, $df=3$, $p<0.05$).

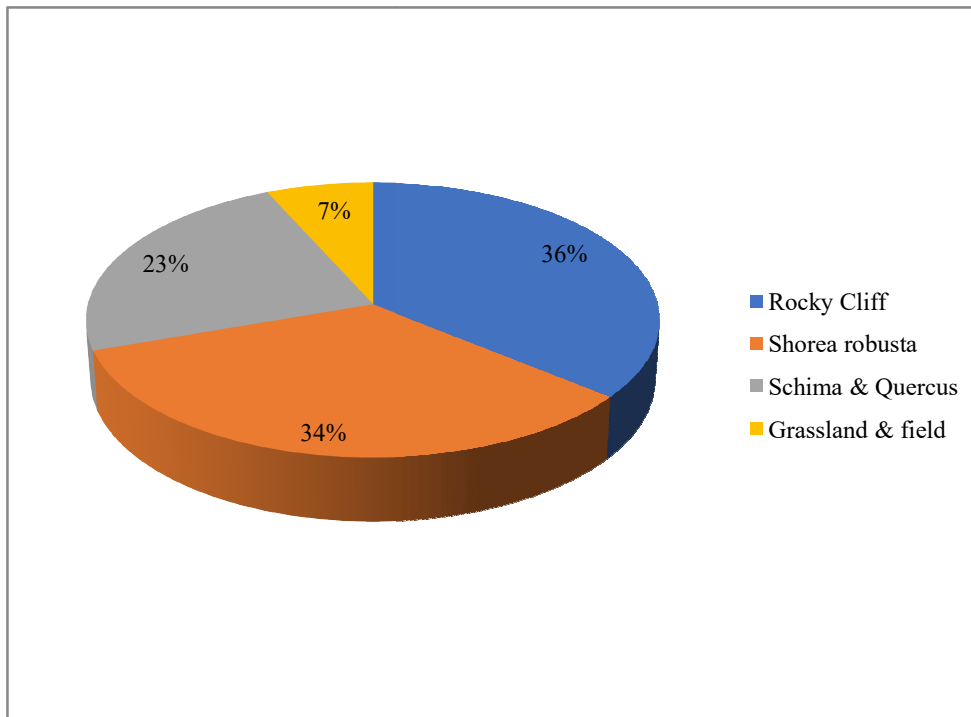


Figure 4. Forest type utilized by Himalayan gorals in the study area

4.2.2 Distribution of fecal pellets based on aspect

The collections of pellets were recorded at different aspects in the study areas. Most of the pellets deposition was found in southern aspect (n=35) followed by southeast (n=24), east (n=12) and west (n=9). The research also concluded that there was no evidence of habitat utilization in northwest aspect. The findings indicated that Himalayan goral preferred southern slope the most.

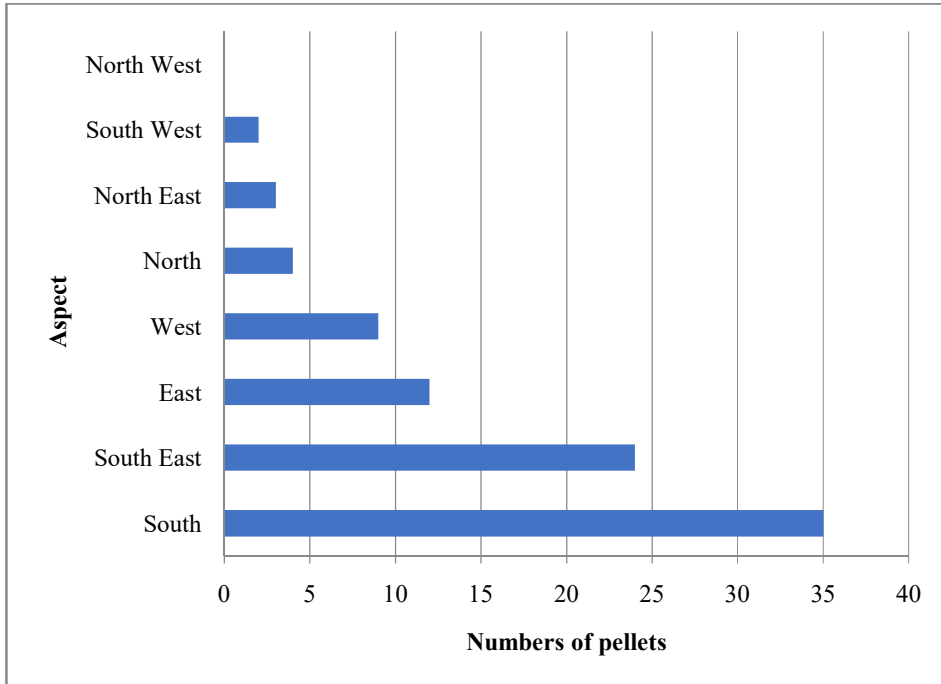


Figure 5.Different aspect utilized by Himalayan goral

4.2.3 Distribution of fecal pellets based on slopes

The highest depositions of pellet groups (79.77%) were found on the steep slope (>51°), whereas 17.98% were found in moderate slope (25°–50°). With increase in slope, faeces deposition was seen to increase. The finding indicated that goral favored steeper slopes. The southern edge of steep slope included the majority of the fecal groups.

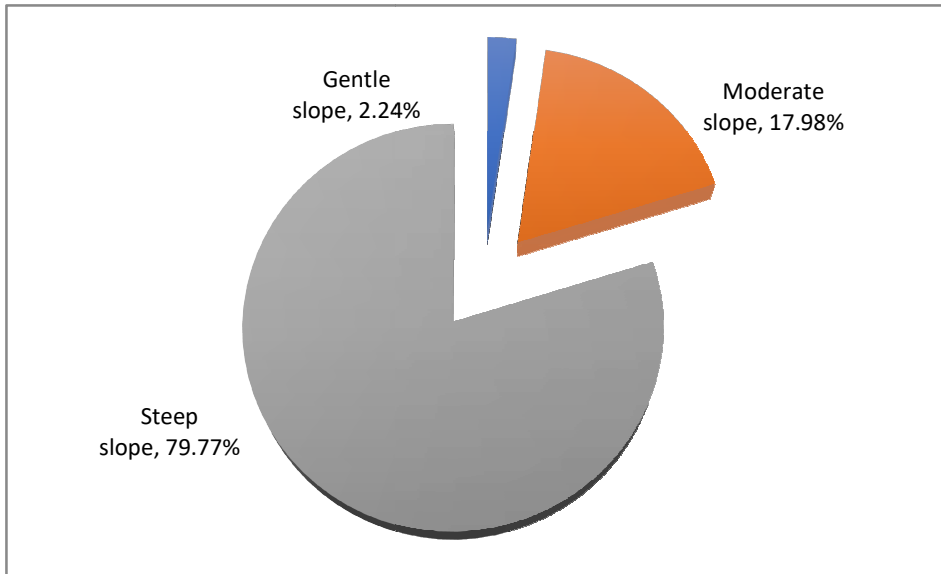


Figure 6.Habitat utilization of Himalayan gorals in different slopes

4.2.4 Distribution of fecal pellets based on elevation

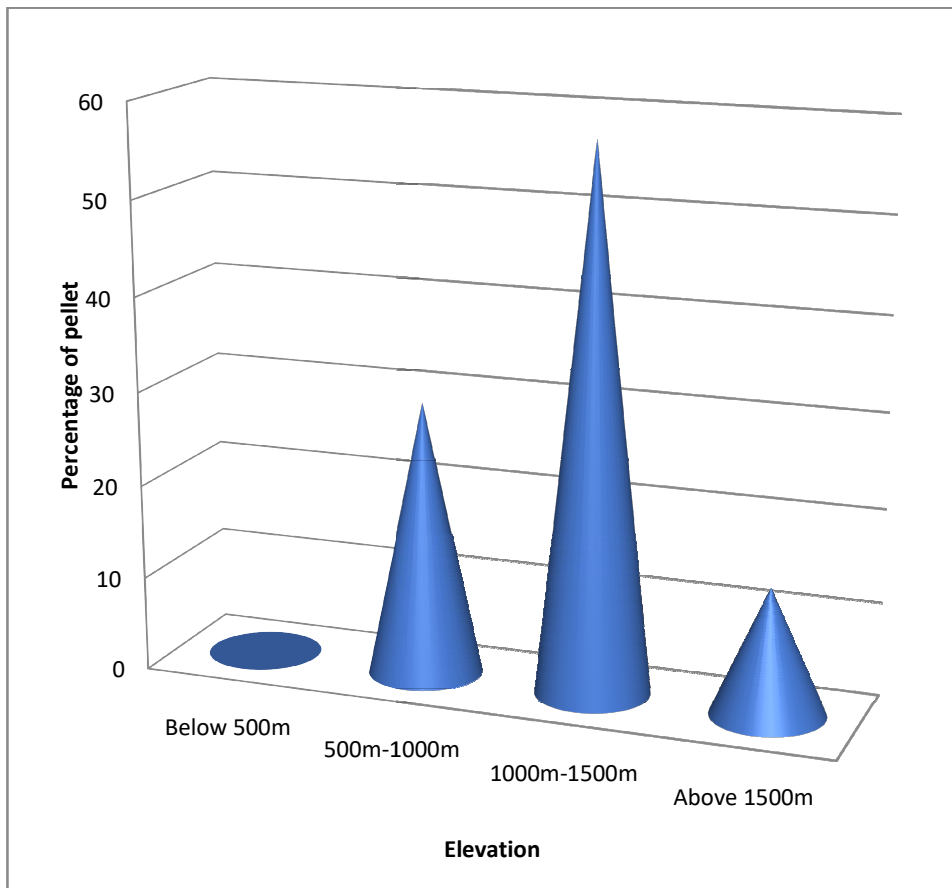


Figure 7. Presence of fecal pellets of Himalayan gorals in different elevations

The pellets were found from the elevation of 925m to 1580m asl. The highest percentage of pellets deposits found was 57.3% from the elevation of 1000m to 1500m followed by 29.21% between 500–1000m and 13.48% above 1500m asl. The sign of goral was not seen below the elevation of 500m, that means Himalayan gorals avoid the habitat utilization below 500 m asl. It revealed that Himalayan gorals preferred the elevation as (1000m–1500m) > (500m–1000m) > (above 1500m) ($\chi^2=64.753$, $df=3$, $p<0.05$).

Table 1.GLM between the pellet abundance with different habitat and disturbance variables.

Model Parameters	Estimate (β)	Std. Error (SE)	z-value	Pr(> z)
(Intercept)	1.9104	2.6412	0.723	0.4695
Elevation	-0.0021	0.0017	-1.161	0.2457
Slope	0.04946	0.0149	3.303	0.0009***
Aspect	-0.0015	0.0021	-0.732	0.4639
Distance to nearest water body	-0.0007	0.0007	-1.074	0.2827
Distance to nearest human settlement	0.0003	0.0005	0.552	0.5807
Distance to nearest livestock observed	0.0006	0.0006	0.903	0.3665
Distance to road	-0.0006	0.0004	-1.395	0.0431*
Canopy cover	-0.0369	0.0229	-1.608	0.0478*
Ground cover	-0.0148680	0.0201	-0.736	0.4615

Significance codes: 0'***'0.001'***' 0.01'*' 0.05'.'

The presence of Himalayan goral was influenced significantly by slope, distance to road and canopy cover. GLM showed significant positive relation between slope and number of goral fecal deposits ($p=0.0009$). The result showed that the number of goral pellet increased with the increase in slope. There is positive relationship between slope and presence of goral pellet.

The number of Himalayan goral fecal deposits decreased significantly as the distance to road increased. ($p=0.043$). The GLM showed a significant relation between canopy cover and presence of Himalayan goral pellet (0.0461).The abundance of pellets increased with decrease in canopy cover. There is negative relation between canopy cover and presence of goral pellet.

4.3 Conservation threats to Himalayan goral

A total of 42 respondents were interviewed, among them 69.05% were male and 30.95% were females. Around 86% of respondents reared the livestock around the community forest. A collection of questions was asked to the respondent about the condition and threats of the Himalayan gorals in the study areas. They claimed that the most significant danger to Himalayan goral is poaching. They are mostly hunted for the purpose of obtaining meat. Poachers hunted with guns and other traditional traps. Respondents also informed that the illegal hunting has been minimized after the declaration of the Mahabharat Goral

Conservation Area. Along with that, the other threats to the Himalayan goral were forest fire, over grazing, predators, and other anthropogenic activities. According to the respondents, the major threats to the Himalayan goral included poaching followed by forest fire, over grazing and anthropogenic activities.

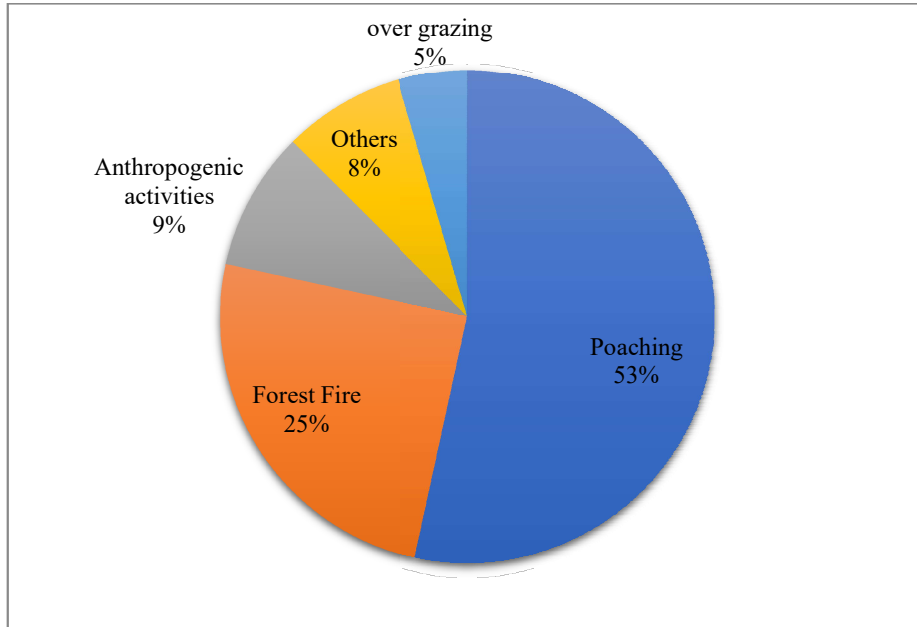


Figure 8.Major threats on Himalayan Goral in the study area.

About 49% of the respondents confirmed poaching of goral in different parts of study area. 45% of the respondent denied about the poaching activities and 6% did not want to answer.

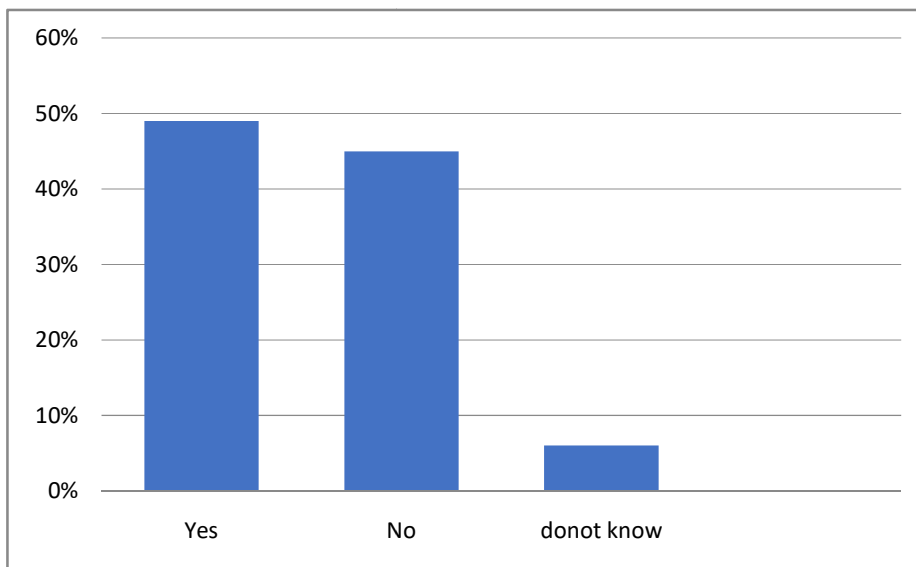


Figure 9.Respondents view about poaching of goral

5. DISCUSSION

5.1 Distribution of Himalayan gorals

This study observed the distribution and habitat utilization of Himalayan gorals by direct observation and fecal pellet survey in Nawalpur District, central Nepal. Himalayan gorals are said to be found in numerous protected areas, including the Mahabharat range and steep hilly places outside of the protected area. Nawalpur District is thought to have a good goral population. According to current research, Himalayan gorals are broadly dispersed throughout the MGCA. Fecal dropping was the primary indicator utilized to assess animal habitat, distribution, and habitat utilization. According to the sign study, it suggests that gorals have clumped distribution in all the blocks which is supported by study of (Thapa et al. 2011).

During the research, Himalayan gorals were identified at the elevations ranging from 925m to 1580m asl. Highest fecal droppings were recorded from 1000m to 1500m as compared to other elevation zones in the study area. Slope is a major component for preferable habitat of Himalayan gorals. The present report shows that the Himalayan gorals prefer steep slopes of 51°–75°. This result is supported by different studies. Gorals typically live in rocky, forested mountainous terrain between 1000 m and 4000 m elevation (Schaller 1967). The distribution of goral observed from elevations between 800 m and 1200 m was indicated by (Anwar & Chapman 2000). Thapa et al. (2011) suggested that the goral was found distributed between the elevation of 964 m to 1591 m. The reason behind observation of Himalayan gorals in higher elevations might be due to human disturbance.

Gaston (1981) reported that gorals are spread between 1800m and 3700 m, with abundance peak around 2200 m to 3400 m. The elevation range of Himalayan gorals was found to be from 3000 m to 4200m in the study of Sikkim Himalaya (Srivastava and Kumar 2018). Highest fecal droppings were recorded between 2000m to 3000m elevation range in API Nampa Conservation area, Nepal, (Sherpa 2014). According to Bhattacharya et al. (2012), Goral was detected over the broadest elevation range 1730 m–3670 m in Khangchendzonga Biosphere Reserve, Sikkim, India. This contradiction is due to the low range of hill in my study area.

5.2 Habitat utilization by Himalayan gorals

Habitat utilization is a major aspect of the species. According to the present study, Goral preferred rocky cliff area the most as their habitat utilization followed by *Shorea robusta* forest, *Schima* & *Quercus* mixed forest. The findings also indicated that Himalayan goral preferred southern steeper slopes the most. According to Karki(2021),the habitat utilization of goral was mostly seen in rock cliff area and *Quercus* forest, followed by Sal-Terminalia forest and mixed hardwood forest. According to Abbas & Rooney (2015), Himalayan goral is associated with *Pinus roxburghii* and prefers habitat with sufficient open area with ledges of steep rocks. Schaller (1967) and Mishra (1993) found in the study that goral species mostly frequent steep, rocky areas. In this study about 80% of pellet deposits were found in steep slopes of ($>50^\circ$). According to (Thapa et al. 2011), goral preferred rocky cliff areas followed by *Shorea* mixed forest whereas, the highest pellet deposits were recorded from the steep slope of ($51^\circ-70^\circ$). The preferable habitats for goral was found mostly in steep grassy slopes (Fakhar-I-Abbas et al. 2012).

Himalayan goral was mostly found in subtropical sal woodland, subtropical pine broad-leaved forest, temperate broad-leaved forest, and rocky and grassy places and covered 67% of research area and widely distributed (Paudel et al. 2015). The Churia hills in the southern section of the region, which is a remote place with a rich cover of grass, are only the location with high-quality habitats for Himalayan goral. According to Sherpa (2014) , the habitat preferred by goral was grassland followed by rocky cliffs, and the goral liked south facing steep slopes more in that area. Most of the pellets deposition was found in southern aspect (n=35) followed by southeast (n=24), east (n=12) and west (n=9). This finding is also supported by study of (Thapa et al. 2011) in which highest pellet deposits were recorded from the southern aspect. This might be due to as goral is diurnal animal and southern aspect receives more sunlight hence has slightly longer day time.

5.3 Conservation threats of Himalayan gorals

Locals' response to the questionnaires concluded the presence of goral in the study area. They also claimed that poaching is major threat to goral. They mostly hunted to obtain meat. Poachers used guns and other traditional method for hunting the goral. Other threats such as over grazing, predators and other anthropogenic activities were also recorded in the area. In the present study, most of the respondents claimed that the peak time for poaching is at night in the study area. This result is similar to finding of Yang et al. (2013) in which it is

mentioned that gorals are facing threats due to poaching destruction of their habitat, degradation, habitat fragmentation, changes in land use pattern, fire, fodder collection, fuel wood collection, overgrazing etc. Reason behind it is lack of public awareness about the importance of conservation of wild species and interest of humans in free meat.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In the survey, 89 fecal pellet deposits of Himalayan gorals were observed from the study area. Two Himalayan gorals were sighted; one in Khalde dada and another in Ramche along with 3 hoof marks, one at Rudragadi Dada and two at Khalde Dada were seen. The Himalayan gorals were found to be distributed from the elevation of 925m to 1580m asl and avoiding the elevation below 900 m asl. Distribution of gorals was confirmed by the indirect evidence that is pellet deposits. It was confirmed that the distribution of Himalayan gorals' pellets were clumped in the Mahabharat Goral Conservation Area in Nawalpur District. Goral used steep slopes (51° – 75°) and mostly used southern aspect. Goral mostly used rocky cliff area as habitat followed by *Shorea robusta* forest. There was positive relationship between slope and presence of goral pellets and negative relation between goral pellet and distance to road and canopy cover. The study also confirmed that poaching was the major conservation threats for the Himalayan goral followed by forest fire, and overgrazing.

6.2 Recommendations

Based on the results of this study and field observations, following recommendations could be made for the conservation of Himalayan gorals in the Mahabharat Goral Conservation Area.

1. Human disturbance and poaching are the major threats to the Himalayan gorals. Therefore, Conservation awareness is much needed in the study area.
2. Presence of livestock in the forest showed negative relation to the abundance of fecal pellets of gorals. Therefore, livestock grazing of cattle should be managed properly.
3. Himalayan gorals are one of the least studied mammals facing conservation challenges. Therefore, regular monitoring of the goral population should be done.
4. A local community program, targeted at preventing forest and the wildlife population should be adopted in the area to safeguard the species of the region.

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APPENDIX 1

Questionnaire Sheet

Name of the Respondent:

Gender:

Occupation:

1. Which animals are found in your area?
2. How many times have you seen them in this month?
3. Have you seen Himalayan goral in this area?
4. How many times have you seen it?
5. In which places the sign of gorals are found more?
6. What color and size do they have?
7. Do they harm human?
8. Do you know what do they feed?
9. What types of habitat do they like most?
10. At what time they are seen the most?
11. Is there poaching of goral in this area?
12. What are the main threats of goral?
13. What are the predators of goral?
14. At what time they are poached most?
15. Which weapons are used to poach?
16. Has poaching increased or decreased in last 5 years?
17. Why are they killed?
18. In Which season does poaching increases?
19. Do you think conservation of goral is important?
20. Are local people interested in conservation of goral?
21. Does they destruct agriculture field in village?

APPENDIX 2

Data Collection Sheet

SN	TN	Sp N	E	E	Pp N	E	Elev	S°	As	As°	Go To	Dr To	Dr	Ne	O	V	FP	DTW	DTH	DTC	DTR	Ca	Can	S			
1	1	27	46.337	84	7.113		1384	20	E	82	0	0	0	0	0	0	0	660	512	305	400	25	15	RW			
2	2	27	46.475	84	6.844	27	46.449	84	6.814	1475	25	S	187	0	1	1	0	1	0	0	466	882	800	725	0	1.26	D
3	3	27	46.716	84	6.813	27	46.78	84	6.814	1580	30	NE	34	0	1	1	0	0	1	0	630	1212	1200	1057	0	1.26	D
4	4	27	46.412	84	6.305	27	46.368	84	6.342	1453	38	W	269	0	1	1	0	1	0	0	588	667	800	80	0	2.01	D
5	5	27	46.19	84	6.455					1380	22	W	265	0	0	0	0	0	0	0	890	556	256	40	0	0	D
6	6	27	46.129	84	6.397	27	46.282	84	6.315	1376	22	SW	242	0	1	1	0	1	0	0	792	722	815	60	10	0.3	D
7	7	27	46.285	84	6.204	27	46.239	84	6.023	1412	31	S	188	0	1	1	0	1	0	0	887	1302	825	65	12	5.2	D
8	8	27	46.164	84	5.947	27	46.101	84	5.847	1425	38	S	175	0	1	1	1	0	0	0	912	1567	896	55	4	3.4	D
9	9	27	46.138	84	5.668	27	46.098	84	5.572	1488	42	SW	205	0	1	1	1	0	0	1	940	1899	902	79	12	5.9	D
10	10a	27	46.058	84	5.405	27	45.979	84	5.382	1480	55	S	189	1	8	3	1	1	1	0	960	2008	1516	115	16	2.6	D
	10b					27	45.98	84	5.369	1486	56	S	180	0		1	1	0	0	0	961	2009	1517	115	12	5.8	D
	10c					27	45.982	84	5.369	1481	56	S	181	0		4	2	1	1	0	961	2009	1518	115	18	8.9	D
11	11	27	46.068	84	5.406	27	46.08	84	5.401	1511	68	S	173	0	3	3	2	1	0	0	981	2001	1498	105	15	9	RD
12	12	27	46.148	84	5.334	27	46.172	84	5.36	1603	70	S	175	0	2	2	2	0	0	0	1112	1998	1356	665	25	45	D
13	13	27	46.231	84	5.538	27	46.248	84	5.672	1540	69	SE	131	0	1	1	0	1	0	0	1214	2005	1256	700	29	55	D
14	14	27	46.297	84	5.811	27	46.409	84	5.868	1558	61	NE	26	0	2	2	1	1	0	0	715	1551	1102	859	0	6.8	D
15	15	27	46.427	84	5.947	27	46.467	84	6.016	1555	33	S	180	0	3	3	2	1	0	0	100	1250	275	516	0	7	W
16	16	27	46.466	84	6.207	27	46.406	84	6.132	1466	37	SE	140	0	2	2	2	0	0	0	498	1055	312	401	0	4	RW
17	17	27	46.032	84	6.383					1335	29	NE	300	0	0	0	0	0	0	0	675	300	285	379	15	4	RD
18	18	27	45.791	84	6.43	27	45.63	84	6.536	1212	41	SE	138	0	2	2	1	1	0	0	388	805	785	1350	22	12	D
19	19	27	45.566	84	6.558	27	45.396	84	6.522	1048	51	E	94	0	2	2	1	1	0	0	401	1258	1112	1720	23	15	RD
20	20	27	45.335	84	6.534					994	22	NW	349	0	0	0	0	0	0	0	900	1600	1558	2112	56	25	RD
21	21a	27	45.33	84	6.559	27	45.267	84	6.708	990	55	N	3	0	4	2	2	0	0	0	810	2016	1946	2424	10	4.5	D
	21b					27	45.256	84	6.766	1017	56	N	5	0		2	1	1	0	0	812	2024	1948	2426	12	5	D
	21c					27	45.253	84	6.741	1013	60	N	8	0		0	0	0	0	2	808	2026	1952	2428	11	6	D
22	22a	27	45.26	84	6.733	27	45.224	84	6.811	1015	68	E	98	1	10	2	1	1	0	0	816	2558	2498	2830	12	6	D
	22b					27	45.214	84	6.817	1009	69	E	99	0		3	2	1	0	0	817	2560	2500	2833	11	2	D
	22c					27	45.206	84	6.821	1003	67	E	96	0		3	1	1	1	0	815	2566	2505	2834	12	3	D
	22d					27	45.19	84	6.851	1001	65	E	94	0		2	1	1	0	0	813	2535	2510	2838	10	4	D
23	23a	27	45.192	84	6.888	27	45.199	84	6.923	1009	71	SE	126	0	19	4	2	1	1	0	810	3078	3006	3252	12		D
	23b					27	45.213	84	6.935	1004	72	SE	129	0		2	1	1	0	0	805	3080	3008	3254	8	4	D
	23c					27	45.205	84	6.931	1009	74	SE	145	0		3	1	1	1	0	806	3082	3010	3265	9	3	D
	23d					27	45.209	84	6.934	1006	70	SE	141	0		3	2	0	1	0	805	3082	3012	3266	10	4	D
	23e					27	45.216	84	6.936	1004	71	SE	144	0		3	2	1	0	0	804	3088	3018	3267	8	6	D
	23f					27	45.215	84	6.935	1004	72	SE	149	0		1	1	0	0	0	804	3087	3017	3268	11	8	D
	23g					27	45.195	84	6.934	1010	74	SE	140	0		2	1	1	0	0	807	3089	3019	3269	12	8	D

	23h					27	45.185	84	6.95	1002	70	SE	142	0		1	1	0	0	0	801	3089	3019	3270	12	8	D	
24	24a	27	45.165	84	6.991	27	45.163	84	7.005	968	61	S	190	0	10	3	1	1	1	0	612	3288	3208	3359	12	5	D	
	24b					27	45.15	84	7.015	943	60	S	189	0		2	1	0	1	0	610	3280	3200	3360	17	4	D	
	24c					27	45.159	84	47.008	961	62	S	181	0		2	1	1	0	0	605	3292	3212	3361	10	4	D	
	24d					27	45.147	84	7.016	938	63	S	183	0		1	1	0	0	0	599	3285	3205	3362	17	4	D	
	24e					27	45.143	84	7.027	927	64	S	184	0		2	1	1	0	0	598	3286	3204	3364	20	4	D	
25	25	27	45.103	84	6.979	27	45.146	84	6.806	943	38	S	175	0	2	2	1	1	0	0	1024	2526	2486	2848	12	6	D	
26	26	27	45.117	84	6.741	27	45.212	84	6.691	951	40	W	270	0	2	2	2	0	0	0	895	2038	1975	2466	11	8	D	
27	27	27	45.364	84	6.4					986	22	NW	340	0	0	0	0	0	0	0	912	2516	2486	2895	45	25	RW	
28	28a	27	45.252	84	6.145	27	45.237	84	6.125	971	74	W	269	0	6	3	2	1	0	0	899	2998	2902	3212	29	6	D	
	28b					27	45.238	84	6.127	971	75	W	286	0		2	2	0	0	0	899	3000	2904	3214	29	6	D	
	28c					27	45.293	84	6.126	991	73	W	280	0		1	1	0	0	0	895	3002	2906	3216	21	7	D	
29	29a	27	45.317	84	6.102	27	45.322	84	6.094	958	55	S	282	0	4	2	2	0	0	0	250	3412	3338	3746	19	5	D	
	29b					27	45.339	84	6.132	956	57	S	285	0		2	1	1	0	0	251	3412	3340	3747	24	5	D	
30	30	27	45.312	84	6.551					978	24		315	0		0	0	0	0	0	300	3612	2609	3940	85	14	RW	
31	31	27	45.123	84	6.569					826	22		320	0		0	0	0	0	0	223	4012	2208	4354	65	16	RW	
32	32	27	44.898	84	6.536					689	12		345	0		0	0	0	0	0	150	4515	1706	4852	44	25	RW	
33	33	27	44.751	84	6.66					565	10		322	0		0	0	0	0	0	140	5012	1208	5368	66	30	RW	
34	34	27	44.665	84	6.934					500	10		337	0		0	0	0	0	0	130	5512	712	5855	78	20	RW	
																89	52	28	9									

TN= Transect Number Sp= Starting point, N= North, E= East, Pp= Presence point, Elev= Elevation, S°= Slope(°), As= Aspect, As(°)=Aspect(°), Go To= Goral in total transect, Dr To= Droppings in transect, Dr= Droppings, Ne= New, O= Old, V= Very old, FP= Foot Print, DTW= Distance to water, DTH= Distance to human settlement, DHC= Distance to nearest cattle, DTR= Distance to road, Ca= Canopy cover, Can= Ground cover, S= Soil type

APPENDIX 3

Photo Plates



Figure 10.Rocky cliff area in the study area



Figure 11.Fresh fecal pellet deposits with GPS



Figure 12.Old fecal pellet deposits with GPS



Figure 13.Fresh and old fecal deposits with GPS



Figure 14.Water source



Figure 15.Weapon (in making process) which can be used for poaching



Figure 16. Hoof marks of Himalayan goral with GPS seen in Khalde Dada



Figure 17. Hoof marks of Himalayan goral seen in Khalde Dada